The Effects of Emission Trading on the Pulp and Paper Industry in Europe

DISSERTATION
for obtainment of a doctoral degree
at the University of Hamburg
Faculty of Mathematics, Informatics and Natural Sciences

submitted by

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Hamburg 2007

Genehmigt vom Department Biologie
der Fakultät für Mathematik, Informatik und Naturwissenschaften
an der Universität Hamburg
auf Antrag von Professor Dr. C. THOROE
Weiterer Gutachter der Dissertation:
Herr Professor Dr. A. FRÜHWALD
Tag der Disputation: 02. Juli 2007

Hamburg, den 15. Juni 2007

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Abstract

Since January 2005, the European pulp and paper industry has been subject to the newly introduced emission trading scheme. Manufacturing costs have been affected directly, primarily due to scarce emission allowances and administrative costs, and indirectly, primarily due to increasing raw material (fibre, chemicals) and energy (electricity, fuels) costs. Even under the "most-likely" scenario the total out-of-pocket effect is severe for certain manufacturing processes. Key drivers are increasing fibre and electricity costs. Immediate actions need to be taken to maintain competitiveness and profitability against the background of imports from outside the EU. Numerous potential actions focusing on raw material and energy costs, on pricing, and partially going beyond current business have been sketched. However, politicians on a European and national level should also take action to prevent a decline in the pulp and paper industry in Europe as a result of unintended side effects of environmental and energy legislation.

Key words

Pulp, paper, emission trading, competitiveness, profitability, electricity price, wood price, pulp price, recommendation

Abstract

Seit Januar 2005 ist die Europäische Zellstoff- und Papierindustrie dem Emissionsrechtehandel unterworfen. Herstellkosten sind direkt, insbesondere durch knappe Zuteilung von Zertifikaten und administrative Kosten, und indirekt, insbesondere durch steigende Rohstoff- (Holz, Chemikalien) und Energiekosten (Strom, Brennstoffe) betroffen. Schon unter dem wahrscheinlichsten Szenario ist der kassenwirksame Effekt für einige Herstellungsprozesse schwerwiegend. Haupttreiber sind die Anstiege von Faser- und Stromkosten. Von Seiten der Industrie müssen dringend Handlungen unternommen werden, um Wettbewerbsfähigkeit und Profitabilität vor dem Hintergrund von Importen aus dem Nicht-EU Raum zu erhalten. Jedoch sind auch die Politiker auf Europäischer und nationaler Ebene gefordert, Maßnahmen zu ergreifen, einen Niedergang der Zellstoff- und Papierindustrie in Europa als Folge unbeabsichtigter Nebeneffekte der Umwelt- und Energiegesetzgebung zu verhindern.

Schlüsselbegriffe

Zellstoff, Papier, Emissionsrechtehandel, Wettbewerbsfähigkeit, Profitabilität, Strompreis, Holzpreis, Zellstoffpreis, Handlungsempfehlung

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Thanks

This thesis originated during my scientific work as an external PhD student at the Institute for Economics and the Institute for Wood Physics and Mechanical Technology of Wood at the Federal Research Centre for Forestry and Forest Products in Hamburg.

My primary thanks are dedicated to my doctoral adviser Professor Dr. Carsten Thoroe and Professor Dr. Arno Frühwald who supervised the dissertation. I would like to thank both of them for their strong support in defining the objective of the investigation, for persistently challenging the hypotheses, and for the provision of valuable advice on methodological questions during our continual discussions.

My special thanks are devoted to the representatives of the nine pulp and paper manufacturers, who participated in the investigation. I would like to thank the people responsible in the headquarters of the companies for joining the investigation, for supporting, shaping, and sharpening the focus, and for selecting the mills to approach for the case studies. Additionally, I would like to thank all the engineers and controllers in the mills who provided valuable insights into the energy setting of their mills and the effects of the environmental regulation in their respective countries and who made available all the data needed to model the effects of emission trading on the pulp and paper industry. I am fully aware that they spent remarkable amounts of time on providing this data and am very grateful to them.

In addition, I would like to thank the "Gesellschaft der Förderer und Freunde des Zentrums Holzwirtschaft an der Universität Hamburg e.V." for funding the travel costs associated with this investigation.

Hamburg, July 2007 Jan-Henrik Hübner

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List of abbreviations

a	Year (annum)
AAU	Assigned Amount Unit
Art.	Article
BAPA	Buenos Aires Plan of Action
BAT	Best-available techniques
BBKP	Bleached birch kraft pulp
bdt	Bone dry ton
BEKP	Bleached eucalyptus kraft pulp
BHKP	Bleached hardwood kraft pulp
BFB	Bubbling fluidised bed (boiler)
BLGCC	Black liquor gasification combined cycle
BLGMF	Black liquor gasification motor fuels
C	Carbon
CCGT	Combined Cycle Gas Turbine
CEO	Chief Executive Officer
CER	Certified Emission Reduction
CDM	Clean Development Mechanism
CFB	Circulating fluidized bed (boiler)
CHP	Combined heat and power generation
COP	Conference of the Parties
CO_2	Carbon dioxide
CTMP	Chemi-thermo-mechanical pulp
EBIT	Earnings before interests and taxes
EBITDA	Earnings before interests and taxes, depreciation and amortisation
EC	European Community (since 1992, before EEC; not to be confused with the European Communities, the processor of the EU)
ECF	Elemental chlorine free
EEC	European Economic Community
EEX	European Energy Exchange
ERU	Emission Reduction Unit
EU	European Union
EUR	Euro
ETS	Emission Trading Scheme (entirety of all EU Directives, Decisions etc. on emission trading)
GJ	Gigajoule
HFO	Heavy fuel oil
JI	Joint Implementation
kV	Kilo volt
LFO	Light fuels oil
LULUCF	Land use, land use change, and forestry

LWC	Light-weight coated paper
MRG	Monitoring and reporting guidelines (Commission decision 2004/156/EC)
Mt	Megaton
MWh	Megawatt hour
NAP	National allocation plan
NBSK	Northern bleached softwood kraft pulp
OCC	Old corrugated carton
ONP	Old newsprint
PCC	Precipitated calcium carbonate
PGW	Pressurised groundwood
RES	Renewable energy sources
RMP	Refiner mechanical pulp
ROCE	Return on capital employed
ROE	Return on equity
SGW	Stone groundwood
t	Ton
TCF	Total chlorine free
TMP	Thermo-mechanical pulp
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
UWF	Uncoated woodfree paper
VAT	Value added tax

1. Preface – emission trading calls for research

In late 2003, when the investigation was initiated, European pulp and paper manufacturers had to face a new challenge. The European Union and its member states prepared the introduction of a new instrument of environmental politics: emission trading.

Global discussions on climate change and protection for more than 20 years had prepared the ground. Its cornerstones were the adoption of the United Nations Framework Convention on Climate Change in Rio de Janeiro 1992 and the adoption of the Kyoto Protocol 1997. On a European level, it still took five years until the EU Parliament and Council adopted Directive 2003/87/EC which was the basis for the actual emission trading scheme in Europe and the link between the obligations of nations to reduce their greenhouse gas emissions and actions to be taken by individuals. The Directive defined two phases for emission trading in Europe. The first one, from 2005 to 2007, was intended as a pre-phase to the global emission trading scheme introduced by the Kyoto Protocol. The second phase, from 2008 to 2012, corresponds to the period defined in the Kyoto Protocol.

Four industry sectors are directly subject to the EU emission trading scheme until 2012. The pulp and paper industry is one of them. Thus, it appeared evident that pulp and paper manufacturing would face direct effects from emission trading. However, indirect effects, arising from raw material and energy price increases, also seemed probable.

Accordingly, three key questions emerged from a business or microeconomic perspective:

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment?

A thorough investigation on the available status of research revealed that these questions had hardly been touched and thus had been rather insufficiently answered. The few available publications primarily did not differentiate between the different pulp and paper manufacturing processes nor did they pay sufficient attention to the indirect effects.

Thus, a large scale research effort was started in spring 2004 in parallel to the still developing European and national legislation. 22 pulp and paper mills in nine European countries, representing all economically relevant manufacturing processes, were approached for a multiple case study. The qualitative research design comprised interviews with the people responsible on corporate level and management and engineers in the mills. Based on data gathered from mills (energy consumption and supply, raw material input, cost breakdowns etc.), a sophisticated model has been developed to forecast the direct and indirect effects of emission trading based on different scenarios. Three hypotheses on the above-mentioned first key question have been tested and accepted:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters as according to the manufacturing process, level of integration, energy mix etc.
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

As is common for qualitative empirical research, inductive generalisation has been made by replication. Other than statistical evidence used for quantitative research, this approach allows conclusions and predictions also beyond the actually investigated combination of characteristics.

The scope was set to all relevant manufacturing processes, principally all countries within the now EU 27 and the time period 2005-2012. The temporal boundary originated from the horizon of global and European-wide treaties and legislation on climate protection, i.e., from the Kyoto Protocol and the European emission trading scheme according to Directive 2003/87/EC which both define a pathway until 2012. High uncertainty for the time post-2012 argued for limiting modelling to the defined period. However, legislation, prices, and all scenario variables have been continuously updated to the status of February 28th 2007.

The existing thesis comprises four main chapters. In chapter 2, a thorough overview is provided of the environmental political instrument emission trading, its legislatory implementation in Europe, and presumable direct and indirect effects on pulp and paper manufacturing. Chapter 3 briefly introduces the research methodology applied. Chapter 4 is crucial as it provides a detailed answer to the first key question, quantifying all the direct and indirect effects based on three defined scenarios and classifying emission trading as one influencing factor, which interacts with other recent energy-related developments, in the operational and strategic decision making of pulp and paper companies. Chapter 4 displays all the analyses with respect to the empirical part of the investigation and subsequent testing of the three above-mentioned hypotheses. Chapter 5, however, is not of lesser importance. In 5.1, the implications of the manufacturing cost increase modelled in chapter 4 are assessed. 5.2 provides 114 actions for pulp and paper manufacturers aiming to maintain or reestablish profitability and competitiveness despite the partially severe effects of emission trading. 5.3 comprises recommendations for politicians on a European and national level with regard to future legislation on emission trading, energy taxation, promotion of electricity generation from renewable energy sources, and finally the liberalisation of electricity markets. Chapter 5 closes with an outlook on the time beyond 2012. A summary closes the thesis in chapter 6.

2. Background – emission trading will affect the pulp and paper industry

2.1 Starting point – the pulp and paper industry is affected by emission trading

2.1.1 Emission trading – not the only instrument of climate politics

2.1.1.1 Climate political instruments – one objective, various instruments

Environmental politicians have a wide set of political instruments at their disposal to counteract climate change by reducing emissions of greenhouse gases from the combustion of fossil fuels. This set of instruments ranges from encouragement of voluntary actions to compulsory command-and-control legislation. The instruments address the emitting company directly (its management respectively its shareholders) or its customers as Fig. 1 shows. Emission trading uses external force to move the emitting company to action and ranges somewhere in the middle between a market-based solution and regulation.

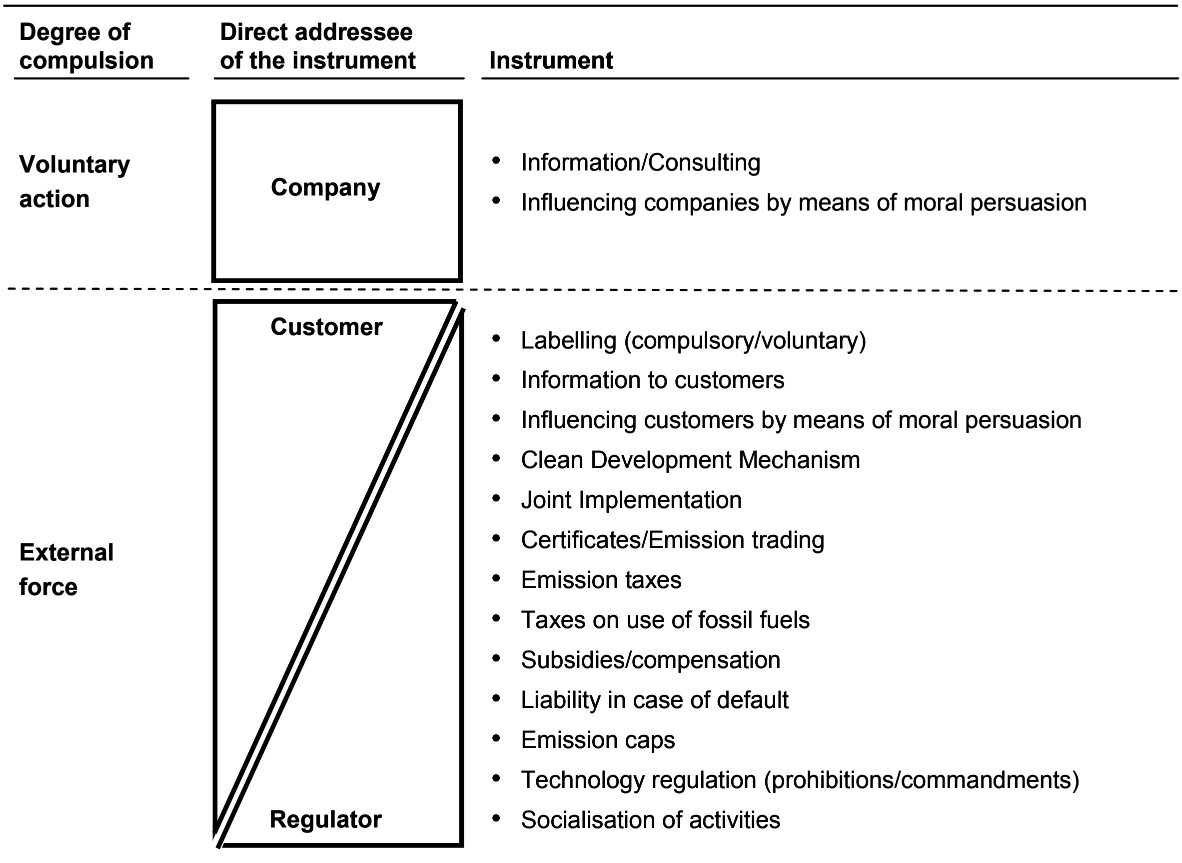

Fig. 1: Climate political instruments

Concerning the instruments listed in Fig. 1, two things need to be noted: first, the exhaustiveness of this list is a function of the granularity. Potential "additional" instruments are most probably derivatives of the instruments shown. Furthermore, some "instruments", such as e.g., "voluntary commitment of the industry", are rather the results of instruments than instruments themselves. Second, all of these instruments could be used for the reduction of emissions of greenhouse gases, but not all of them are currently in use in Europe. The most relevant will be outlined in chapter 2.1.1.4. If these instruments are used simultaneously, interferences take place which may reduce the effectiveness of each single instrument (e.g., emission trading vs. emission taxes). This will be discussed in more detail in chapter 2.1.1.5.

2.1.1.2 Emission trading – the theory behind it

The economic introduction of emission trading starts with the analysis of private costs and social costs. In 1920, Arthur C. Pigou was the first economist who attended to the divergence between what he called "marginal private net product" and "marginal social net product". This divergence, nowadays referred to as an external effect or externality, can be either positive or negative, i.e., the private costs can be higher or lower than the social costs. Although Pigou (Pigou, 1920, p. 172) conceded that both possibilities exist, he concluded:

> *"When there is a divergence between these two sorts of marginal net products, self-interest will not, therefore, tend to make the national dividend a maximum;"*

He doubted that Adam Smith's "invisible hand" overcomes this problem of negative external effects and favours governmental intervention to safeguard the fact that common interest is taken into account (Pigou, 1920, p. 195):

> *"No 'invisible hand' can be relied on to produce a good arrangement of the whole from the combination of separate treatments of the parts. It is, therefore, necessary that an authority of wider reach should intervene and should tackle the collective problems of beauty, of air, of light, and those other collective problems of gas and water."*

Whereas it was comparably quiet in environmental economics during the next three decades, Ronald H. Coase published a fundamental article "The Problem of Social Cost" in 1960 (Coase, 1960). He demonstrated that external effects automatically disappear, i.e. private and social costs coincide with each other, as soon as property rights are introduced and transaction costs can be neglected. In this case, all the parties involved take up direct negotiations and irrespective of the effective rules of liability and the initial allocation of property rights the Pareto efficient allocation[1] of resources is achieved. The difference is made only on the individual level. Absence of liability favours the active person, while existence of liability is advantageous for the passive person. Additionally, Coase discovered the reciprocal nature of the problem. He strongly disagreed with Pigou who saw externalities as a victim situation in which one party is causally and legally liable (Coase, 1960, p. 1):

> *"The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is wrong. We are dealing*

[1] This term, named after the Italian economist Vilfredo Pareto, means that no alternative allocation can be found that makes at least one individual better off, without making any other individual worse off.

with a problem of reciprocal nature. To avoid the harm on B would inflict harm on A. The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A? The problem is to avoid the more serious harm."

However, Coase's article should not be reduced to this case of absence of transaction costs as he discussed solutions for external effects in case of the existence of transaction costs in about half of the article. He concluded (Coase, 1960, p. 16)

"In these conditions the initial delimitation of legal rights does have an effect on the efficiency with which the economic system operates…"

and proposed governmental intervention for this case. In favouring regulation over market-based solutions in certain cases, he is supported by Harold Demsetz (Demsetz, 1967, p. 357):

"The soot from smoke affects many homeowners, none of whom is willing to pay enough, but the cost of their getting together may be enough to discourage effective market bargaining. The negotiating problem is compounded even more if the smoke comes not from a single smoke stack but from an industrial district. In such cases, it may be too costly to internalize effects through the market place."

This citation reveals the major obstacle to market-based solutions of environmental problems. Most environmental goods (e.g., clean air) are common goods, i.e., they are scarce and excludability is not feasible. While externalities concerning private goods can be eliminated through the introduction of property rights and direct negotiations between both parties relatively easily, such a Pareto-efficient solution is hardly possible concerning common goods. A Pareto-efficient solution would mean an optimal level of pollution. This optimal level is definitely above "zero" as John H. Dales clarified (Dales, 1968, p. 15):

"We know, however, that to prevent either pollution or pollution damage costs money, and that no one is going to pay more to prevent damage than the money equivalent of the damage suffered. So it is most unlikely that we will pay to avoid all pollution damage. To the extent that we prefer to suffer the welfare damages caused by pollution rather than suffer the money costs of preventing them, we may reasonably say that some pollution is a good thing. The questions are always: 'How much?' and 'At what cost?'"

This optimal level of pollution can be achieved in two ways: it is either determined scientifically and decided politically or it is negotiated in a market between those who pollute and those who suffer from pollution. While the first solution would be Pareto-efficient only "by chance" and for a brief moment, solutions achieved in properly working markets are Pareto-efficient automatically. However, very often real market conditions are far from perfect. The negotiation of the optimal level of pollution is such an imperfect market. Whereas one party (the industrial company polluting the air) can buy or sell property rights without noteworthy difficulties, the other party (the group of all the people affected by pollution of air) is highly fragmented. Extremely high transactions costs or the free-rider problem hinder this party from acting efficiently in the market of buying or selling property rights. Thus, a market-based solution of environmental problems will hardly be Pareto-efficient in practice either. While some economists call this a "market failure", it seems to be more precise to talk of imperfect market conditions caused by "government failure". The market mechanism itself would work perfectly if the framing conditions would allow it to. Profound sketches of the underlying dispute between the Pigouvian-Interventionists and the Free-Market-Environmentalists, who often refer to the Coase Theorem formulated by George J. Stigler (1966), have been published by Robert Taylor (1992), Julian Morris (1998), and especially by Michael R. Butler and Robert F. Garnett (2003).

Although Pigou, Coase, and partially Demsetz have published pioneering books and articles that have been important cornerstones for environmental economics, they have only superficially touched on the theory of emission trading. In 1968, John H. Dales was the first economist to devote deeper thoughts to emission trading. Having discussed the advantages of regulation and subsidisation before, he regarded pollution charges (taxes) as the best instrument in environmental economics so far but still saw two problems (Dales, 1968, p. 93):

> *"There remain, however, two awkwardnesses in the scheme: the trial-and-error-procedure that is necessary before the Board can hit on the 'right' level for the pollution charge; and the 'guesstimate' it must make about how much existing polluters should reduce their wastes in order to allow new-comers (people or factories) to settle in the region without increasing the total amount of waste discharged into the water system."*

He suggested overcoming these two awkwardnesses with an even better instrument: setting up a "market" for "pollution rights". Dales started a more detailed description on how a trade in emission allowances could look and discusses the economics behind it. He began with a defined number of pollution rights that are auctioned to all polluters. New entrants could purchase required rights from a certain reserve deposited at the authorities or from other holders. Besides actual polluters, anybody should be able to trade or speculate with pollution rights. Dales assumed that the scarcity of the pollution rights and, thereby, their price would increase with economic growth. Market rules need to be set by an authority which also takes on the role of a broker. Dales considered the duration of the pollution rights and emphasises that the total volume of pollution rights needs to be constant to give all participants confidence in the trade scheme. Dales already saw the administrative effort (costs) connected with emission trading but estimated it to be minor compared to the same effort with other political instruments. He saw more problems in "diffuse" pollution, i.e., pollution not originating from "emission points" but from hundreds of small sources.

Whereas we can agree with Dales' own assessment (Dales, 1968, p. 100)

> *"Pollution Rights markets would automatically set the correct level of the pollution charge [...] and would also automatically, and continuously, adjust the level of the charge to take account of economic growth…"*

the following point needs to be stressed: emission trading allows a cost minimal achievement of a defined emission level but due to the problems mentioned above (transaction costs, free-riding), it does not allow the determination of the Pareto-efficient level of pollution. Thus, Dales' assumption (Dales, 1968, p. 95/96)

> *"Conservation groups might well want to buy up some rights merely in order to prevent their being used…"*

is hardly realistic. This overestimate, however, should not decrease Dales' importance as a precursor of current emission trading schemes.

As emission trading has now been anchored in the context of environmental political instruments, the following section of this chapter will be devoted to price building in an emission trading scheme. We start at the level of an individual company and reach the economic level afterwards.

The company in this example emits a certain amount of CO_2 expressed by V_T. An emission trading scheme is introduced. A certain share of V_T can be covered by emission allowances received for free (v_F). However, as v_F is lesser than V_T, acting business-as-usual results in a scarcity of emission allowances (V_S). In order to close the gap, the company can either reduce emissions internally or purchase emission allowances in the market. For internal emission reduction, the company has identified six measures (i = 1-6), each having a certain reduction volume v_i and respective specific reduction costs C_i. Fig. 2 illustrates the situation.

In the upper section of Fig. 2, the six abatement measures are ranked by their specific reduction costs. As we can see, the company can meet the reduction target through internal measures. However, the company can also decide to replace one or more of the internal reduction measures by the purchase of emission allowances in the market. The price willingness for the purchase of emission allowances depends on the internal measures which can be replaced. This can be observed in the lower section of Fig. 2. If, for example, measure 4 is replaced by a purchase of emission allowances, the price willingness PW_4 equals the specific reduction costs C_4. If measure 3 is replaced, the price willingness PW_3 would be equal to C_3 and so on. In case the company did not have a sufficient internal emission reduction volume, the price willingness would be capped through the breakeven point of profitability, i.e., all the profit could be eaten up by the purchase of emission allowances. The price willingness in Fig. 2 is sorted in reverse order to the internal abatement measures, a display common for macroeconomic demand functions.

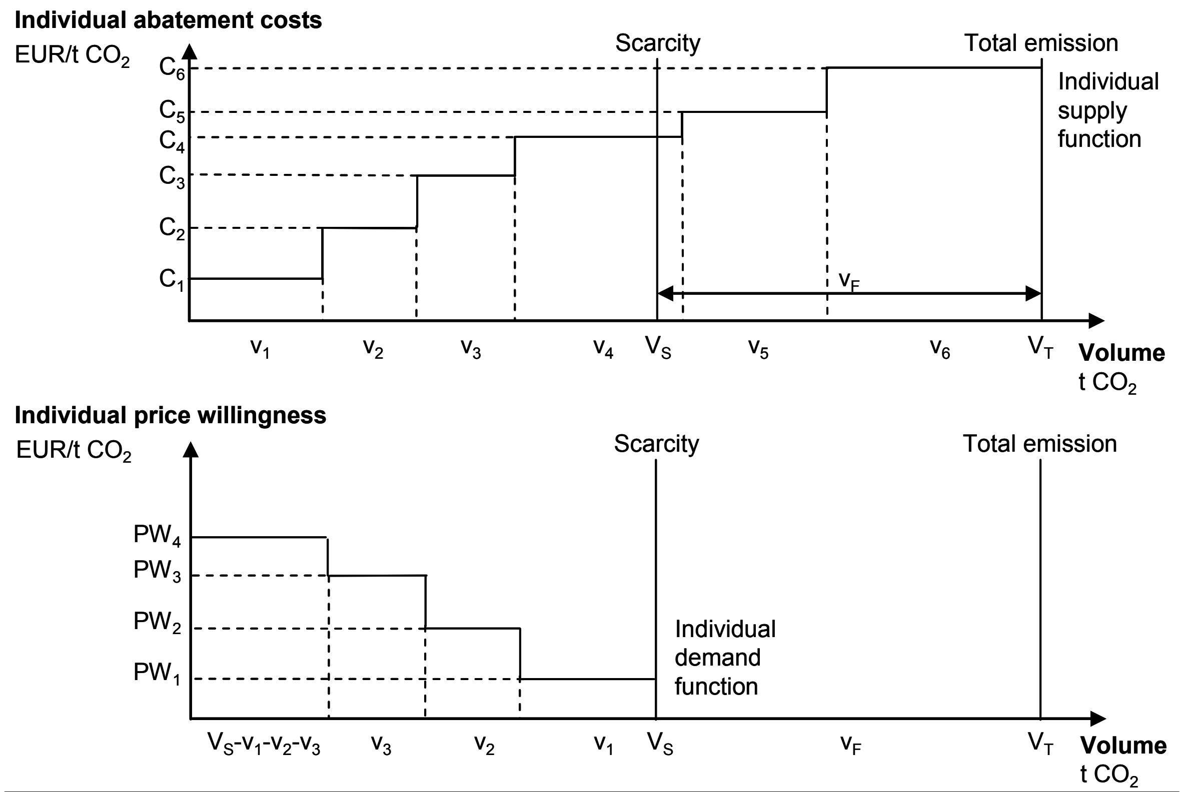

Fig. 2: Individual CO_2 abatement costs and price willingness

As we see, both the individual abatement cost function and the respective price willingness function are still step functions. Switching from the company to the macroeconomic level, both functions correspond with smooth supply and demand functions which originate from an aggregation of all individual abatement cost functions respectively price willingness functions. This is illustrated in Fig. 3.

The market mechanism results in equilibrium with a traded volume of V_M emission allowances at a market price of P_M. All other price levels would cause a surplus (P_1) or shortage (P_2) of emission allowances. However, it needs to be noted that real markets for emission allowances are usually imperfect and may especially suffer from a lack of liquidity. Most relevant drivers for the liquidity are the number of participants under the trading scheme and the scarcity of allocation. The fewer participants and the less scarcity, the less liquid the market is. Expectations about the future scarcity and market price also have a significant influence on the liquidity. The associated uncertainty was one reason for the development of derivatives of emission allowances which have arisen alongside the actual spot market.

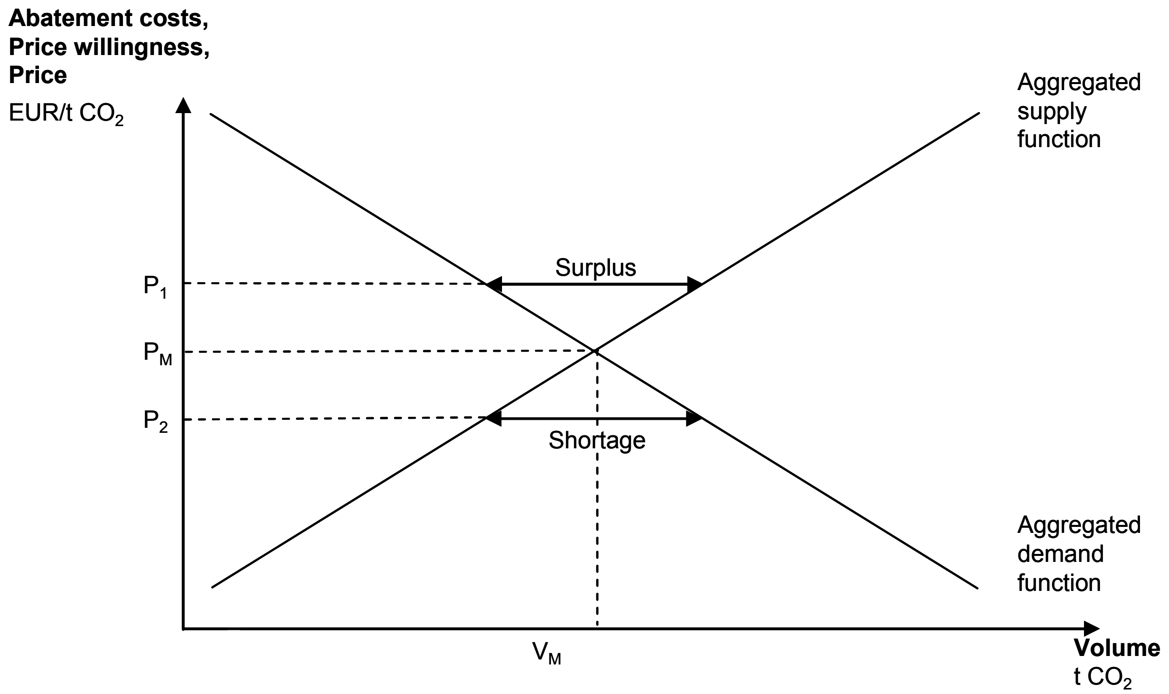

Fig. 3: Market mechanism resulting in equilibrium of supply and demand functions

The gross financial effect of emission trading on an individual company has a direct and an indirect component. The direct component originates from the scarcity of emission allowances, the opportunity cost of emission allowances received for free and administrative costs. Details are illustrated in the next section of this chapter and in Fig. 4.

The upper case A of Fig. 4 directly refers to the example introduced in Fig. 2. The company has six emission abatement measures at its disposal. All of them have positive costs. The market price of emission allowances P_M is the driver for the decision, which of the measures should be implemented. In the specific case, it is favourable to implement actions 1, 2, and 3, while covering the remaining volume V_S-v_1-v_2-v_3 with purchased allowances.

In the lower case B of Fig. 4, the individual abatement cost curve of the company is different. Five measures (1-5) are characterised by abatement costs below the market price of emission allowances. Only measure 6 has higher specific costs. Measures 1 and 2 even offer CO_2 savings at negative costs. – The question if the management should not have implemented these measures already prior to the introduction of emission trading is another story. – In this case, it is favourable to implement all five measures and sell the excess allowances v_F-v_6 in the market.

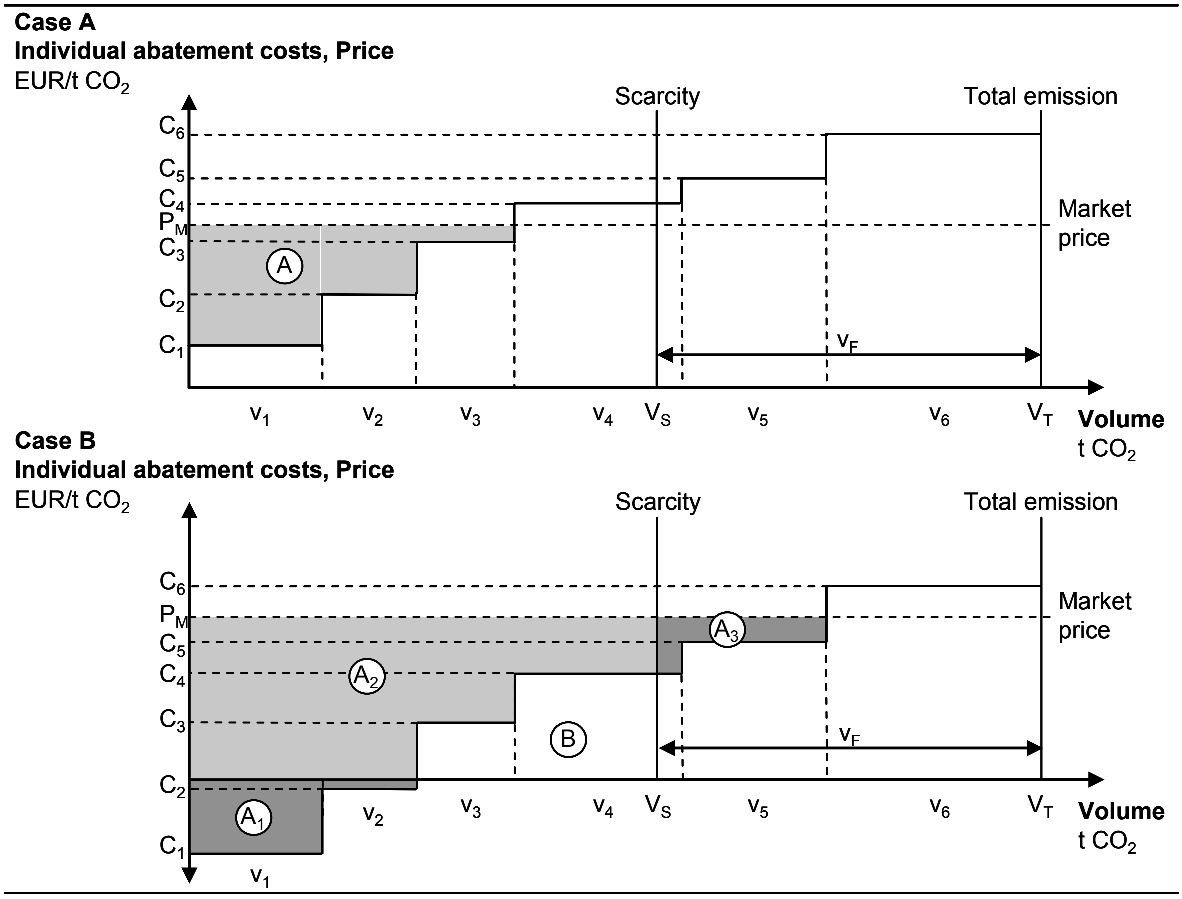

Fig. 4: Direct effect of emission trading

As noted above, the direct effect has three components: the scarcity of emission allowances, the opportunity cost of emission allowances received for free, and administrative costs. This can be transposed to equations as follows:

The direct effect of scarce emission allowances is defined in Eq. 1:

$$E_{DS} = V_S \cdot P_M - \sum_{i=1}^{n} (v_i \cdot Max(P_M - C_i, 0))$$

Eq. 1: Direct effect originating from scarce emission allowances

E_{DS}: Direct effect originating from scarce emission allowances [EUR]
V_S: Scarcity [t CO_2]
P_M: Market price emission allowances [EUR/t CO_2]
i: Emission reduction measure
v_i: Emission reduction volume of measure i [t CO_2]
C_i: Specific emission reduction cost of measure i [EUR/t CO_2]

The first term of Eq. 1 describes the rectangle delimited by volume and price axes, the market price of emission allowances $P_{M,}$ and scarcity V_S. The second term deducts the grey shaded area A. A reflects the gain from implementing CO_2 reduction measures, characterised by specific abatement costs below market price.[1] This is very evident in upper case A of Fig. 4. In lower case B, it gets a little more complicated. Actions 1 and 2 have negative abatement costs and should have been implemented anyway, i.e., irrespective of the introduction of emission trading. Action 5, in turn, is implemented at positive costs although this is not required by the scarcity. The rationale behind this implementation is the generation of emission allowances at costs below market price and selling them at P_M. Depending on the ratio between A_1, A_3 and B, the entire term E_{DS} may even become negative (if $A_1 + A_3 > B$). This, however, does not limit the theoretical or mathematical correctness of the generalisable equation.

The second component of the direct effect are the opportunity costs of allowances received for free. Though, one caveat is required at this point: for each allowance which is used to cover V_T while alternative uses for the allowance exist, its employment causes opportunity costs irrespective of if it has been received for free or purchased. Thus, formally also the allowances purchased to cover V_S have opportunity costs. Though, to allow a differentiation, the costs of purchased allowances, being out-of-pocket costs, are called "costs of scarce emission allowances" in the following sections, while only the costs of employed allowances received for free are called "opportunity costs of allowances received for free". The rationale behind their consideration is the possibility to sell unused emission allowances on the market. As long as the authorities potentiate this sale (for limitations, see chapter 2.1.2.4 in the context of electricity pricing) and they are employed and thus excluded from alternative uses, their opportunity value needs to be regarded as costs as long as. Considering that the scarcity may be negative too (overallocation, i.e., if $v_F > V_T$), the additional effect is:

$$E_{DO} = P_M \cdot Min(V_T, v_F)$$

Eq. 2: Direct effect originating from opportunity costs of emission allow. received for free

E_{DO}: Direct effect originating from opportunity value of emission allowances received for free [EUR]
P_M: Market price emission allowances [EUR/t CO_2]
V_T: Total volume of emission allowances employed [t CO_2]
v_F: Free allocation [t CO_2]

[1] One caveat should be noted at this point: in existing chapter 2.1.1.2, the theoretical background of emission trading is presented. In this context it is reasonable to deduct the second term, i.e., the gain from implementing CO_2 reduction measures, from the first term, while calculating E_{DS}. In chapter 4, for several reasons, (see chapter 4.2.2.4.2.1) the internal reduction measures are left besides for the calculation of the direct effect of scarce emission allowances.

The administrative costs of emission trading E_{DA} as a third component of direct costs comprise internal costs (consumption of management and accountant capacity) and external costs (consultants, auditors, fees for official acts of authorities) arising only once for preparation towards the emission trading or being recurring each year. The vast majority of the administrative costs are out-of-pocket costs, only a small portion is strictly speaking opportunity costs (available management capacity if volume is fixed).

In addition to the three levers of the direct effect, emission trading can have an – even severe – indirect effect. This effect originates from price changes in input factors such as raw materials and energy caused by emission trading. An evident example is the increase in the electricity price, due to scarce emission allowances in a lignite fired power plant (see chapter 2.1.2.4 for the actual mechanics of electricity pricing and the effects of emission trading on power prices). This example, as with all other cases in which input factors are directly affected by emission trading, will be classified as an indirect effect of first order. In contrast, price changes of input factors due to indirect effects, will be classified as indirect effect of second order. Examples of these indirect effects of second order are increases in chemicals' prices if increasing electricity prices affect the production of chemicals, or increases in wood prices due to rising competitiveness in electricity generation from wood compared to electricity generation from lignite which is facing scarcity of emission allowances. Additionally, it needs to be noted that the indirect effect is not limited to companies which are subject to the emission trading scheme. Everybody, companies as well as private customers, can be affected by this indirect effect of increasing raw material and utility prices. Obviously, the indirect effect of emission trading is not intended but, if perceived, accepted by policy makers.

Considering direct and indirect effect, the gross financial effect of emission trading is calculated as:

$$E_G = E_{DS} + E_{DO} + E_{DA} + E_I$$

Eq. 3: Gross financial effect of emission trading

E_G: Gross financial effect of emission trading [EUR]
E_{DS}: Direct effect originating from scarce emission allowances [EUR]
E_{DO}: Direct effect originating from the opportunity value of emission allowances received for free [EUR]
E_{DA}: Direct effect originating from administrative costs [EUR]
E_I: Indirect effect of emission trading [EUR]

From the gross financial effect we arrive at the net financial effect by deducting two components. First, the opportunity value of the emission allowances received for free (F) is

deducted. Although these allowances need to be regarded as (opportunity) costs, they do not involve any expenditure (out-of-pocket expense or cash effective).
Therefore, Eq. 4 and Eq. 5 apply:

$$E_{DO} = F$$

Eq. 4: Opportunity costs and value of emission allowances received for free

$$E_O = E_{DS} + E_{DO} + E_{DA} + E_I - F$$

Eq. 5: Out-of-pocket effect (cash effect) of emission trading

E_{DO}: Direct effect originating from the opportunity value of emission allowances received for free [EUR]
F: The opportunity value of emission allowances received for free [EUR]
E_O: Out-of-pocket effect (cash effect) of emission trading [EUR]

It can be possible to pass on a part of the resulting out-of-pocket effect ($E_{O,}$ descriptive also called cash effect) to customers. The degree of this recovery from price increases (R) strongly depends on the competitive situation in the respective markets. Thus, the net financial effect of emission trading is calculated as:

$$E_N = E_{DS} + E_{DO} + E_{DA} + E_I - F - R$$

Eq. 6: Net financial effect of emission trading – part I

$$E_N = V_S \cdot P_M - \sum_{i=1}^{n} (v_i \cdot Max(P_M - C_i, 0)) + P_M \cdot Min(V_T, v_F) + E_{DA} + E_I - F - R$$

Eq. 7: Net financial effect of emission trading – part II

E_N: Net financial effect of emission trading [EUR]
E_{DS}: Direct effect originating from scarce emission allowances [EUR]
E_{DO}: Direct effect originating from the opportunity value of emission allowances received for free [EUR] CO_2
E_{DA}: Direct effect originating from administrative costs [EUR]
E_I: Indirect effect of emission trading [EUR]
F: Opportunity value of emission allowances received for free [EUR]
R: Recovery from price increases [EUR]
V_S: Scarcity [t CO_2]
P_M: Market price emission allowances [EUR/t CO_2]
i: Emission reduction measure
v_i: Emission reduction volume of measure i [t CO_2]

C_i: Specific emission reduction cost of measure i [EUR/t CO_2]

V_T: Total volume of emission allowances employed [t CO_2]

v_F: Free allocation [t CO_2]

An overview is provided by Fig. 5.

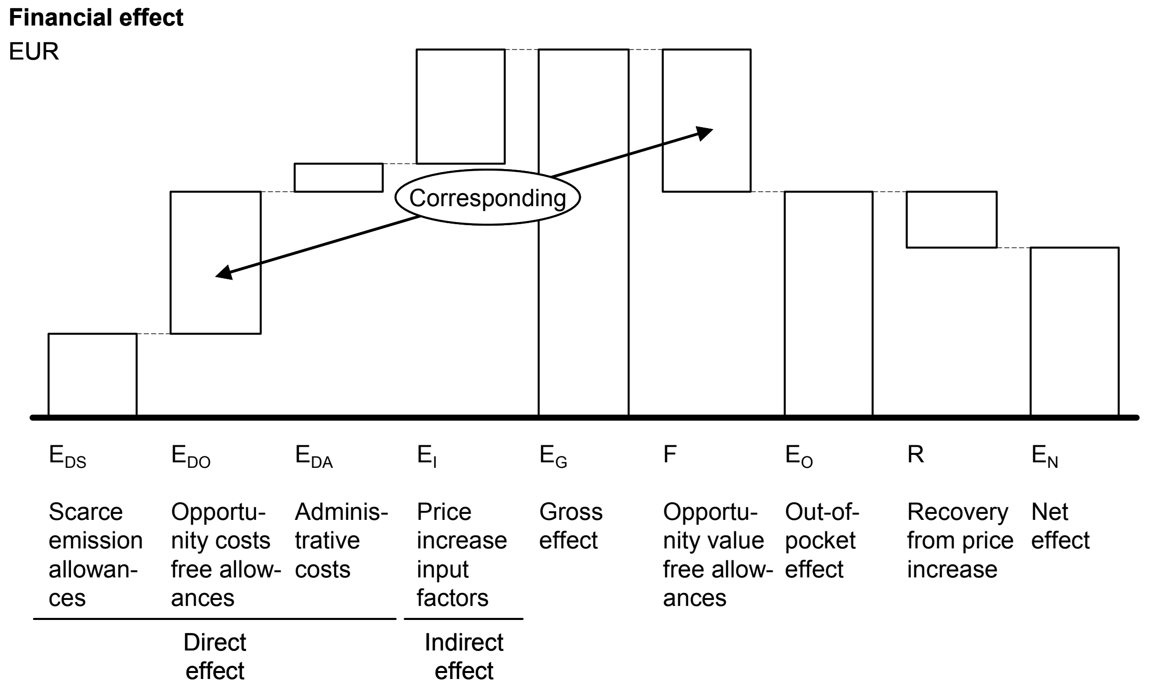

Fig. 5: Overview of gross and net financial effect of emission trading[1]

As emission trading has been anchored in the context of environmental political instruments and the financial effect on companies has been derived in the previous sections of this chapter, the subsequent section will provide an overview of specific aspects which need to be decided when setting up an emission trading scheme. Decisions are made on the design in seven main aspects (see Fig. 6).

[1] The term "out-of-pocket effect" has been chosen for the sake of illustrativity. Although a very small portion of the effect may be characterised as being not out-of-pocket (usage of management capacity for administrative purposes), this seems to be justified. Gaining illustrativity overcompensates for a potential mischaracterisation of a few-Cent-per-ton portion.

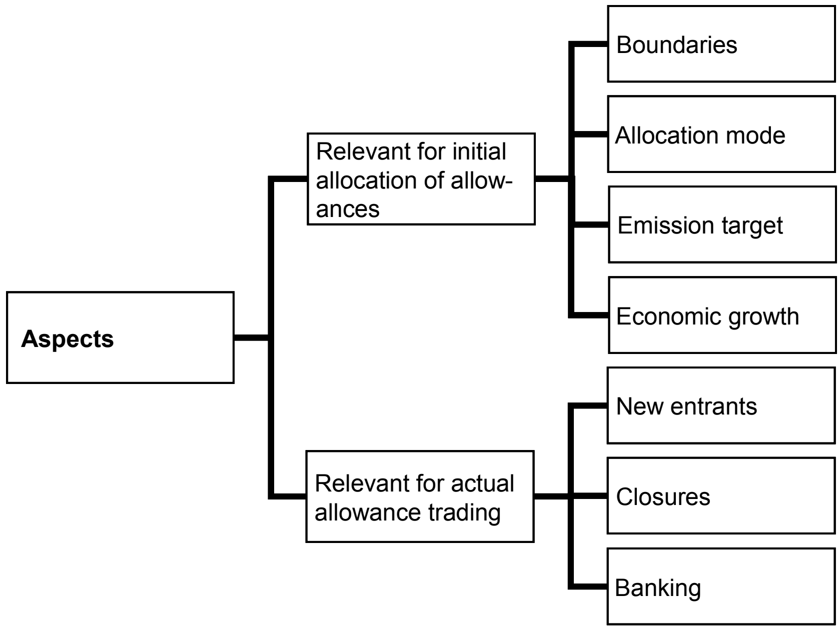

Fig. 6: Important aspects in the design of an emission trading scheme

In the following, the seven aspects presented above will be discussed in more detail. Four of them are relevant for the initial allocation of emission allowances. The other three gain relevance as soon as the trade with allowances has started. Numerous authors have published books, working papers, and articles about the design of emission trading schemes and the number of publications has increased significantly in the run-up to the European emission trading scheme. As the discussion of these aspects and respective literature does not take an unjustified predominant role in this thesis, both the discussion and the references are intentionally limited here.[1]

(1) Boundaries
The first and widest reaching decision in the design of an emission trading scheme is the definition of the boundaries. Within this topic the very first question is whether emissions should be covered by an upstream or a downstream approach. While the upstream mode subjects the manufacturing or import of fossil fuels to the obligation to keep a certain amount of emission allowances, the downstream mode obliges the consumers of these fuels to hold allowances. Wackerbauer (2003) discusses the advantages and disadvantages of both approaches. As nearly all existing emission trading schemes follow the downstream approach, we concentrate on the respective next questions of this approach too. These are three at the same tier: Which sectors? Which gases? Which types of emission? Fig. 7 illustrates this solution space with the example of the European emission trading scheme.

[1] "Flexible Instrumente im Klimaschutz" by the Fraunhofer Institut System- und Innovationsforschung (Betz et al., 2005) deserves a special mention as it can be regarded as a reference manual for entire emission trading, clean development mechanism, and joint implementation, while other publications tend to concentrate on certain aspects.

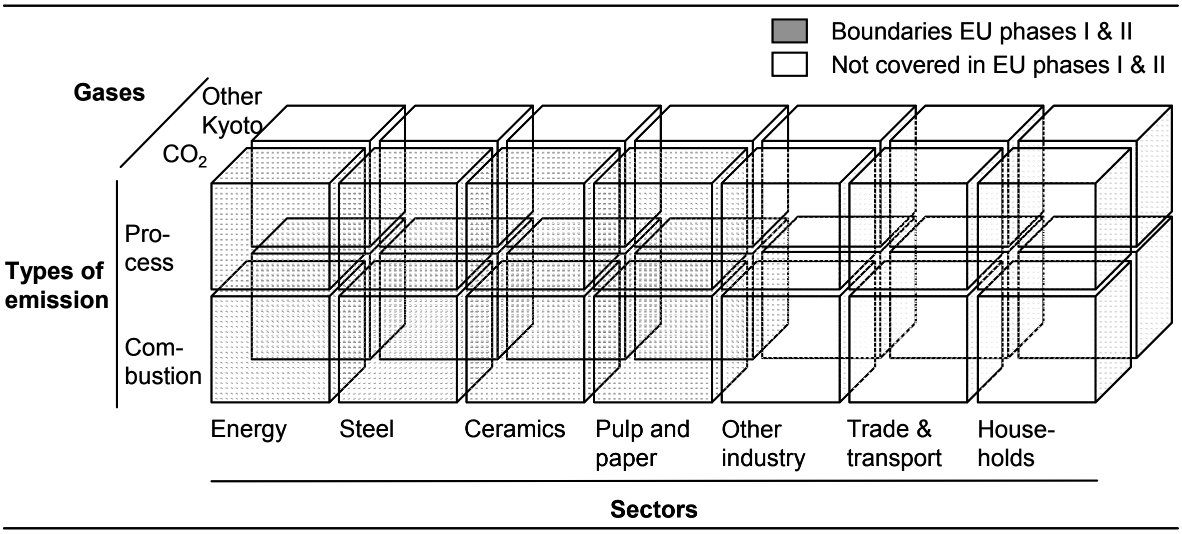

Fig. 7: Options for the boundaries in an emission trading scheme

While every extension of the scheme by other industries or gases may open additional opportunities for cheap emission reduction, at the same time it increases the complexity. Thus, a full coverage of all gases and all sectors is hardly reasonable. However, it may be assumed that the European emission trading scheme could be extended to the five other gases mentioned in the Kyoto Protocol[1] and air travel in the phase beyond the currently defined frame, i.e., beyond 2012. Another aspect in the context of boundaries is a minimum threshold of emissions. It could be wise for reasons of proportionality of administrative efforts. Besides the nominal boundaries defined for the set-up of an emission trading scheme, the legislator may decide to open the feasibility of opting-in and opting-out for certain emitters.

(2) Allocation mode

With respect to the allocation mode, macro- and micro-allocation need to be differentiated. The problems of the macro-allocation, i.e., of the definition of the national emission target and the top-down breakdown into the sectors covered or not covered by emission trading have been looked at by the AGE (2003b). The options for the micro allocation depend on whether the cap-and-trade or the baseline-and-credit approach has been chosen. While the first sets up a trade with emission allowances, the latter sets up a trade with emission reductions.[2] The prevailing cap-and-trade approach opens up the options for the micro-allocation displayed in Fig. 8.

[1] Methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6)

[2] Wackerbauer (2003) and Klemmer et al. (2002) discuss both approaches in detail.

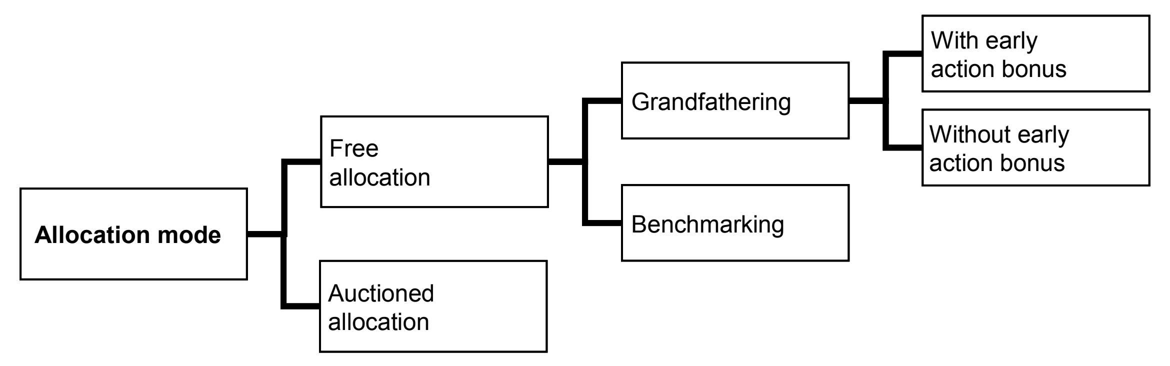

Fig. 8: Options for the allocation mode in an emission trading scheme

The emission allowances can be auctioned or allocated for free by the authorities. In the case of free allocation, benchmarking and grandfathering are possible. While in the case of benchmarking allowances are allocated based on the production output of the installation, grandfathering is oriented to historic emissions in defined base years. Different from benchmarking, grandfathering does not reward efforts of emission reduction before the base years; however, additional bonuses can be granted for these early actions. By contrast, maluses can be assigned for the use of ecologically disadvantageous technologies in a grandfathering system too. These correction factors could be avoided using the benchmarking approach. Additional bonuses, e.g., for the promotion of cogeneration, are purely political decisions.[1]

(3) Emission target

In order to meet the obligations from international agreements, many countries have to reduce their emission levels against base years or current emissions. In the case of auctioning or benchmarking as the allocation mode, this can be implemented by a defined level of auctioned allowances or "stretch" benchmarks. If grandfathering has been chosen, the question of implementing the target is a little more difficult. In this case, one or more compliance factors can be used. A compliance factor of 0.95, for example, means that the emissions have to be reduced by 5% against the base years. Fig. 9 shows potential target levels.

[1] More valuable descriptions of problems referring to the allocation mode can be found in publications by Harrison and Radov (2002), Dril et al. (2003), Butzengeiger (2001), Butzengeiger et al. (2001), Spieth and Röder-Persson (2003), and Bode (2003).

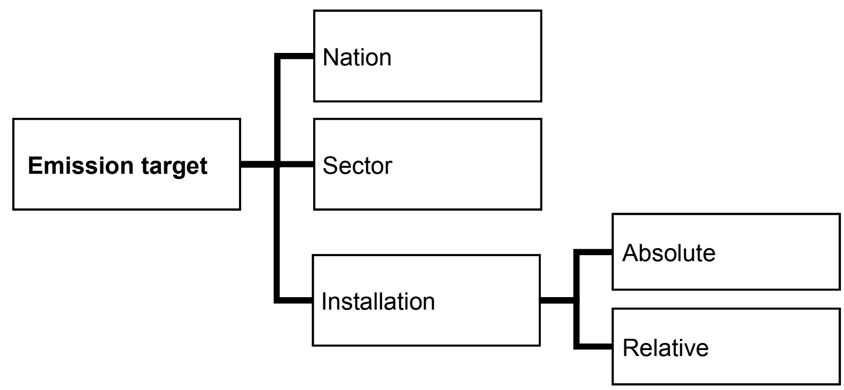

Fig. 9: Options for the emission target level in an emission trading scheme

A national target level forces all companies in all sectors to the same reduction percentage counted against the emissions in the base years. In contrast, sectoral targets allow for a reflection of the differences in international competitive pressure amongst the industry sectors. Installation-specific targets could provide an even better reflection. However, associated activities in regulatory management endanger any impartial allocation.

Relative emission targets, i.e., emission targets oriented to the production output of single installations, provide a full reflection of economic growth, but almost inevitably lead to not meeting the absolute emission target.[1]

In a multi-period emission trading scheme, such as e.g., the EU emission trading scheme which will be introduced in detail in chapter 2.1.2.2, the emission target can be varied between periods. In this case, banking (see paragraph (7) below) may gain in importance.

(4) Economic growth

Fig. 10 illustrates the options for the reflection of economic growth in a trading scheme.

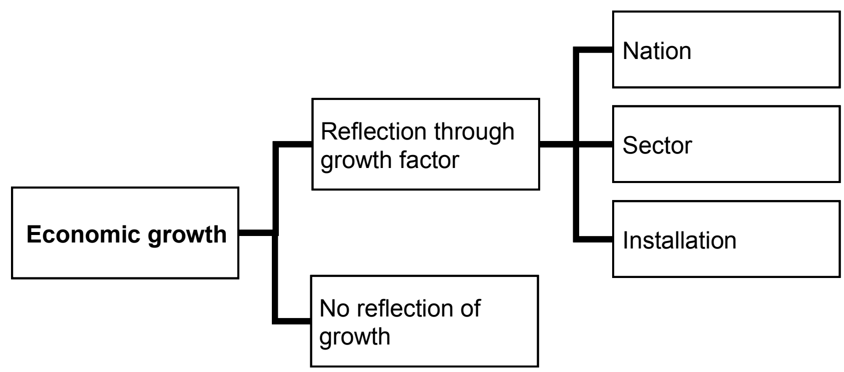

Fig. 10: Options for the treatment of economic growth in an emission trading scheme

[1] Details can be found in Butzengeiger et al. (2001).

The derivation of the growth factor comprises analogies to the definition of the emission target. It can be linked to the development of the gross domestic product (national growth factor) or negotiated with trade associations or companies.

(5) New entrants

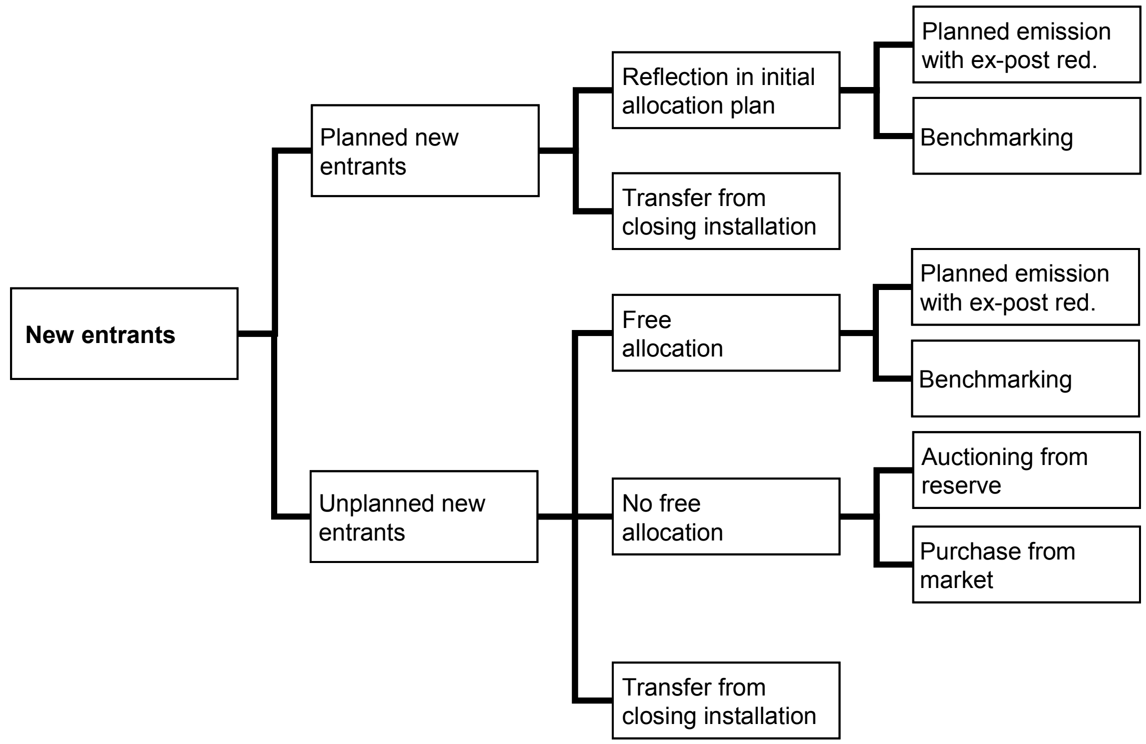

Fig. 11: Options for the treatment of new entrants in an emission trading scheme

In respect of the treatment of new entrants, i.e., of installations which start their operations when emission trading is already in place, planned and unplanned new entrants need to be differentiated. While planned installations are usually reflected in the initial allocation plan, unplanned installations may receive allowances from a reserve or have to purchase the required emission allowances in the market. As the allocation cannot be based on historic emissions of a base period, usually planned emissions or benchmarks are used for free allocations. Besides these ways of allocation, the authorities may open up the possibility to transfer emission allowances from an old closing plant to a new installation. This typically provides another incentive for a switch to cleaner technology. Fig. 11 illustrates all possible treatments.[1]

(6) Closures

The treatment of plant closures in emission trading schemes is relatively straightforward. If the authorities have opened up the possibility to transfer emission allowances from a closing

[1] For further details, publications by Wackerbauer (2003), Spieth and Röder-Persson (2003), and AGE (2003a) can be recommended.

installation to a new one (with a respective adjustment for differing production capacities), the operators will probably chose this option. Otherwise, the allocation of emission allowances will simply end with the last year of operation. The authorities may then decide to reduce the allocation for the last year of operation ex-post if the production or the emission falls below a certain threshold.[1] Fig. 12 provides an overview of options for the handling of closures.

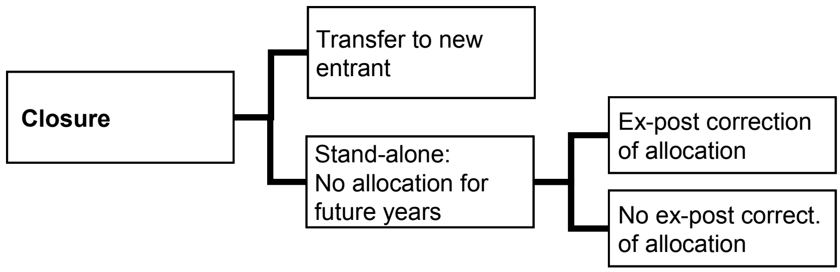

Fig. 12: Options for the treatment of closures in an emission trading scheme

(7) Banking

The introduction to the major aspects of the design of an emission trading scheme ends with banking, respectively borrowing. Banking means that allowances which have been allocated for a certain period can be saved and used in one of the following periods. Borrowing stands for the opposite. If a trade scheme is divided into periods composing more than one year, intra-period and inter-period banking and borrowing can be differentiated. As banking across periods entails the risk of not meeting the overall emission target in the following periods, most emission trading schemes limit the possibilities of banking. As Fig. 13 shows, this limitation can either be a strict prohibition of inter-period banking or an imitation to certain (national) allowances. Borrowing inter periods is usually totally prohibited.[2]

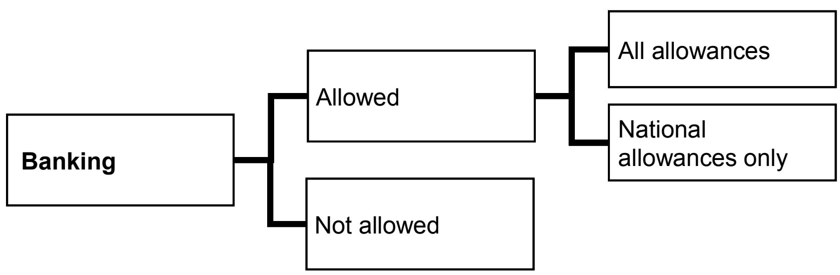

Fig. 13: Options for the treatment of banking in an emission trading scheme

[1] More detailed descriptions can be found in Spieth and Röder-Persson (2003) and AGE (2003a).
[2] For further details, publications by Butzengeiger et al. (2001), Spieth and Röder-Persson (2003), Graichen and Requate (2003), and Wackerbauer (2003) can be recommended.

2.1.1.3 Existing emission trading schemes – the instruments has proven itself

Emission trading as an environmental political instrument was implemented more than ten times during the last decade before it was finally introduced in the European Union. The existing emission trading schemes have overcome their teething troubles and, finally, the instruments has proven its effectiveness. The two most prominent ones are the SO_2 trade in the USA and the CO_2 trade in the United Kingdom.[1]

With the amendment of the Clean Air Act of 1990, the USA introduced SO_2 emission trading on January 1st 1995. The aim of this program is a 50% reduction of SO_2 emissions from power plants. The programme comprises three phases with significant increases in the reduction targets from phase to phase. In a grandfathering approach, emission allowances were allocated for free to the installations. While new entrants received 65% of the allowances for free in the first few years, they now have to purchase emission allowances entirely. Initially comparably low targets, cheap emission reduction opportunities from fuel switches, and the possibility of banking the allowances led to a market of limited liquidity during the first few years. Most participants expected rising SO_2 certificate prices and, therefore, kept their allowances. Several changes in the "rules of the game" have helped to overcome these initial weaknesses, but increased the uncertainty for the participating companies too.[2]

The second prominent example is the CO_2 emission trade in the United Kingdom which has been embedded in a Climate Change Programme since 2002. Different from the US programme, participation in the UK programme is voluntary and comprises two main routes and two further options for participation. Participants in the direct route are incentivised by government subsidies. In an auction, they "buy" these subsidies by offering emission reductions counted against certain historic emissions. Thereby, they receive an absolute emission target (cap-and-trade approach). In contrast, participants in the agreement route commit themselves to an individual Climate Change Levy Agreement with the authorities. A certain reduction target against a baseline (baseline-and-credit approach) is rewarded with an 80% statutory notice for the Climate Change Levy. The two further options for participation are a project for emission reduction operating with credits and the opening of a trader's account.[3]

Besides these and other official emission trading schemes, some companies have introduced similar approaches internally. Grohmann (2001) and Brockmann et al. (1999) describe the

[1] A very detailed overview is provided by Hansjürgens and Gagelmann (2003).

[2] Detailed descriptions of this first US emission trading scheme can be found in Rehbinder (2001) and Klemmer et al. (2002).

[3] One of the most valuable descriptions of the UK system can be found in Spieth (2002), others are by Wackerbauer (2003) and Klemmer et al. (2002).

internal scheme of BP plc. Hansjürgens and Gagelmann (2003) refer to Royal Dutch Shell plc. Although the intention of these internal emission trading schemes is rather cost-saving than emission reduction, they can provide helpful proposals for climate protection politics. Likewise, business games give suggestions for the actual designing of trade schemes.[1]

2.1.1.4 Other political instruments – from regulation to market

As pointed out in chapter 2.1.1.1, emission trading is only one political instrument counter-acting climate change within a wide set of instruments at the disposal of environmental politicians. The effects of the newly implemented European emission trading scheme (details follow in chapter 2.1.2.2) on the pulp and paper industry need to be considered in the context of existing environmental legislation applying several of these instruments. Thus, it seems necessary to outline the most important of these political instruments briefly in the following paragraphs of this chapter.

(1) Regulation
Besides from the socialisation of activities, regulation is the strongest political instrument at the disposal of politicians. Typically it is classified as a command-and-control policy (Dröge et al., 2003) comprising commands and prohibitions. Non-compliance results in sanctions (closure or penalties). Dales differentiates "across-the-board" and "point-by-point" schemes (1968, p. 84-89). While the first obliges all individuals to do the same thing (e.g., 20% reduction of emissions), the latter allows differentiation.

The advantages of regulation are its effectiveness, the ease of managing the implementation and the relatively broad acceptance of the population, due to familiarity with its application (Dröge et al., 2003). Another advantage is the differentiability which helps counteract environmental hot-spot problems (Koch and Wieneke, 2001). In contrast, disadvantages are economic inefficiency and unfairness, respectively the inevitability of significant administrative efforts to overcome these problems. Meyer and Ströbele (2001) demonstrate the economic inefficiency of "across-the-board" regulation mathematically. Individuals are forced to reduce their emissions at different marginal avoidance costs. Thus, the aggregated costs of emission reduction cannot be at a minimum. Additionally, individuals have no further incentive to reduce emissions if they have fulfilled their specific target and early actions to reduce emissions are not rewarded. "Point-by-point" regulation could overcome these economic weaknesses and provide by "by chance" an efficient solution. However, administrative efforts will make proportionality doubtful. Furthermore, lobbying will be opposed to an efficient solution as well.

[1] See Schleich et al. (2002) and Steinbrecher and Hahn (2003).

Examples of technology regulation are numerous. With respect to emission trading the EU Directive 1996/61/EC on integrated pollution prevention and control introducing emission caps (see chapter 2.1.2.2) is the most relevant.

(2) Subsidies

Dröge et al. define subsidies as (Dröge et al., 2003, p. 30):

> *"Economic benefit received by a private agent from public funds at no cost or below cost of producing the benefit [...] or [...] financial assistance (e.g. direct payments, tax exemptions) from the government to the private sector."*

They are a common instrument of environmental politicians occurring as direct subsidies from the government and as indirect subsidies, i.e., the transfer of funds from individuals to other individuals with the authorities only setting the rules. Specific subsidisation (i.e., the amount of subsidies granted for avoiding one unit of pollution) can be differentiated by technologies in order to promote the development of certain technologies.

The direct incentivisation of the polluter to reduce their emissions is advantageous. As for companies, neither the purchase prices of raw materials and energy nor the tax burden rise directly and, therefore, industry typically favours subsidies over other instruments (Dales, 1968). However, as no subsidies can be paid without funding, welfare is reduced elsewhere. Thus, Dales concludes that subsidies are neither fair nor efficient, as the recipients of the subsidies most probably have different reduction costs.

An example of subsidies is the promotion of electricity generation from renewable energy sources and of cogeneration in Germany. As these subsidies are not paid from the government's budget but funded by all electricity consumers, they can be classified as indirect subsidies. For details, please see chapter 2.1.2.3.

(3) Emission taxes and energy taxes

Emission taxation needs to be differentiated from the taxation of the consumption of energy sources such as fossil fuels or electricity. While the first directly taxes the pollution, the latter penalises a preliminary stage that will result in pollution. The additional VAT has a similar effect but not an ecological intention.

The instrument of emission taxation can be traced back to Pigou (1920, "Pigouvian-tax"). He suggested a charge for all pollution proportional to the marginal damage. Due to better ease of handling, nowadays the purchase of fossil fuels is often subject to taxation instead. Additionally, taxes are levied on the consumption of electricity independently from the actual source of energy. Lobbying activities have usually led to exemptions or special provisions for certain industry sectors. The rationales behind these provisions are differences in the competitiveness between sectors and in the tendency to relocate production to other countries (leakage effect). Some countries have introduced emission taxes in the course of implementing ecological tax reforms, refinancing e.g., the reduction of social security contributions.

Compared to regulation and subsidisation, emission taxation has one major advantage: it is economically efficient (Dales, 1968). The polluters reduce their emissions until the marginal avoidance costs equal the costs from taxation. Any further reduction would be more expensive than paying the taxes. Thus, companies with low marginal avoidance costs avoid more than those with high marginal avoidance costs (Dröge et al., 2003). The sole disadvantage is that the optimal level of emission (assuming it is known) can only be achieved in a trial-and-error approach (Dales, 1968). The authorities will hardly be able to calculate upfront which tax level will result in the optimal level of emission. Efficiency is lost as soon as exemptions from taxation are agreed for certain industries. An additional risk of inefficiency arises if energy consumption is taxed instead of pollution. Emission from different energy sources may be taxed differently and some emissions might be taxed twice (fuels for electricity generation).

The consumption of fossil fuels and electricity is subject to taxation in the entire EU with some temporary arrangements for the transition countries. Emissions are taxed only in Denmark, Netherlands, Norway, and Sweden. For details, please see chapters 2.1.2.2 and 2.1.2.3.

(4) Clean Development Mechanism and Joint Implementation

Besides from emission trading, Clean Development Mechanism and Joint Implementation are flexible mechanisms for reductions of greenhouse gas emissions which have been introduced with the Kyoto Protocol (for details, see chapter 2.1.2.1). They can be regarded as derivatives of emission trading. Both are project-based, i.e., they refer to emission sources that are not subject to the emission trading scheme anyway. These projects have two partners domiciled in different countries. While a project is conducted in country A, it is financed by a partner B in country C or by country C itself. The CERs (Certified Emission Reductions) in the case of Clean Development projects, respectively ERUs (Emission Reduction Units) in the case of Joint Implementation measures, are credited to the financing partner. Thus, CERs and ERUs acquired by company B help the company to comply with its reduction target from the emission trading scheme effective in country C and additionally helps country C to fulfil its Kyoto target. The basic difference between CDM and JI is that in JI projects both partners are domiciled in a country listed in Annex I of the UNFCCC (United Nations Framework Convention on Climate Change) while in CDM measures the project is conducted in a non-Annex-I country. While CERs can already be converted in the European emission trading scheme since 2005, ERUs cannot be used before 2008. Details for crediting projects have been defined in the Marrakesh Accords.

The major advantage of CDM and JI is the potential for additional emission reductions at low costs. The wider the range of potential emission reduction projects is, the lower the costs are. Additionally, it can be assumed that especially developing countries (partners for CDM projects) offer numerous emission reductions at very low or even negative costs (e.g., fuel switch). Furthermore these countries can benefit from the knowledge and technology transfer involved. Uncertainties concerning crediting of the individual measures are disadvantageous. The two main problems related to crediting are the definition of the baseline against which the reductions are counted and the proof of additionality compared to any development which would have taken place anyway. The interpretation of the additionality requirement is still disputed in CDM and JI. In the strict sense of "project additionality", the project's business case is unprofitable without the revenue from ERUs or CERs and gains profitability only with certification. In a more moderate sense of "environmental additionality", the project only needs to reduce CO_2 emissions or increase absorption compared to the baseline. Whereas all doubt-free cases are accredited by an independent certifier in accordance with UNFCCC rules, all doubtful cases are decided by the highest authorities of JI and CDM, the JI Supervisory Committee, respectively the CDM Executive Board at the UN.

(5) Labelling

The economic literature differentiates labels and certificates. While labels have a clear consumer orientation, certificates are rather authority-oriented. Referring to labelling, Dröge et al. (2003) assume the following UNCTAD definition (UNCTAD, 1994):

> *"[...] the use of labels in order to inform consumers that a product is determined by a third party to be environmentally more friendly relative to other products in the same category [...]"*

Furthermore, they structure the different types of labels into governmental vs. private and compulsory vs. voluntary labels. Whereas labels provide consumers with information to facilitate a choice between different suppliers, certificates are intended to allow authorities to monitor certain actions or properties.

The advantage of labelling is that this instrument limits the freedom of individuals least. It assumes fully rational behaviour of consumers. In contrast, it is the instrument with the lowest effectiveness. Even if all consumers understand the favourability of the environmentally friendlier product, the above-mentioned free-rider problem hinders a significant effect. Different from labelling, certification should not be regarded as an instrument itself but only as a means of implementing political instruments such as regulation or subsidisation.

Examples of the instrument of labelling are energy efficiency classes for white goods (governmental, compulsory), proof of origin for electricity (governmental, compulsory), "Blauer Engel" for chemicals (governmental, voluntary), and "Bioland" for food or "Environmental Product Declaration" for building products (private, voluntary).

2.1.1.5 Interferences – interaction with other political instruments

Although theoretically all other political instruments aimed at the reduction of greenhouse gas emissions have become dispensable with the introduction of emission trading, they will probably coexist in Europe in the future (Wackerbauer, 2003). Regulation (based on the IPPC Directive) will still be the base for the permission of the installation. Emission or energy taxes as well as subsidies and labelling will persist – at least for the next few years. Thus, it seems necessary to highlight the interactions and potential interferences between emission trading and the other political instruments which have been outlined in chapter 2.1.1.4.[1]

(1) Emission trading vs. regulation

The coexistence of regulation and emission trading significantly jeopardises economic efficiency. As pointed out in the previous chapter, emission trading reduces emissions until a certain emission level is reached. At this point, all polluters have equal marginal avoidance costs. The total costs of reduction are at a minimum. In contrast, regulation forces polluters to reduce their emissions regardless of their marginal avoidance costs. Thus, some polluters end up with marginal avoidance costs which exceed those that would have been reached with emission trading. The total costs of reduction are not at a minimum anymore. The stronger the intervention of regulation compared to the intervention of emission trading, the further the effect on welfare deviates from economic efficiency.

European environmental legislation enforces the instrument of regulation in the IPPC-Directive 1996/61/EC[2]. The participants in the European emission trading scheme largely coincide with the companies subject to this Directive. Interferences between regulation of this Directive and the subsequent national laws with emission trading arise, as the Directive obliges companies to apply best-available-techniques (BAT), provides the base for emission caps, and calls for efficient consumption of energy (Wackerbauer, 2003). These regulatory interventions are far from being efficient. Some polluters are forced into emission reductions at unjustifiable marginal avoidance costs.

A potential solution to this conflict is the respective amendment of Directive 1996/61/EC. An initial allocation of emission allowances according to a BAT-benchmark as suggested by Rehbinder and Schmalholz (2002) does not in itself prevent the inefficiency. Only a combination of the respective initial allocation with a deletion of the regulatory clauses in the Directive eliminates the inefficiency and promotes clean technologies.

[1] The requirements of an emission trading scheme in the context of general and other specific principles of legislation have been described in detail by Butzengeiger (2001).

[2] Directive 1996/61/EC of the Council of 24 September 1996 on Integrated Pollution Prevention and Control (Council of the European Union, 1996), for details see chapter 2.1.2.2.

(2) Emission trading vs. subsidies
The coexistence of emission trading and subsidisation also results in inefficient achievement of the reduction target. The efficiency inherent in emission trading is lost as soon as subsidisation leads to emission reductions at higher marginal avoidance costs. If, for example, electricity generation from photovoltaic is subsidised at 500 EUR/MWh[1], the marginal CO_2 avoidance costs for the society are about 1,000 EUR/ton CO_2[2]. At the same time, the price of emission allowances is about 20-25 EUR/ton CO_2. Even if the price of emission allowances increased by 100 or 200% and if all other climate political instruments were fully replaced by emission trading, which would result in a tighter allocation of emission allowances, there is still a factor of 10-20 in between both marginal avoidance costs. While this spread in marginal avoidance costs is a strong sign of economic inefficiency with regard to current reduction of CO_2 emissions, the high subsidisation may be justified by the expectancy of a significant decrease in marginal avoidance costs due to a learning curve. As scientific estimates on the learning curve and with it the future marginal avoidance costs of photovoltaic versus other emission reduction opportunities are very difficult to make, the degree of subsidisation is finally a political question.

(3) Emission trading vs. emission taxes and energy taxes
As pointed out in the previous sections, emission trading and emission taxes each achieve emission reduction at equal marginal avoidance costs and emission reductions are achieved cost efficiently. The major difference is that emission trading determines the final emission level ex-ante, while emission taxes do this ex-post. If emission taxation is introduced in addition to an existing emission trading scheme, the price of emission allowances and the traded emission volume decrease, whereas the overall CO_2 costs increase. While the supply function for emission allowances remains constant, the demand function has a negative offset equal to the tax rate, as it reflects the price willingness for CO_2 costs. With the introduction of the tax in addition to emission trading, both instruments have to share this price willingness (see Fig. 14).

[1] Feed-in tariffs for electricity from certain photovoltaic installations according to the German Renewable Energy Act are currently EUR/MWh 574, while the actual electricity price is about EUR/MWh 40.

[2] 500 kg CO_2/MWh can be assumed for the average CO_2-intensity of European power generation. The numbers do not include the initial CO_2 emission of producing the equipment.

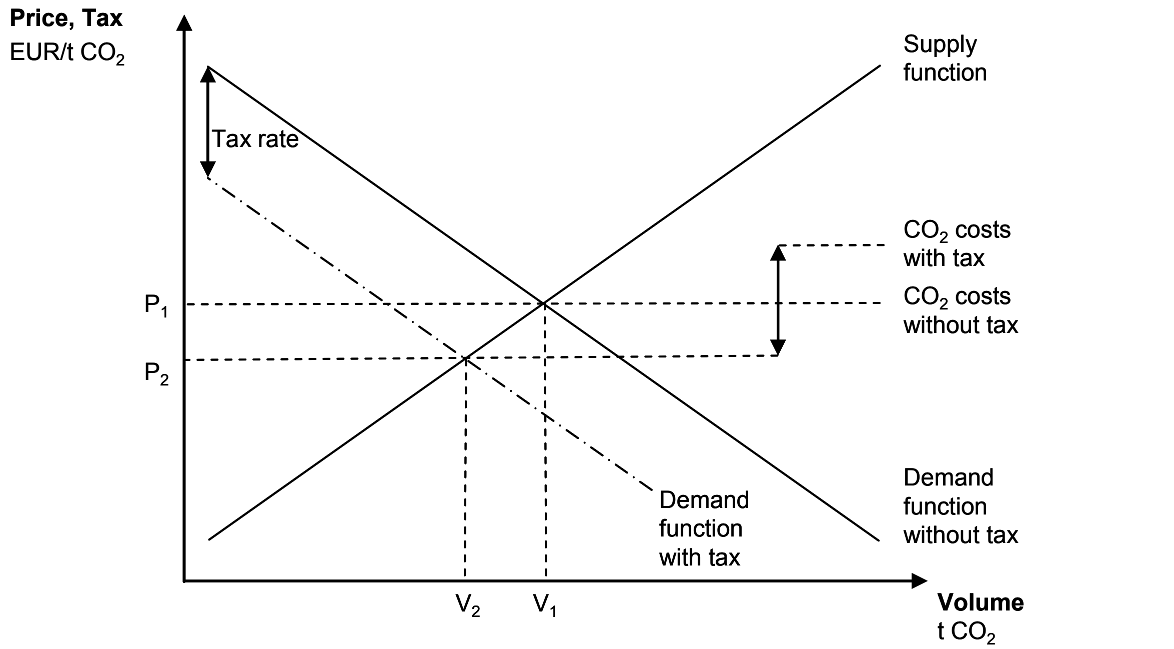

Fig. 14: Interaction between emission trading and emission taxes

As long as the supply curve does not have the same offset too – which would not be reasonable – the decrease in the certificate price does not equal the tax rate. Thus, the overall CO_2 costs are higher than before, unless the allocation of emission allowances is expanded to compensate for the effect. Anyway, there is no good reason to believe that the efficiency of an efficient quantity instrument or an efficient price instrument increases with the combination of both instruments.[1] The caveat above does not imply differences in the boundaries. If, for example, the price for emission allowances is set internationally, while only some sectors in some countries are subject to taxation, the effect of the tax on the certificate price is even lower. This can result in a double burden for these sectors. Other aspects are energy taxes instead of emission taxes and the use of the funding from taxation.

Due to the interference of emission trading and emission taxation, some economists as e.g. (e.g., Wackerbauer, 2003) suggest exemption of sectors subject to emission trading from energy taxation, as is largely the case in Germany and the United Kingdom. However, others such as Rehbinder and Schmalholz (2002) raise the issue of disturbed competition, due to unjust subsidisation in the form of exemption from energy taxation.

(4) Emission trading vs. Clean Development Mechanism and Joint Implementation

Emission trading and both other mechanisms for reductions of greenhouse gas emissions take their legal foundation from the Kyoto Protocol. CDM and JI are designed as complements to

[1] The argumentation of Philibert and Pershing (2002) referring to an investigation by Roberts and Spence (1976) that hybrid instruments have advantages over pure quantity or price instruments (emission trading respectively emission taxation) is not conclusive as both instruments themselves are efficient. A gain in efficiency through a combination is not feasible.

the instrument of emission trading. Thus, there is no (negative) interference in economic efficiency. Solely the conversion of CERs, ERUs, and emission allowances may cause difficulties due to the above-mentioned uncertainties in crediting specific emission reductions (versus absolute reduction targets) and potentially temporal limitation of the duration of the reduction in CDM and JI projects.

(5) Emission trading vs. labelling
There is no obvious interference between emission trading and labelling. As pointed out in chapter 2.1.1.2, emission trading provides a cost-minimal achievement of a defined emission level, whereas it does not determine the optimal level itself. A labelling scheme can just be supportive. If the consumers have understood the ecological implications with all the associated costs and benefits, they can act accordingly. Those who have not understood the implications or are conscious free-riders do not diminish the efficiency of emission trading. The transaction costs of labelling are the only restriction.

(6) Emission trading vs. voluntary commitments
Although voluntary commitments of industry to reduce emissions cannot be regarded as an instrument of environmental politics (see chapter 2.1.1.1), they may come into conflict with the instrument of emission trading. In the case of the commitment of German industry, the commitment was adopted under two conditions: (1) participating industry sectors received significant provisions from energy taxation and funding of subsidies for the generation of electricity from renewable energy sources and cogeneration and (2) the government agreed not to take further regulatory actions as long as the commitment is met. Thus, Bode (2002) assesses that in the case of mandatory participation of these industrial sectors, both instruments are nominally incompatible. Wackerbauer (2003) regards the specific reduction targets for an entire sector in the commitment versus installation-specific and absolute reduction targets in the emission trading scheme as the practical problem. To solve it, economists call for a smooth introduction with a sufficient initial allocation. Boie (2002) suggests a solution using the opting-out clause and Wackerbauer (2003) is in favour of two routes of participation with a certain gateway to transfer emission allowances from one to the other.

2.1.2 Climate protection – the political objectives are clear

2.1.2.1 Global discussions on climate change – a long run-up until Kyoto

Many conferences on climate protection have taken place during the last three decades. It is hard to identify the first step of the long run-up of political events towards the Kyoto Protocol, which finally became effective on February 16th, 2005.

Most observers, however, regard the First World Climate Conference in Geneva 1979 as the initial step of really global weight, although the World Climate Program initiated aimed at coordinating research on climate change rather than at effecting political actions. The next visible step was the Vienna Convention on the Protection of the Ozone Layer in 1985, followed by the Montreal conference in 1987, focusing on substances that deplete the ozone layer. The subsequent International Conference of the Changing Atmosphere, which took place in Toronto 1988, resulted in the first political actions, the formation of the World Atmosphere Fund, and an action plan for the protection of the atmosphere. The Toronto meeting was then followed by the International Meeting of Legal and Policy Experts on the Protection of the Atmosphere in Ottawa 1989. The subsequent Second World Climate Conference in Geneva 1990 is generally regarded as a failure, as the politicians demonstrated very low commitment to change in their behaviour towards air pollution and the climate. In the same year, the Intergovernmental Panel on Climate Change, a council of scientists issued its First Assessment Report on the Threat of Climate Change (IPCC, 1990).

The next milestone was the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro 1992. This conference adopted the United Nations Framework Convention on Climate Change (UNFCCC, (United Nations, 1992)) which defined the scope for future political action on all greenhouse gases and all human influenced sources and sinks of such gases. It established the emission level of 1990 as the target level, introduced the principle of burden-sharing between nations, and set up the subsequent Conferences of the Parties (COP).

Since 1992, thirteen Conferences of the Parties (COP 1 until COP 12, including COP 6.1 and COP 6.2) have taken place yet. COP 1, held in Berlin 1995, resulted in the Berlin Mandate (United Nations, 1995). It confirmed that developed countries should bear a bigger share of emission reductions than developing countries and defined the aspirations for COP 3. While COP 2 in Geneva 1996 was a failure again, the major breakthrough came with COP 3. This was the meeting of Kyoto 1997. The oft-cited and persistently discussed Kyoto Protocol (United Nations, 1997), which is formally an addendum to the UNFCCC, set an ambitious target and clear guidelines. The target is to reduce the average global greenhouse gas emissions in the first commitment period (2008-2012) to a level 5% lower than the 1990 emission level. An international burden-sharing safeguards that developing countries face less ambitious reduction targets than developed countries. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) have been defined as relevant gases. Core instruments to achieve the reduction are the three so-called Flexible Mechanisms (Emission Trading, Joint Implementation, and Clean Development Mechanism; see 2.1.1.4). To let the protocol come into effect, the signatories installed two hurdles. 55 countries had to ratify the protocol and 55% of the 1990 emissions have to be represented by the ratifications.

The succeeding conferences COP 4 to COP 12 basically detailed the guidelines set in Kyoto. Important end products of these conferences were the Buenos Aires Plan of Action (BAPA at COP 4, (United Nations, 1998)) with a special focus on technology transfer to developing countries, the Bonn Agreement on the Buenos Aires Plan of Action (at COP 6.2, (United Nations, 2001b)) introducing the idea of sinks of greenhouse gases, and the Marrakesh Accords (at COP 7, (United Nations, 2001a)) with a special focus on Clean Development Mechanisms and sinks. More and more, especially since COP 11 in Montreal, targets and measures for climate protection "post-Kyoto", i.e., beyond 2012, the last year covered by the Kyoto Protocol, have attracted the notice of involved scientists and politicians.

An important date for global climate protection was February 16th 2005. Though the Kyoto Protocol had already been adopted in 1997, it took eight years until it came into force, when the Russian parliament, Russia caused 17.4% of global greenhouse gas emissions in 1990, ratified the protocol and, thus, caused the jump over the required 55%-emission hurdle. The first hurdle, ratification by at least 55 countries, had already been overcome with Icelandic ratification in May 2002. However, as countries representing about 38% of the global 1990 greenhouse gas emissions still refuse to sign or ratify the protocol, among them heavyweights such as the USA and Australia, it is doubtful whether the Kyoto Protocol coming into force will stop climate change. Not least, as developing countries tend to increase emissions with economic growth but have no emission (reduction) targets. The question about the effectiveness of the Kyoto Protocol evoked extended discussions, but will not be touched on in this investigation. The Kyoto Protocol is regarded as a legal act which obliges the European Union and its member states as well as other countries which have ratified it to certain actions.

2.1.2.2 The EU Directive – how to implement Kyoto

In the early 1990s, the European Communities (since 1992 the European Union) and its bodies started putting climate change on their agendas. After a relatively slow start, the legislation of the European Communities, later the European Union, evolved more and more rapidly.

Decision 1993/389/EEC[1] was the first Decision fully dedicated to greenhouse gases and the effects of climate change. In 1999, it was superseded by Decision 1999/296/EC[2]. Both aim to set up an EU-wide system for monitoring greenhouse gas emissions and tracking progress of national fulfilments of respective obligations. In the amended Article 2, the Directive commits the EU member states to set up national programmes to limit or reduce their emissions of

[1] Council Decision 1993/389/EEC of 24 June 1993 for a monitoring mechanism of Community CO_2 and other greenhouse gas emissions (Council of the European Communities, 1993)

[2] Council Decision 1999/296/EC of 26 April 1999 amending Decision 1993/389/EEC for a monitoring mechanism of Community CO_2 and other greenhouse gas emissions (Council of the European Union, 1999)

greenhouse gases. The programs have to safeguard, that the Community-wide emission level of 2000 does not exceed the emission level of 1990. The obligations according to the UNFCCC and the Kyoto Protocol have to be met and the planned and actual progress shall be tracked. The member states have to submit their historic and actual emissions of the six Kyoto-gases and detailed and quantified measures to limit or reduce emissions. The Commission monitors the implementation of the measures on an annual basis.

In parallel to the development of Decision 1993/389/EEC, the EU Council adopted the so-called IPPC-Directive 1996/61/EC[1]. It aims at integrated pollution prevention or reduction in several industry sectors. According to Article 4, a permit is required for the operation of all installations in these sectors. The permit is bound to certain requirements. Among these requirements, there are emission caps which are derived from the best available techniques (BAT). The Council determines these caps. Thus, this Directive introduces regulatory means for environmental politics. Later on, this Directive became the anchor for the Directives on emission trading.

In 2000, seven years after the first Decision on greenhouse gases had been adopted and three years after the Kyoto Protocol had been passed, the Commission presented a Green Paper[2] with first thoughts on how emission trading could be implemented in the European Union. The objective of this Green Paper was to initiate a discussion within the EU. In the burden-sharing agreement of the Kyoto Protocol, the EU had committed to reduce its overall greenhouse gas emissions in the first commitment period (2008-2012) to a level of 8% below the emission level of 1990. Counted against the business-as-usual forecasts, this meant a reduction of 14%. From all theoretical considerations, the EU Commission assumed emission trading to be the most efficient instrument to achieve this reduction target. Nevertheless, the Commission considered the target to be stretch and suggested gaining experience with emission trading ahead of the first Kyoto-period in an upfront-phase 2005-2007. To obtain the maximum learning experience from this inner-EU emission trading, the Commission called for a coherent and well-tuned framework equal for all member states. Special focus should be given to definition of the boundaries (industries and gases), the selection of the allocation mode, and the interference or potential alignment with other political instruments.

In 2002, five years after the European Community and other countries had adopted the Kyoto Protocol, the EU Council approved the protocol in its Decision 2002/358/EC[3]. A few days after this approval, all 15 EU member states deposited their relevant ratification papers at the

[1] Directive 1996/61/EC of the Council of 24 September 1996 on Integrated Pollution Prevention and Control (Council of the European Union, 1996)

[2] COM(2000) 87 Green Paper on greenhouse gas emissions trading within the European Union (Commission of the European Communities, 2000)

[3] Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder (Council of the European Union, 2002)

UN. While this can be regarded as a formal step for the EU, it was an important visible step towards the Kyoto Protocol coming into force.

A good year later, in October 2003, the EU Parliament and the Council adopted Directive 2003/87/EC[1]. This Directive is the actual cornerstone of the current EU Emission Trading Scheme (EU ETS). In Article 2 and the respective Annexes I and II, the Directive defines the boundaries of the EU ETS. In the first phase (2005-2007), the following four industry sectors are affected directly: energy activities and refineries, production and processing of ferrous metals, the mineral industry, and finally "other activities" (comprising pulp and paper/board production). Aiming to limit complexity, the Directive focuses solely on CO_2 during the first phase, while the other Kyoto gases can be included from the second phase (first Kyoto period 2008-2012) onwards, if the Commission gives an according recommendation to the Parliament. However, this has not yet taken place. The member states have the possibility to include further industries and small scaled plants of the sectors named above for the first phase (opt-in, Art. 24) and can inquire of the EU bodies to exclude certain installations (opt-out, Art. 27). Articles 9 and 11 oblige the member states to set up national allocation plans (NAPs) for phases I and II. While the phase-I NAPs had to be submitted for approval to the Commission by September 30th 2004, the phase-II NAP drafts needed to be finished by September 30th 2006. The NAPs had to comprise volume and allocation mode down to the level of installations. The allocation has to be free of charge for at least 95% of the certificates for the first phase and for at least 90% for the second phase. Certificates are handed out to the operators of the installations annually until February 28th for the respective year (Art. 10). The certificates are tradeable within the EU member states and in third countries. For all emissions within a certain year, the operators of the installations are obliged to hand back ("pay") the corresponding amount of certificates to the authorities by April 30th of the subsequent year (Art. 11). Thus, banking and borrowing is possible within the same phase. In Article 13, the Directive principally allows banking across phases. The penalties for emissions exceeding the available certificates introduced in Article 16 are rather theoretical, as the certificates will have to be released later on anyway. Article 28 of the Directive enables member states to allow operators of installations to pool their emission certificates over plants, companies, and industries. However, this idea has turned out to be of very limited attractiveness for industry too. Only Article 30, linking the ETS with measures of Joint Implementation and Clean Development Mechanism according to the Kyoto Protocol, has kept its relevance until today. Thus, looking back at this Directive three and a half years after its adoption, some Articles make the Directive a cornerstone, while many have emerged as being non-relevant or requiring further elaboration in additional Directives, Decisions or Regulations.

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Parliament and Council of the European Union, 2003c)

One of these additional Decisions is Commission Decision 2004/156/EC[1], the so-called MRG-Decision (monitoring and reporting guidelines). It refers to Article 14 of Directive 2003/87/EC and details the guidelines for member states on how to set up the monitoring and reporting of the greenhouse gas emissions of the single installations. The MRG-Decision 2004/156/EC, in turn, has been supplemented by Decision No. 280/2004/EC[2]. The latter establishes mechanisms for monitoring emissions, for evaluating the progress towards meeting the respective commitments, for implementing the UNFCCC and the Kyoto Protocol, and for ensuring the timeliness and quality of the reporting by the Community and its member states.

Another of these supportive acts amending Directive 2003/87/EC is Directive 2004/101/EC[3], the so-called Linking Directive. It adds Articles 11a and 11b to Directive 2003/87/EC. Article 11a enables member states to allow operators to use Certified Emission Reductions (CERs) from measures according to Clean Development Mechanisms and Emission Reduction Units (ERUs) from Joint Implementation measures instead of certificates originating from the ETS. Article 11b explicitly outlines that the CERs and ERUs have to comply with the standards defined in UNFCCC, the Kyoto Protocol, and related documents. Thus, the Linking Directive connects the ETS with the Flexible Mechanisms according to the Kyoto Protocol. A similar exchange will be possible with the Assigned Amount Units (AAUs) according to the Kyoto emission trading.

The next concretising act was the Commission Regulation (EC) No 2216/2004[4]. As a Regulation, it directly takes effect in all member states without additional national legislation. It regulates the setup of the national emission registries with the respective accounts, the cooperation between national registries, and the EU-wide registry, respectively the international registry.

[1] Commission Decision 2004/156/EC of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC (Commission of the European Communities, 2004a)

[2] Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol (European Parliament and Council of the European Union, 2004c)

[3] Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms (European Parliament and Council of the European Union, 2004b)

[4] Commission Regulation (EC) No 2216/2004 of 21 December 2004 for a standardised and secured system of registries pursuant to Directive 2003/87/EC of the European Parliament and of the Council and Decision No 280/2004/EC of the European Parliament and of the Council (Commission of the European Communities, 2004b)

The subsequent Decision 2005/166/EC[1] again refers to a previous Decision. It lays down the rules for implementation of Decision 280/2004/EC and thus refers to monitoring and reporting as a fourth step in a cascade starting at the initial "cornerstone" Directive 2003/87/EC.

For the time being, the latest act amending Directive 2003/87/EC is Commission Decision 2005/381/EC[2]. This Decision defines the questionnaire which the member states have to apply for the annual progress reporting to the Commission. Further respective publications of the Commission do not have any legal character. They only give advice to the member states for setting up registries, deciding on taxation etc.

Despite the IPPC-Directive on pollution prevention and control, the eleven other legal acts of the European Union which have been cited so far aim solely to reduce the emission of greenhouse gases. Just during the last four years since 2003, no less than eight Directives, Decisions, and Regulations on the European Emission Trading Scheme have been adopted (this does not even include the 26 Decisions on the approval of the national allocation plans). However, two other political fields need to be noted here too as both of them aim to reduce the emission of greenhouse gases too. These two fields are the promotion of electricity generation from renewable energy sources (RES) and cogeneration (CHP) as well as the taxation of energy products and electricity. To limit the details here, only the most relevant acts of EU legislation will be touched. Thus, the following listing cannot be exhaustive.

The so-called RES-Directive 2001/77/EC[3] sets up the basis for the promotion of electricity from renewable energy sources (sometimes also called green electricity). While the global target for RES-electricity for the entire EU is 12% in 2010, Article 3 of the Directive obliges member states to set individual targets and take specific actions to subsidise directly or indirectly electricity generation from renewable energy sources (Art. 4). Article 5 commits the member states to safeguard that this green electricity will be certified. The member states have to make sure that the grid operators grant producers of environmentally friendly electricity access to their networks (Art. 7).

[1] Decision 2005/166/EC of European Parliament and of the Council of 10 February 2005 laying down rules implementing Decision No 280/2004/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol (Commission of the European Communities, 2005b)

[2] Commission Decision 2005/381/EC of 4 May 2005 establishing a questionnaire for reporting on the application of Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Commission of the European Communities, 2005a)

[3] Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market (European Parliament and Council of the European Union, 2001)

The twin of this RES-Directive is CHP-Directive 2004/8/EC[1] which sets up the basis for the promotion of cogeneration. Basically the member states are obliged to set up effective support schemes (Art. 7) to safeguard the certification of electricity from cogeneration (Art. 5) and to monitor and report the effect of the measures towards the Commission (Art. 10 and 11).

The taxation of energy products and electricity is regulated in Council Directive 2003/96/EC[2]. The member states have to introduce levels of taxation which may not be lower than the minimum levels prescribed by Article 7 and Annex I of the Directive. Exemptions for certain energy products, electricity origins or uses are defined in Articles 2 and 14-19.

Thus, currently no fewer than 15 EU Directives, Decisions, and Regulations on the ETS, on the promotion of RES-electricity and CHP-electricity as well as on taxation of energy products and electricity are in effect. This obviously means considerable complexity for the EU and its bodies, for the member states, and for the affected companies within the different industry sectors. The liberalisation of the gas and electricity markets within the Community with the two respective Directives 2003/54/EC[3] and 2003/55/EC[4] has not even been mentioned so far, although at least the liberalisation of the electricity markets can be regarded as being supportive or even an enabler for indirect effects of emission trading to industrial electricity customers. The complexity increased when on May 1st 2004 ten and on January 1st 2007 two more countries acceded to the EU. In principle, they had to adopt EU legislation on that date. While in some political fields, the EU has taken pressure off these countries by granting transition periods to develop corresponding national legislation (e.g., on energy taxation), they are fully involved in the ETS which now covers all 27 member states.

2.1.2.3 National legislation – to each their own

As outlined in the previous sections, the legislation on emission trading is embedded in the more general legislation on climate protection which started years earlier but is, in many cases, less tangible and has more the character of a declaration of intent. It has been pointed out too that emission trading is acting in the same arena as energy and emission taxation, the promotion of RES and CHP as well as all legislation aiming at reduction of greenhouse gas emissions by regulatory means. Thus, all of these instruments basically penalise the

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[1] Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (European Parliament and Council of the European Union, 2004a)

[2] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity (Council of the European Union, 2003)

[3] Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC (European Parliament and Council of the European Union, 2003a)

[4] Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC (European Parliament and Council of the European Union, 2003b)

combustion of fossil fuels for heat and electricity generation. The liberalisation of the gas and electricity markets also affects the effectiveness of emission trading. This interaction of laws on these political instruments is the case for the EU legislation, as it is the case for all national legislation of the 27 member states as the respective EU Directives and Decisions have been implemented in about 15 to 25 laws and regulations by country. This adds up to approximately 500 national laws and regulations aimed at or seriously affecting climate protection. As the comparison of national legislation is not an objective of this investigation, presenting or comparing all these legal acts will be avoided. Opposed to this matrix of comparisons, two slices of this legislation will be examined in the following sections. In the first, a vertical slice of all national legislation aimed at or seriously affecting climate protection of one member state will be examined. Germany has been chosen as the case example. In the second, a horizontal slice of the main features of the 25 respectively 27 national allocation plans, the core acts of national emission trading legislation, will be compared.

As far as the EU legislation is concerned, the German emission trading laws and regulations need to be put into the context of the general climate protection legislation. The oldest and at the same time most often amended German law aimed at the limitation or reduction of all kinds of emissions is the Federal Emission Control Law (Bundes-Immissionsschutzgesetz[1]) which was adopted in 1974. Although the German Government assigned its first minister for the environment in 1986, there was no legislation dedicated to the prevention of global climate change until 1998 apart from this Federal Emission Control Law which is a purely regulatory instrument. The petroleum tax was designed as an indirect tax (consumption tax) without any clear ecological intention. With the change in the German Government to a red-green coalition in 1998, one year after the Kyoto Protocol and two years ahead of the EU Commissions Green Paper on greenhouse gases, climate protection climbed higher on the agenda. However, it was a long time until the first dedicated laws on emission trading were adopted. Initially, the new government went for a double strategy. On the one hand, it renewed and accentuated the Climate Protection Agreement (Klimaschutzvereinbarung[2]) with the central associations of German industry. This agreement had been closed in 1995 and renewed in 1996 with the previous government. While industry agreed upon certain specific and later absolute emission reductions in CO_2 and the other Kyoto gases, the government guaranteed not to enforce the targets by political law if the commitments were implemented successfully. This agreement was last renewed and extended by the promotion of CHP in 2001. On the other hand, in parallel to this voluntary commitment of German industry, the government started implementing the eco-tax reform in 1999.

[1] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundestag of the Federal Republic of Germany, 1974)

[2] Vereinbarung zwischen der Regierung der Bundesrepublik Deutschland und der deutschen Wirtschaft zur Klimavorsorge (Bundesregierung of the Federal Republic of Germany et al., 2000)

The first step in the eco-tax reform was the Law for Introduction into the Eco-Tax Reform[1] introducing the Electricity Tax Law (Stromsteuergesetz) and amending the Petroleum Tax Law (Mineralölsteuergesetz) in March 1999. The income from this new eco-tax is used to support the national pension insurance system. Already in December 1999, the eco-tax rates had been increased with the Law for Continuation of the Eco-Tax Reform[2]. In 2002, the next amendment came with the Law for further Development of the Eco-Tax Reform[3]. Finally, the taxation of fuel and electricity was amended by the Law for Reorganisation of Fuel Taxation and Amendment of Electricity Tax Law on July 15th 2006[4], replacing the former Petroleum Tax Law by the new Energy Tax Law in Article 1 and amending the Electricity Tax Law in Article 2. To date, the reimbursement conditions are EUR 512.50 retention and 95% reimbursement of the excess of eco-tax over saved contributions to pension insurance. While the ordinary electricity tax rate is 20.50 EUR/MWh, the reduced rate for industry is 12.30 EUR/MWh, whereof typically about 2 EUR/MWh remain after deduction of savings on pension insurance. Taxation of fossil fuels is less concise as there is a wide range of fuels and tariffs, on the one hand, and "Mineralölsteuer" consists of an "old" component which is an indirect tax without any ecological intention and a "new" component which is the eco-tax component. Both are treated differently in the reimbursement.

In parallel to the eco-tax reform, the government introduced promotion mechanisms for RES and CHP. The first law to promote green electricity was the Renewable Energy Sources Act[5] of March 2000 which was last amended in July 2004[6]. The vertices of the Renewable Energy Sources Act are the obligation of electricity grid operators to connect turbines generating electricity from renewable energy sources (§ 4) and defined feed-in tariffs for all kinds of green electricity (§§ 5-11). Though, feed-in tariffs are paid only if the boiler, respectively turbine, is operated with bio-fuels only. The supplementary Biomass Regulation[7] defines details concerning the fuels which count as renewable energy sources. According to the Renewable Energy Sources Act, each electricity customer is obliged to take a certain percentage of green electricity from the grid (in 2005 it was 10.2%). The customer is charged a

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[1] Gesetz zum Einstieg in die ökologische Steuerreform (Bundestag of the Federal Republic of Germany, 1999a)

[2] Gesetz zur Fortführung der ökologischen Steuerreform (Bundestag of the Federal Republic of Germany, 1999b)

[3] Gesetz zur Fortentwicklung der ökologischen Steuerreform (Bundestag of the Federal Republic of Germany, 2002c)

[4] Gesetz zur Neuregelung der Besteuerung von Energieerzeugnissen und zur Änderung des Stromsteuergesetzes (Bundestag of the Federal Republic of Germany, 2006b)

[5] Erneuerbare-Energien-Gesetz as Article 1 of the Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz – EEG) sowie zur Änderung des Energiewirtschaftsgesetzes und des Mineralölsteuergesetzes (Bundestag and Bundesrat of the Federal Republic of Germany, 2000)

[6] By the Gesetz zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich (Bundestag of the Federal Republic of Germany, 2004b)

[7] Verordnung über die Erzeugung von Strom aus Biomasse (Biomasseverordnung – BiomasseV) (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2001) latest amended by Erste Verordnung zur Änderung der Biomasseverordnung of August 9th 2005 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2005)

regulated fee of 5.50 EUR/MWh on all electricity purchased, respectively 91.40 EUR/MWh on the green electricity purchased (approximately equalling the average feed-in-tariff for RES electricity). According to a hardness clause in the Renewable Energy Sources Act (§ 16), the charge for green electricity can be capped for industrial customers. The cap is 0.50 EUR/MWh for all industrial customers (referring to total electricity purchase) who consume more than 10 GWh and have electricity costs exceeding 15% of total value-added. This cap usually comes into play for pulp and paper manufacturers. The latest amendment to the Renewable Energy Sources Act has been the First Law amending the Renewable Energy Sources Act[1].

The twin law of the Renewable Energy Sources Act is the Cogeneration Act[2] of March 2000 amended by the Law for the Maintenance, the Modernization, and the Extension of Co-generation[3]. The latter rules the electricity grid operator's obligation to connect cogeneration turbines. The sales price of electricity from cogeneration consists of a negotiable base price which includes the grid costs avoided, plus a regulated premium (§ 4). The premium ranges between 15.30 EUR/MWh and 51.10 EUR/MWh and decreases over time (§ 7). It is bound to physical transfer of the electricity to avoid a sell-and-buy-back of electricity which is used internally. The electricity grid operators can pass on these costs of subsidizing cogeneration to their end customers. The respective surcharge is 0.50 EUR/MWh but capped at 0.25 EUR/MWh for industrial customers under certain conditions (§ 9).

In 2003, a year after the German ratification of the Kyoto Protocol[4] and in line with EU Directive 2003/87/EC, the German Government introduced emission trading as a fourth political instrument aimed at reducing greenhouse gas emissions – beside regulation, energy taxation, and subsidisation of RES and CHP. Several drafts of an Emission Trading Law have resulted finally in three laws and two respective regulations. The cornerstone for the German legislation on emission trading is the Greenhouse Gas Emission Trading Law[5] of July 8th 2004. This law is the direct implementation of EU Directive 2003/87/EC and sets the framework for the allocation and rules for the actual emission trade. It decides upon the participants (§2), obliges the operators of all affected installations to monitor and report the emissions (§5), defines the character of the allowances (tradeable, valid for one phase etc., §6)

1 Erstes Gesetz zur Änderung des Erneuerbare-Energien-Gesetzes of November 7th 2006 (Bundestag of the Federal Republic of Germany, 2006a)

2 Gesetz für den Schutz der Stromerzeugung aus Kraft-Wärme-Kopplung (Bundestag of the Federal Republic of Germany, 2000)

3 Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (Bundestag of the Federal Republic of Germany, 2002a) latest amended by Article 170 of Zuständigkeitsanpassungsverordnung of October 31st 2006 (Bundesministerium der Justiz of the Federal Republic of Germany, 2006)

4 By Gesetz zu dem Protokoll von Kyoto vom 11. Dezember 1997 zum Rahmenübereinkommen der Vereinten Nationen über Klimaänderungen (Kyoto Protokoll) (Bundestag of the Federal Republic of Germany, 2002b)

5 Gesetz über den Handel mit Berechtigungen zur Emission von Treibhausgasen (Treibhausgas-Emissionshandelsgesetz – TEHG) which is Article 1 of the Gesetz zur Umsetzung der Richtlinie 2003/87/EG über ein System für den Handel mit Treibhausgasemissionszertifikaten in der Gemeinschaft (Bundestag and Bundesrat of the Federal Republic of Germany, 2004)

and assigns the Federal Environmental Agency (Umweltbundesamt respectively Deutsche Emissionshandelsstelle) as the relevant authority.

The actual allocation of allowances for phase I, however, was done earlier (March 31st 2004) by the Federal Ministry for Environment in the National Allocation Plan[1]. This plan outlines in detail the principles of allocation of emissions rights down to the level of installations. An overview of these principles will be given later on in this chapter. After its conditional approval by the EU Commission, this NAP became the basis for the respective Allowance Allocation Law 2007[2] which confirms its guiding principles and basic numbers (allocation target, compliance factor etc.). The supporting Allowance Allocation Regulation 2007[3] details the modalities for calculating the emissions. In turn, the 11th Federal Emission Control Regulation[4] defines details of the emission declaration and the emission report which the operators of installations subject to German emission trading legislation have to submit to the authorities. Finally, the respective Emission Trading Cost Regulation 2007[5] entitles the authorities to decide upon charges for all official acts. Based on these three laws and two regulations, emission trading started in Germany on January 1st 2005.

Meanwhile one further law and one further regulation have been adopted, the draft of the NAP for phase II has been submitted and conditionally approved by the EU Commission, and another law is in preparation. Analogous to EU Linking Directive 2004/101/EC[6], the Flexible Mechanisms Law[7] safeguards the crediting of ERUs and CERs earned in Joint Implementation and Clean Development Mechanism actions to German emission trading legislation. Preparation for the compilation of the phase II NAP was supported by the Data

[1] National Allocation Plan for the Federal Republic of Germany 2005-2007 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2004c)

[2] Gesetz über den nationalen Zuteilungsplan für Treibhausgas-Emissionsberechtigungen in der Zuteilungsperiode 2005 bis 2007 (Zuteilungsgesetz 2007 – ZuG 2007) (Bundestag of the Federal Republic of Germany, 2004a)

[3] Verordnung über die Zuteilung von Treibhausgas-Emmissionsberechtigungen in der Zuteilungsperiode 2005 bis 2007 (Zuteilungsverordnung 2007 – ZuV 2007) (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2004d)

[4] Elfte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Emissionserklärungen und Emissionsberichte - 11. BImSchV) (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2004a)

[5] Kostenverordnung zum Treibhausgas-Emissionshandelsgesetz und zum Zuteilungsgesetz 2007 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2004b)

[6] Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms (European Parliament and Council of the European Union, 2004b)

[7] Gesetz über projektbezogene Mechanismen nach dem Protokoll von Kyoto zum Rahmenübereinkommen der Vereinten Nationen über Klimaänderungen vom 11. Dezember 1997 (Projekt-Mechanismen-Gesetz – ProMechG) of Sebtember 22nd 2005 (Bundestag of the Federal Republic of Germany, 2005) latest amended by by Article 170 of Zuständigkeitsanpassungsverordnung of October 31st 2006 (Bundesministerium der Justiz of the Federal Republic of Germany, 2006)

Gathering Regulation 2012[1] which was decided together with the draft of the NAP for the trade phase 2008-2012[2] on June 28th 2006 by the Federal Cabinet. It was intended to allow gathering of the 2003 and 2004 emission data required for the final version of the phase II NAP. In parallel to the examination of NAP II proposal by the Commission, the respective ministry has prepared a draft for the law amending legal basis of Emission Trading with respect to Allocation Period 2008-2012[3] which will give the NAP II a legal character as soon as it has been modified in accordance with the EU Commission's conditions for approval in spring 2007.

In this chapter, an overview has been given of the German laws and regulations aimed at or seriously affecting climate protection. Besides the actual legislation on emission trading, the relevant laws on energy taxation and promotion of electricity generation from renewable energy sources and cogeneration have been introduced. These three political instruments have a direct effect on climate protection. A remarkable – but indirect – effect is also caused by the legislation on the liberalisation of the gas and electricity markets. However, even without any further illustration of the respective Power Industry Law[4], the complexity and the interactions of the laws and regulations aimed at or seriously affecting climate protection should have become evident. To make it explicit once again: all of these instruments penalise the combustion of fossil fuels for heat and electricity generation. The interference of these instruments has been discussed in chapter 2.1.1.5. This evidence for complexity and interference in German legislation stands as the case example for all EU member states. Thus, it should have become evident too that it would go by far beyond the scope of this investigation to provide similar detailing for the remaining 27 EU member states. The horizontal slice in the second part of this chapter will focus on a comparison of the 25 national allocation plans[5].

As we have seen above, the legislation on emission trading has developed quite rapidly during the last four years. During this period, the national allocation plans of the initially 25 now 27 member states have also been subject to numerous changes. An overview of the currently

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[1] Verordnung über die Erhebung von Daten zur Aufstellung des nationalen Zuteilungsplans für die Zuteilungsperiode 2008-2012 (Datenerhebungsverordnung 2012 – DEV 2012) of July 11th 2006 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2006d)

[2] Draft of Nationaler Allokationsplan 2008-2012 für die Bundesrepublik Deutschland of June 28th 2006 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2006c)

[3] Draft of Gesetz über den nationalen Zuteilungsplan für Treibhausgas-Emissionsberechtigungen in der Zuteilungsperiode 2008 bis 2012 (Zuteilungsgesetz 2012 – ZuG 2012) of October 31st 2006 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2006a)

[4] Gesetz über die Elektrizitäts- und Gasversorgung amended by Zweites Gesetz zur Neuregelung des Energiewirtschaftsrechtes, which came into force on July 1st 2005 (Bundestag and Bundesrat of the Federal Republic of Germany, 2005)

[5] Another horizontal slice would be the comparison of national legislation on the promotion of RES (see chapter 4.2.3 and especially Tab. 8 and Tab. 9).

valid versions for the phase 2005-2007 can be found in Appendix 1 and a sketch of the NAPs for the period 2008-2012 in Appendix 2. As of February 2007, 13 NAPs for phase II have been conditionally approved by the EU Commission, most recently the Slovenian on February 5th 2007. Another eleven have been notified to the Commission as drafts, while approval was still pending, one was published for public consultation, and finally two have not been published by the member states yet.

Each of the national allocation plans outlines in detail the principles of allocation of emissions rights down to the level of installations on about 30 to 150 pages. The recurrent topics are mode of allocation (grandfathering vs. benchmarking), reflection of economic growth, treatment of early actions, new installations and closures. Country-specific additional topics are covered in the NAPs (e.g., reserves for exit from nuclear power in Germany). As all published surveys on national allocations plans that can be found in the Internet (Cozijnsen (2004), COGEN (2004) Climate Action Network Europe (2004), Zetterberg et al. (2004)), are either outdated as they refer to draft versions or do not allow comparability of the NAP's relevant topics, Tab. 1 and Tab. 2 provide an overview of the most important aspects of the phase I NAPs. A detailed discussion of the effects of the values of the topics that appear will follow in the next chapter.

Country	Opt in	Opt out	Allocation mode	Charges	Early action bonus	Cogeneration bonus	Allocation target	Remarks
Austria	No	No	Grandfathering with benchmarking component	Free (100.0%)	Yes	Yes	Sector	
Belgium (Flanders)	No	District heating, transport of natural gas	Benchmarking voluntary (otherwise reduced grandfathering)	Free (100.0%)	Yes	Yes	Sector	
Belgium (Wallonie)	No	4 small energy installations	Grandfathering with benchmarking component	Free (100.0%)	No	Yes	Sector	
Belgium (Brussels)	???	???	???	Free (100.0%)	???	???	Sector	Only 2% of Brussels emissions from industry
Cyprus	No	No	Grandfathering	Free (100.0%)	No	No	Installation	
Czech Republic	No	Few small energy installations	Grandfathering	Free (100.0%)	Yes	Yes	Sector	
Denmark	No	No	Grandfathering (benchmarking for electricity)	Free (95.0%), auctioning (5.0%)	No	No	Sector	
Estonia	No	No	Grandfathering	Free (100.0%)	???	???	Sector	
Finland	District heating < 20 MW	No	Grandfathering	Free (100.0%)	No	No	Sector	
France	No	Few small energy installations	Grandfathering	Free (100.0%)	No	No	Sector	
Germany	No	No	Grandfathering (planned emission as exception)	Free (100.0%)	Yes	Yes	Total	
Greece	No	No	Emission forecast	Free (100.0%)	No	No	Total	Allocation based on forecasted emissions
Hungary	No	No	Grandfathering	Free (97.5%), auctioning (2.5%)	Yes	No	Sector	
Ireland	No	No	Grandfathering	Free (99.25%), auctioning (0.75%)	No	No	Sector	

Italy	No	No	Grandfathering/benchmarking (varies by sector, pulp and paper: grandfathering)	Free (100.0%)	No	No	Sector	
Latvia	Small installations on demand	Any installation on demand	Grandfathering	Free (100.0%)	Yes	No	Sector	
Lithuania	???	???	Grandfathering (benchmarking for energy)	Free (98.5%), auctioning (1.5%)	No	No	Sector	
Luxembourg	???	???	Grandfathering	Free (100.0%)	No	Yes	Total	
Malta	No	No	Grandfathering	Free (100.0%)	No	No	Total	Only 2 installations on Malta
Netherlands	No	Installations < 25 kt CO_2 p.a. on demand	Grandfathering	Free (100.0%)	Yes	Yes	Sector	
Poland	No	Installations < 5 kt CO_2 p.a.	Grandfathering (benchmarking as exception)	Free (100.0%)	Yes	Yes	Sector	
Portugal	No	No	Grandfathering	Free (100.0%)	No	No	Sector	
Slovakia	No	No	Grandfathering	Free (100.0%)	No	No	Sector	
Slovenia	Energy installations 15…20 MW	No	Grandfathering w. benchmarking component	Free (100.0%)	Yes	Yes	Sector	
Spain	No	No	Grandfathering	Free (100.0%)	No	Yes	Sector	
Sweden	Energy installations < 20 MW	No	Grandfathering	Free (100.0%)	No	No	Total	
United Kingdom	No	64 installations in 2005 and 2006	Grandfathering	Free (100.0%)	No	No	Sector	Growth factors for sectors with relative climate change agreements

Tab. 1: Overview on national allocation plans of all EU 25 countries for phase I (2005-2007) – part I

Country	Compliance factor P&P	Economic growth	New entrants	Closures	Banking	Total allocation (Mt p.a.)	Balance (allocation vs. BAU)	Remarks
Austria	96.4%	Yes (sector)	Reserve 0.3 Mt p.a., first come first served	No allowances for future years, no ex-post reduction	No	33.00	Short	
Belgium (Flanders)	100.0%	No	Reserve, allocated according benchmark	No allowances for future years, no ex-post reduction	No	30.92	Short	
Belgium (Wallonie)	87.5%	No	Reserve 0.5 Mt p.a., first come first served	???	No	28.11	Short	
Belgium (Brussels)	???	???	???	???	No	4.13	Short	Only 2% of emissions from industry
Cyprus	100.0%	Yes (total)	No reserve for unplanned new entrants	???	No	5.70	Long	
Czech Republic	100.0%	Yes (sector)	Reserve 0.67 Mt p.a.	???	No	107.88	Long	
Denmark	100.0%	Yes (electricity exports)	Reserve 1.0 Mt p.a.	No allowances for future years, no ex-post reduction	No	33.50	Short	
Estonia	100.0%	Yes (sector)	Reserve 0.65 Mt p.a.	???	No	21.59	Long	
Finland	94.7%	No	Reserve 0.83 Mt p.a., allocated according benchmark	No allowances for future years, no ex-post reduction	No	45.50	Short	
France	96.8%	Yes (sector)	Reserve 1.1 Mt p.a.	No allowances for future years, no ex-post reduction	Yes	126.30	Short	
Germany	97.1%	No	Reserve 9.0 Mt p.a., compliance factor 1.0 for 14 years, transfer from old install. possible	No allowances for future years, ex-post reduction if production falls below 60% of base years	No	503.00	Short	
Greece	100.0%	Yes (sector)	Reserve 0.13 Mt p.a., transfer from old install. possible	No allowances for future years, no ex-post reduction	No	74.42	Short	
Hungary	100.0%	Yes (sector)	Reserve 0.6 Mt p.a., allocated according benchmark	No allowances for future years, no ex-post reduction	No	29.90	Long	
Ireland	100.0%	No	Reserve 0.3 Mt p.a., allocated according projected emissions, first come first served	No allowances for future years, no ex-post reduction	No	22.32	Short	

Italy	100.0%	Yes (sector)	Reserve 39.0 Mt p.a., allocation according benchmark, transfer from old installation possible in most sectors	No allowances for future years, hardly ex-post reduction	No	240.72	Short	
Latvia	100.0%	No	Reserve, allocated according benchmark, first come first served	???	???	4.57	Long	
Lithuania	75.0%	Yes (total)	Reserve 0.67 Mt p.a., allocated according to BAT, first come first served, transfer from old installation not possible	No allowances for future years, no ex-post reduction	???	12.27	Long	
Luxem-bourg	91.0%	No	Reserve 0.4 Mt p.a., allocated according benchmark, compliance factor 1.0, transfer from old installation possible	No allowances for future years, no ex-post reduction	???	3.52	Short	
Malta	100.0%	Yes (sector)	Reserve 0.75 Mt p.a.	???	???	2.94	Long	Only 2 installations
Nether-lands	97.0%	Yes (sector)	Reserve 4.0 Mt p.a., first come first served	???	No	98.30	Short	
Poland	100.0%	Yes (sector)	Sectoral reserves total at 3.26 Mt p.a., allocated according benchmark, transfer from old installation possible	No allowances for future years, no ex-post reduction	Yes	286.19	Long	Banking only with Polish allowances
Portugal	100.0%	Yes (total)	Reserve 3.1 Mt p.a., allocated according benchmark, first come first served, transfer from old installation possible	No allowances for future years, no ex-post reduction	No	38.90	Short	
Slovakia	100.0%	Yes (sector)	Reserve 0.15 Mt p.a., allocated according benchmark, first come first served	???	No	30.50	Long	
Slovenia	95.8%	No	Reserve 0.7 Mt p.a., allocated according benchmark, first come first served, transfer from old installation possible	No allowances for future years, no ex-post reduction	???	8.78	Short	
Spain	100.0%	Yes (sector)	Reserve 5.42 Mt p.a. allocated according benchmark, first come first served	No allowances for future years, no ex-post reduction	No	172.31	Short	
Sweden	100.0%	No	Reserve 1.8 Mt p.a., allocated according benchmark, first come first served	???	???	22.90	Short	
United Kingdom	100.0%	Yes (sector)	Reserve 15.6 Mt p.a., allocated according benchmark, first come first served, transfer from old installation not possible	No allowances for future years, no ex-post reduction	???	245.43	Short	Opt out to align with UK emission trading scheme

Tab. 2: Overview on national allocation plans of all EU 25 countries for phase I (2005-2007) – part II

Summarizing the comparison of the national allocation plans for phase I (2005-2007) in a few sentences, the basic findings are the following:

- The possibilities of opting-in and opting-out have been used to a negligible extent by a few member states only
- Grandfathering is the predominant mode of allocation, benchmarking is at most used as an additional component
- Almost all certificates are allocated for free, auctioning of allowances can be neglected
- Early actions and CHP are fostered by additional allocation in about a third of the member states
- Economic growth is reflected in most member states; growth factors are applied for total allocation, for sectoral allocation or for individual allocation
- New entrants will receive certificates for free, according to BAT-benchmarks in nearly all member states
- In the case of closure of installations, the certificates for the subsequent years have to be handed back to the authorities
- Total annual allocation for phase I about 2,200 Mt CO_2
- Installations located in Eastern Europe are better off due to a tendency of over-allocation to these countries

As noted above, following EU Directive 2003/87/EC[1] the member states needed to submit their drafts of phase II NAPs to the Commission by September 30th 2006. Although not all member states have met this obligation, most of the 27 required NAP drafts have been presented to the EU. 13 have been conditionally approved, the member states are currently implementing the conditions and preparing the respective legal acts, another eleven have been notified to the Commission, while approval was still pending, one was published for public consultation, and finally two have not been published by the member states yet.

2.1.2.4 EU allowance market – increasing prices at moderate market volumes

Although national legislation, approvals of the phase I NAPs, and set-up of registries was significantly behind schedule, official trade with EU emission allowances (EUAs) started on January 3rd 2005, closely tied to the trade of allowance precursors in 2003 and 2004 originating from JI and CDM projects. As Sinha (2004) and others describe, primarily public funds of countries and international institutions as well as some private funds have bought these EUA (EU emission allowance) precursors. Major buyers were the Netherlands (CerUPT, ERUPT, International Finance Corporation and Rabobank), the World Bank

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Parliament and Council of the European Union, 2003c)

(Prototype Carbon Fund, Netherlands Clean Development Facility, Community Development Carbon Fund), Japan, and Canada.

After initial hurdles in establishing markets for allowances which had not been issued at that time – 2005 EUAs were credited in the national registries on February 28th 2005 – plain financial products came into existence. Meanwhile, guaranteed rights for EUAs with settlements in different years are traded. For simplification, they are just called "EUA 2005", "EUA 2006" etc.

These EUAs are traded either OTC (over-the-counter), i.e., in a brokered or simple bilateral trade, or at exchanges. The four most important exchanges are the Dutch European Climate Exchange (ECX), a spin-off of the International Petroleum Exchange (IPE) in Amsterdam, followed by the Nord Pool in Oslo, PowerNext in Paris, the European Energy Exchange (EEX) in Leipzig, and the Energy Exchange Austria (EXAA). The ECX has a very strong position, accounting for more than 75% of the volume traded at exchanges, as most significant players on the European CO_2 market are active on the IPE anyway and fees are comparably low. Important brokerages are CO2e (Cantor Fitzgerald and PriceWaterhouseCoopers), GreenStream Network Ltd., GT Energy Ltd./Svensk Kraftmäkling AB, and Natsource Europe Ltd. According to Point Carbon's database (Point Carbon, 2007), in 2006 about 71% of the EUAs were traded OTC, while only 29% were traded at exchanges.

The market participants in the CO_2 trade can be separated into three groups. The first group consists of companies that are actually subject to the emission trading scheme. This group is dominated by utility companies which have received a very high share of initial allocation. According to Gammelin and Hecking (2005), in Germany solely the installations of RWE AG, E.on AG, EnBW AG, and Vattenfall AB received about 80% of the allocation[1]. Nevertheless, some utility companies expected to be net buyers. According to Platts Emmissions Daily of August 12th 2005 (Anon., 2005c), German RWE's CEO Roels announced that RWE expects to purchase 16 million tons CO_2 by 2007 in order to maintain their business activities as planned. The second group of market participants consists of traders in investment banks. The third is formed by the management of JI and CDM projects.

In 2005, trade started with moderate volumes as Fig. 15 shows. According to Point Carbon's estimates[2] (Point Carbon, 2007), in 2005 only about 150 Mt CO_2 were traded, less than 7% of the total annual European allocation of about 2,200 Mt CO_2. Even if Point Carbon has

[1] Approximately 1,200 Mt for three years (about 400 Mt per year) of an overall German allocation amounting to 500 Mt per year

[2] Though Point Carbon is a private company and not a supervisory authority to which all transactions need to be notified, its estimates have turned out to draw a very clear and accurate picture of market developments. Point Carbon observes nearly all significant transactions with EUAs. Until March 8th 2006, Point Carbon quotes comprised OTC volumes of at least 5,000 allowances per transaction only. Afterwards, also volumes traded at the active pan-European exchanges have been included.

underestimated trade volumes by 20%, trade was below 10% of annual allocation. The situation changed in 2006, when trade volumes increased significantly. According to Point Carbon, about 850 Mt CO_2 were traded, corresponding to almost 40% of the allocation.

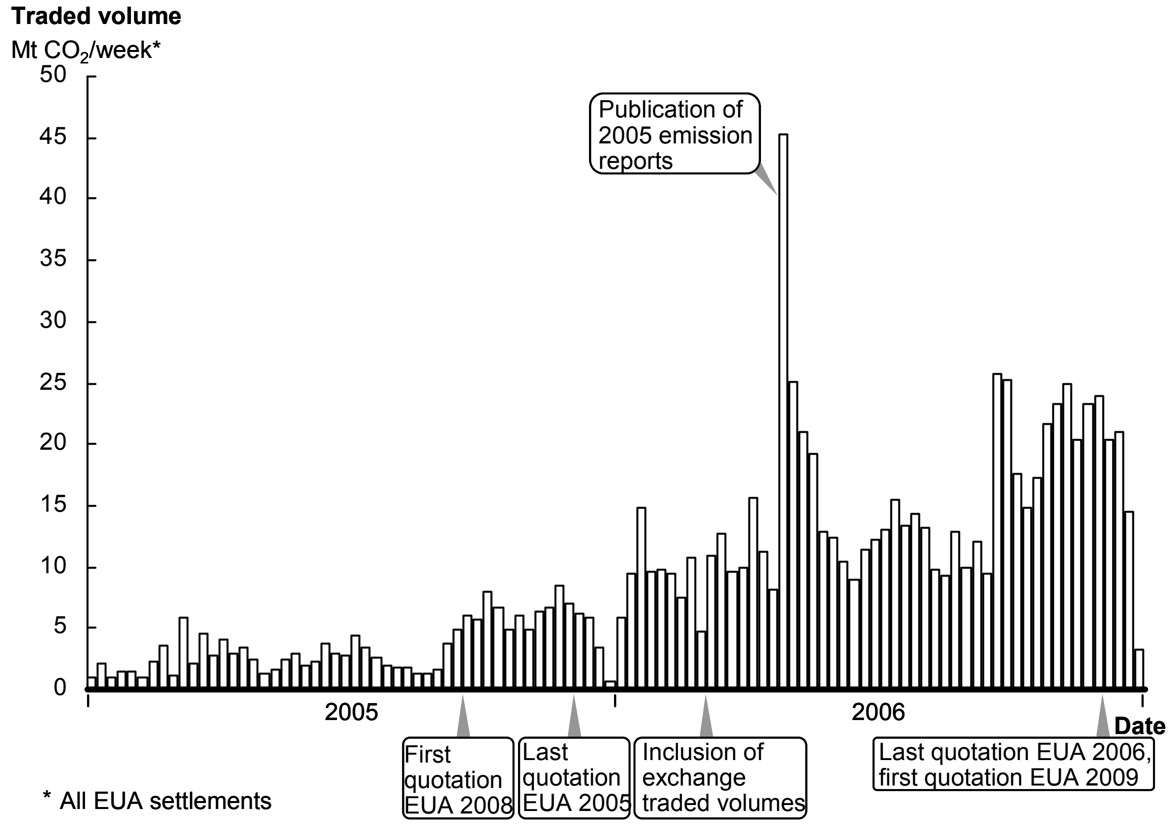

Fig. 15: Traded allowance volumes[1]

An all-time peak in trade volumes accrued in April 2006 when results of the 2005 national emission reports became public. A consumption significantly below allocation caused extreme sales activity, solely on April 26th 12.2 Mt CO_2 were sold, and a price drop by almost two thirds within a week. Lower trade activity during the summer was followed by an increase in autumn 2006 when weekly volumes on average again reached 20 Mt CO_2.

As noted above, EUAs need to be differentiated by their year of settlement. 2005 EUAs were credited to the companies with initial allocation on February 28th 2005 and needed to be handed back for actual CO_2 emissions in 2005 on March 31st 2006. The same applies analogously to the 2006-2009 EUAs. For all EUA which have not been issued yet, plan financial products (futures) are traded named "EUA 2008" etc. Crucial to understanding differences between quotations of EUAs with different settlements is the treatment of banking and borrowing. As outlined in chapter 2.1.2.4, banking is possible within a trade phase but not across trade phases. This means two things for the allowances prices: (1) within a trade phase,

[1] Volumes according to Point Carbon (2007); methodology see above.

different EUAs are closely linked, i.e., prices should only deviate marginally. Across phases, EUAs are hardly linked, i.e., prices can deviate significantly. (2) At the end of a trade phase, the price of allowances either breaks down (if not all allowances issued are utilised) or becomes very high (if more allowances are needed than have been issued). A price ceiling can arise from ERUs and CERs if the scarcity can be covered this way.

Subsequent Fig. 16 provides an overview of the actual development of EU allowance prices. Based on Point Carbon's quotations (Point Carbon, 2007), it displays weekly average prices of the EUAs with settlements between 2005 and 2009.

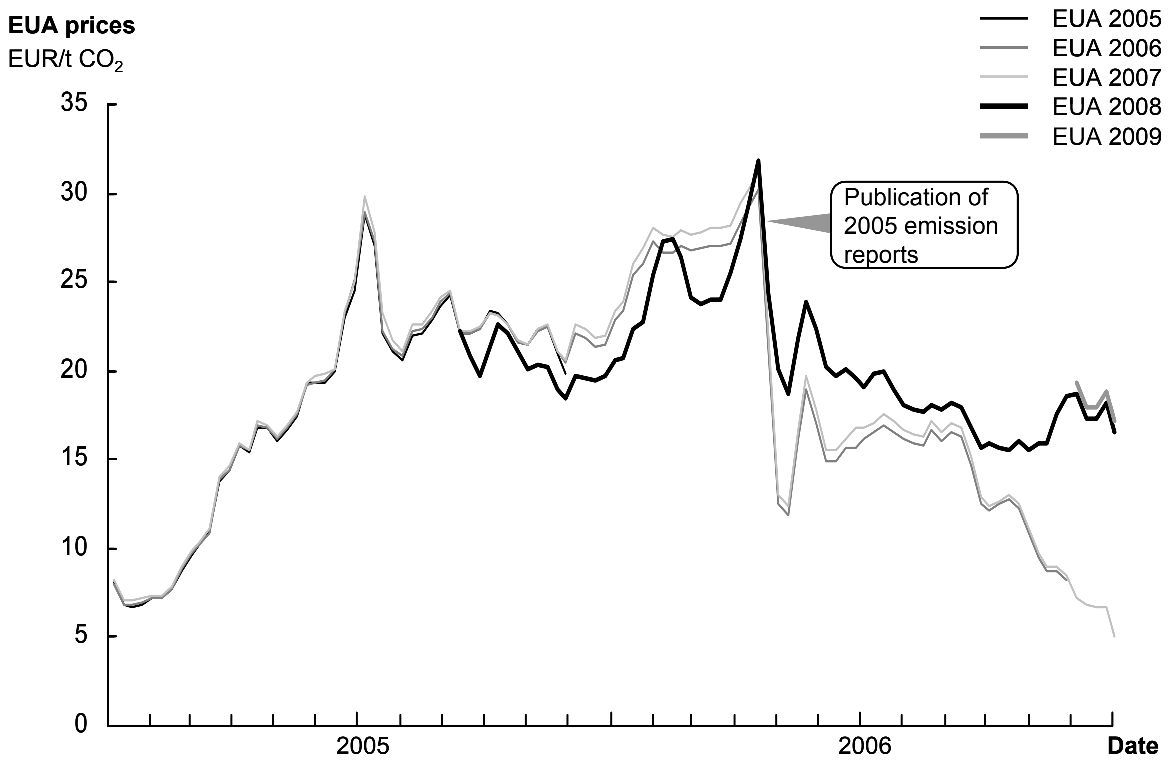

Fig. 16: Allowance price development[1]

In the first half of 2005, prices for phase I EUAs increased drastically – at moderate trade volumes as displayed in Fig. 15. In January, quotations started at about 7 EUR/t CO_2 and boomed until a first peak of over 29 EUR/t CO_2 mid July. After a drop of about 10 EUR/t CO_2, they moved largely horizontally until spring 2006 when they reached a second peak, an all-time high of about 32 EUR/t CO_2, on April 19th 2006. Within a week prices dropped by almost two thirds after the national 2005 emission reports became public. Afterwards, prices recovered, reaching 15 EUR/t CO_2, again and remained fairly constant until mid September. Since then, phase I EUAs and phase II EUAs have decoupled. While EUAs with settlement in

[1] Prices as volume-weighted assessments according to Carbon Market Daily (Point Carbon, 2007); for methodology, see above.

2008 and 2009 kept their value, 2006 and 2007 EUAs constantly declined to an all-time low in February 2007. Just between the end of November and the end of February, phase I allowances lost about 90% of their value. Prices dropped from about 8 EUR/t CO_2 to about 0.80 EUR/t CO_2.

Drivers for these price developments are numerous. Though some have been marginally touched on, a systematisation appears to be required. While Sijm et al. (2005) differentiate supply factors, demand factors, and factors related to market structure, regulation, and intervention, differentiation between the fundamental factors of "volume of allowances", "utilisation of allowances", and "market structure" versus irrational factors (see Fig. 17) seems more practical.

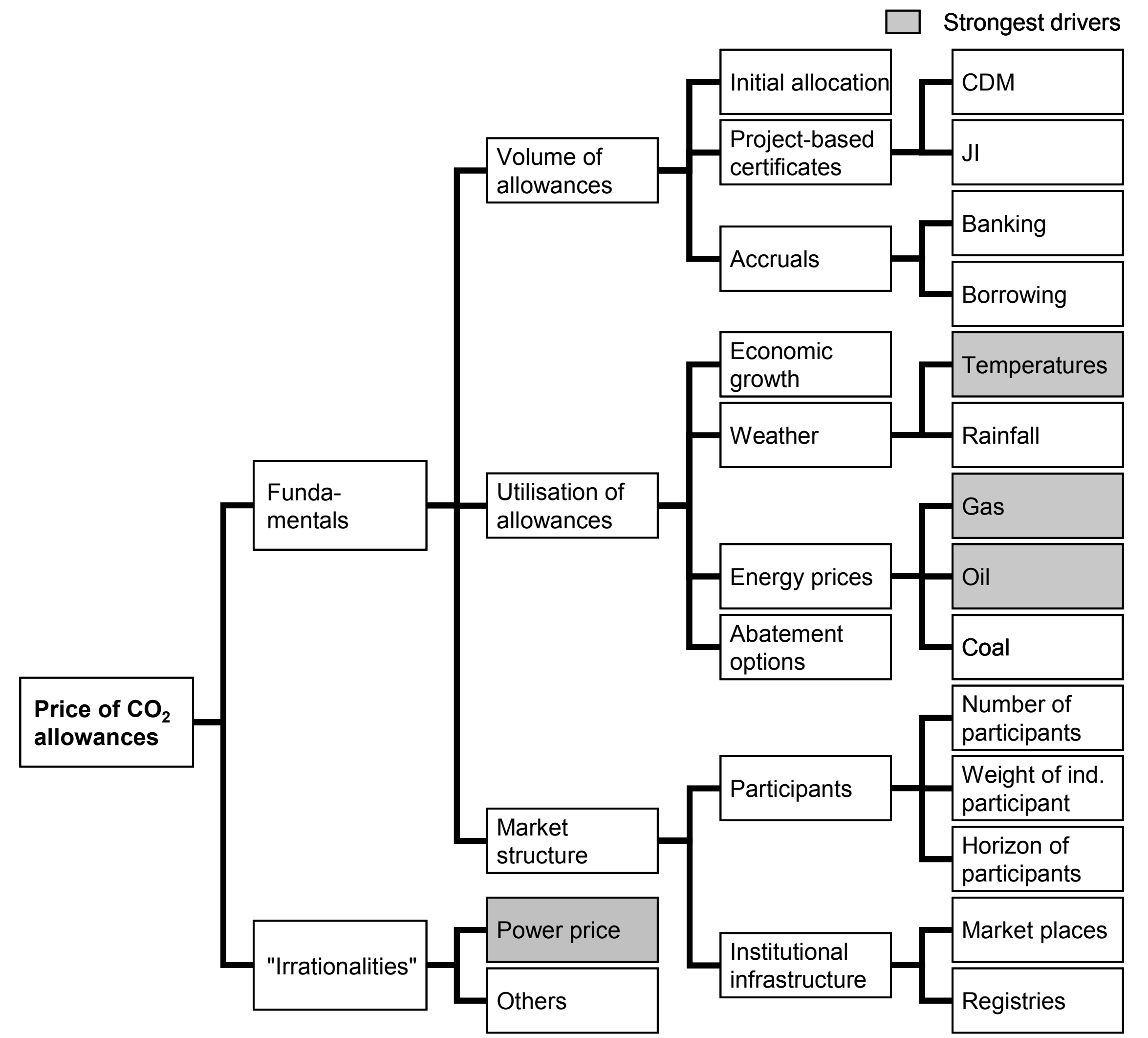

Fig. 17: Drivers for the price of CO_2 allowances

The volume of allowances is determined by the initial allocation, the inflow of CERs and ERUs from JI and CDM projects, and accruals (banking and borrowing). In spring 2005, a significant effect could be observed when the EU was putting pressure on the NAPs of Poland, the UK, and the Czech Republic. Milmo summarised in the Chemical Market Reporter issue of 11-17 April 2005 (Milmo, 2005, p. 10):

> *"The Commission was uncompromising when the UK requested an increase by 20 million metric tons over its original national allocation plan (NAP) [...]. The Commission then demanded a cut of 50 million tons from the Czech NAP and instructed the Polish government to slash its allocation by 140 million tons."*

In parallel to these cut-downs, the price of EUAs rose from about 9.50 EUR/t CO_2 to 15.50 EUR/t CO_2.

Equitable to the actual volume of allowances in the market, the utilisation of the certificates is a very important driver for the price of allowances. Here initially energy prices, i.e., in particular the price relation between various fossil fuels, have prevailed over weather conditions and economic growth. Meanwhile, the importance of these drivers has reversed.

Until autumn 2005, the gas price showed the highest correlation of all fundamentals to the allowance price. Novoszad and Winzer (2005a) demonstrated this correlation clearly in Carbon Market News of August 5th 2005. The rationale behind this correlation is the switch in the merit order of the power plants that takes place if the fuel prices change. If gas gets more expensive, the combined-cycle-gas turbines (CCGT) slip backwards in the merit order and more electricity is produced from lignite or hard coal. As these energy sources have a significantly higher output of CO_2 per MWh, more allowances are needed for electricity generation. Due to the increased demand for allowances the prices rise. This correlation was confirmed by RWEs CEO Harry Roels to Platts Emissions Daily August 12th 2005 (Anon., 2005c) and Carbon Finance of July 22nd 2005 (Anon., 2005a) concerning the UK market. A corresponding but weaker correlation exists between oil and allowance prices.

The price drop in April 2006 at extremely high trade volumes was a result of national 2005 emission reports becoming public. It turned out that industry had emitted less CO_2 than expected. A given allocation was opposed by a significantly lower requirement for allowances. Due to fear of excess allowances in phase I, prices dropped by almost two thirds. This affected both remaining types of phase I EUAs and, to a lower degree, also the 2008 EUAs. The latter is not a fundamental reaction but obviously holders of allowances also questioned their price forecasts for phase II.

The second price drop, which followed for the remaining phase I EUAs since November 2006, is a result of again updated supply/demand forecasts for the first trade phase. Against the background of sufficiently available allowances, the forecast of a mild winter in Europe caused prices to deteriorate. As noted above, 2006 and 2007 EUA quotations dropped by 90% between the end of November 2006 and the end of February 2007. Holders of allowances became unsure, how scarce – or potentially even long – the balance of issued versus required allowances would be at the end of the first trade phase. As banking across phases is not possible within the EU ETS, there is a risk of total loss of value of 2007 EUAs. This risk has obviously been priced in since December 2006.

The third important fundamental factor is the market structure that can be separated into participants and institutional infrastructure. As pointed out above, the participants in the CO_2 trade can be further separated into companies that are actually subject to the emission trading scheme, the management of JI and CDM projects, and (day-) traders. As the latter do not have a fundamental interest in high or low allowance prices but only take advantage of the volatility, this group will be neglected here. The interest of the management of JI and CDM projects can easily be guessed: they favour high prices. The motivation of the companies is more complex. Whereas the numerous participants in the production and processing of ferrous metals, the mineral industry, and pulp and paper production as well as all industrial operators of energy installations strive for low allowance prices in order to have low additional direct and indirect costs of emission trading, the utility companies have a double interest. The first interest is straightforward: they need allowances for the operation of their installations. In the case of scarce allocation, they need to purchase certificates. In this respect, they benefit from low prices. The second interest, in turn, requires an introduction on price setting in electricity markets.

As the marginal land in David Ricardo's Concept of Economic Rent sets the price of grain, the marginal power plant sets the price of electricity (Weizsäcker, 2005). The electricity price for every quarter of an hour equals the short-term variable or marginal cost of the least power plant in the merit order (ranking of power plants by variable costs) that is necessary to cover the actual electricity demand. According to the practiced and generally accepted price setting approach in European electricity markets, the full costs of generation are as irrelevant as all power plants with an earlier position in the merit order. Promotive for this price setting approach are concentration on the supplier (generator) side, the prevailing bundling of generation, and the grid operation as well as highly inelastic demand. The aforementioned marginal power plant in Europe is typically hard coal or gas, on some markets also oil-fired, while hydro power, nuclear, and wind power have lower variable costs. As hard coal, oil, and even gas cause significant CO_2 emissions per MWh electricity generated, respective emission allowances are needed to operate the power plant.[1]

At this point, the second interest of utility companies becomes relevant. The emission allowance required for the last MWh generated by the last power plant in the merit order may

[1] Reinaud (2003) calculates 0.412 t CO_2/MWh for a CCGT and 0.918 t CO_2/MWh for a coal fired power plant. CEPI (2004a) refers to a study carried out by Jaakko Pöyry calculating a CO_2 intensity of the marginal power plant of 0.700 CO_2/MWh.

increase the short-term variable or marginal cost of this MWh and, thus, boost the electricity price. Different from the total cost approach outlined in chapter 2.1.1.2 on the theory behind emission trading, only the marginal allowance for the marginal MWh needs to be considered. As noted above, all other power plants and all allowances employed prior to the marginal allowance are completely irrelevant. Even if all other power plants caused no emissions and all other allowances had been received for free, only the marginal allowance required for the marginal MWh would influence the price. Looking at this marginal allowance, two cases need to be differentiated. It is a significant difference whether the power plant received a short or long allocation of emission allowances. In the case of a short allocation, the utility company needs to purchase this last allowance. The market price of the allowance directly affects the power price. Thus, depending on the CO_2 intensity, an allowance price of 20 EUR/t CO_2 can result in a power price increase of 8-18 EUR/MWh. Some utility companies refer to this argument when looking at increasing electricity prices (Anon., 2005c). In the case of a long allocation, short-term variable costs are only affected if the marginal allowance causes opportunity costs. Thereby, the origination of opportunity costs is bound to two prerequisites: (1) the allowance needs to be employed for generation, i.e., alternative uses are excluded. (2) Alternative uses exist if the allowance is not employed. While the first prerequisite can be adopted right away, the second requires a more thorough consideration: (a) How can the allowance be unlocked from generation? (b) What would happen to the allowance, which has been received for free, if it were unlocked? Unlocking may be realised in two ways: either the same amount of electricity is generated but generation becomes cleaner or specific emissions remain constant while electricity generation is reduced. In the first case, the utility company continues electricity sales at and price and receives additional revenues from selling the allowance. The electricity consumer remains unaffected. In the second case, less electricity is sold – formally this is not a loss for the utility company as sales prices equal marginal costs, i.e., there is no margin anyway – while the allowance is sold in the market. However, the question is whether the allowance can be sold on the market. Some national allocation plans stipulate an ex-post correction of the free allocation in case the production output falls behind the output considered as the base for the allocation. However, even in the national allocation plans stipulating the correction, certain thresholds are defined. In the first German NAP for example, the ex-post correction per rate of production is implemented only if the total emission falls below 60% of the base year emissions. Within a marginal cost consideration, this will never happen. Thus, German utility companies can offer their customers the alternatives of reducing generation or increasing the electricity price by the value of the marginal allowance (RWE, 2007).

This consideration underlines why utility companies have a double interest in looking at the price of emission allowances. Although, as they pass on the price of the marginal allowance in both cases – short and long allocation – the prevailing interest becomes obvious: utility companies strongly favour high allowance prices. As the utility companies received a significant share of the initial allocation – solely the German installations of RWE, E.on, EnBW and Vattenfall received about 18% of the entire European allocation respectively about 80% of the German allocation[1] – their weight allows them to affect the allowance price. In 2005, Germany's Federal Minister for the Environment, Jürgen Trittin, required disclosure of RWE's emission trading strategy from RWE's CEO Roels in order to see whether the company had taken action to drive up the allowance price. In parallel, the German Federal Cartel Office started investigations on whether the utility companies have colluded to affect the certificate price (Gammelin and Hecking, 2005).

The three fundamentals, "volume of allowances", "utilisation of allowances", and "market structure", have been discussed above. The influence of "irrationality" remains to be discussed. In August 2005, Novoszad and Winzer (2005a) described a phenomenon which has no rational justification:

> *"The third key [besides gas and oil prices] to EUA prices are power prices. Even [meant: although] EUA prices should influence power prices, it is often the other way round as energy traders primarily trade power and pick up EUAs on the side. The most observed price is German baseload power with delivery in 2006 (Cal 06). The chart shows the similar development of Cal 06 and EUA prices even though fluctuations in prices are much less intense with power than with EUAs."*

Both (Novoszad and Winzer, 2005b) conceded that obviously the participants have accepted the power price as indicator for the fluctuation of the allowance price. This assessment was shared by the author of Carbon Finance of July 22nd 2005 (Anon., 2005a) which cited traders that weaker German power prices may have contributed to the initial fall in the allowance price on July 20th. This triggered a snowball effect. An overall assessment of the numerous drivers of the allowance price was given in the second August 2005 edition of Argus Power Europe (Anon., 2005b):

> *"The key drivers of EU ETS allowance price so far have turned out to be a complex mix of factors which reflect the wide spectrum of market participants. Coal, gas, and crude oil markets are now tied – only loosely in the case of crude oil – to the emissions markets. This means that each market influences the EU ETS, just as analysts predicted, with the European power market most closely tied to price movements."*

While power prices were obviously important drivers for EUA prices in 2005 and early 2006, the relevance of the drivers has changed again meanwhile. In April 2006, the imbalance of supply and demand of EUAs prevailed, since autumn 2006 power prices have become entirely irrelevant for the 2007 EUAs but are still relevant for the 2008 EUAs. On February 23rd 2007, Novoszad and Winzer conclude (Novoszad and Winzer, 2007, translated):

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[1] According to Gammelin and Hecking (2005) they received 1,200 Mt for three years (about 400 Mt per year) of an overall European allocation of 2,200 Mt per year, respectively 500 Mt per year in Germany.

"Whereas prices of period I allowances result from existing overallocation, period II allowances fall despite the common assessment that companies will receive less allowances in the second trade period than required. This development is caused by decreasing electricity prices, on the one hand, and continuing insecurity regarding the period II national allocation plans, on the other hand. Although, with a good 12 EUR period II allowances should have found their bottom out."

Actual developments on the European CO_2 markets during the first two years have been outlined in the previous sections of this chapter. Subsequent lines are devoted to price forecasts for CO_2 allowances. These forecasts can be based on modelling or on business games reflecting the CO_2 market. Naturally, the reliability of the results of models and business games strongly depends on how well the model or game reflects real market conditions. As business games tend to limit the complexity of the rules in order to ease participation for companies while models can more easily reflect real-life problems, the reliability of models should be somewhat higher. Tab. 3 lists results from models and business games for the first and second phase of the EU ETS. Prices used for modelling of effects of emission trading on the manufacturing costs of pulp and paper are outlined and discussed in chapter 4.2.2.3.

EUR/t CO_2		**Phase I: 2005-2007**			**Phase II: 2008-2012**		
Institution/study	**Date**	**Low**	**Central**	**High**	**Low**	**Central**	**High**
Hessen Tender[1]	2002		6.58				
ICF (2003)	2003	2	5	10	4	10	20
PointCarbon[2]	2003	1.5	5	40	2	7	45
Dresdner Kleinwort Wasserstein (2003)	2003		15			25	
JPMorgan (2003)	2003		6			28	
ILEX (2003)	2003	5-7		15-18	5-7		19-25
Oxera (2004)	2004	5	10	15	5	10	25
Enviros (2007)	2004	6		20	10		25
ECON (2004)	2004	1	5	8	5	8	15
ECCP reference[3]	2004		20			20	
McKinsey[4]	2005		20			20	
Dresdner Kleinwort[5]	2007					19.50	

[1] According to Steinbrecher and Häfner (2003)
[2] According to Sijm et al. (2005)
[3] According to Quirion and Hourcade (2004)
[4] According to Grobbel (2005)
[5] According to Patel and Schumacher (2007)

Tab. 3: Projections and expectations of CO_2 prices

2.1.3 The pulp and paper industry – exposed to emission trading

2.1.3.1 The European pulp and paper industry – at a glance

The subsequent chapter aims to provide an overview of the European pulp and paper industry as far as is necessary to understand why certain processes have been selected for the investigation and what the findings mean for the competitiveness of the industry. Thus, the figures and notes will not draw an exhaustive picture of the European pulp and paper industry. A much more detailed description can be found in the annual publications of the Confederation of European Paper Industries such as e.g., the Annual Statistics (CEPI, 2006b).

Initially, it is important to differentiate the processes, respectively grades of pulp and paper manufacturing. While the term "process" refers to the technical way of producing a good, the term "grade" differentiates goods which may be produced in the same or in different processes. Looking at processes first, the variability in pulp manufacturing is by far wider than in paper manufacturing. It is so wide that it would be reasonable to group different processes again into process categories (e.g., grouping of sulphate pulping, sulphite pulping, and non-wood pulping to chemical pulping). In paper manufacturing, in turn, the differences in the technical ways of producing a good are not that huge. Whether a paper is coated or not, whether it is dried in a conventional drier or using a yankee-cylinder, the basic manufacturing of paper remains quite similar. A simplified illustration of the process steps of the four pulping processes (or process categories according to the above definition) and of paper manufacturing can be found in Fig. 18.

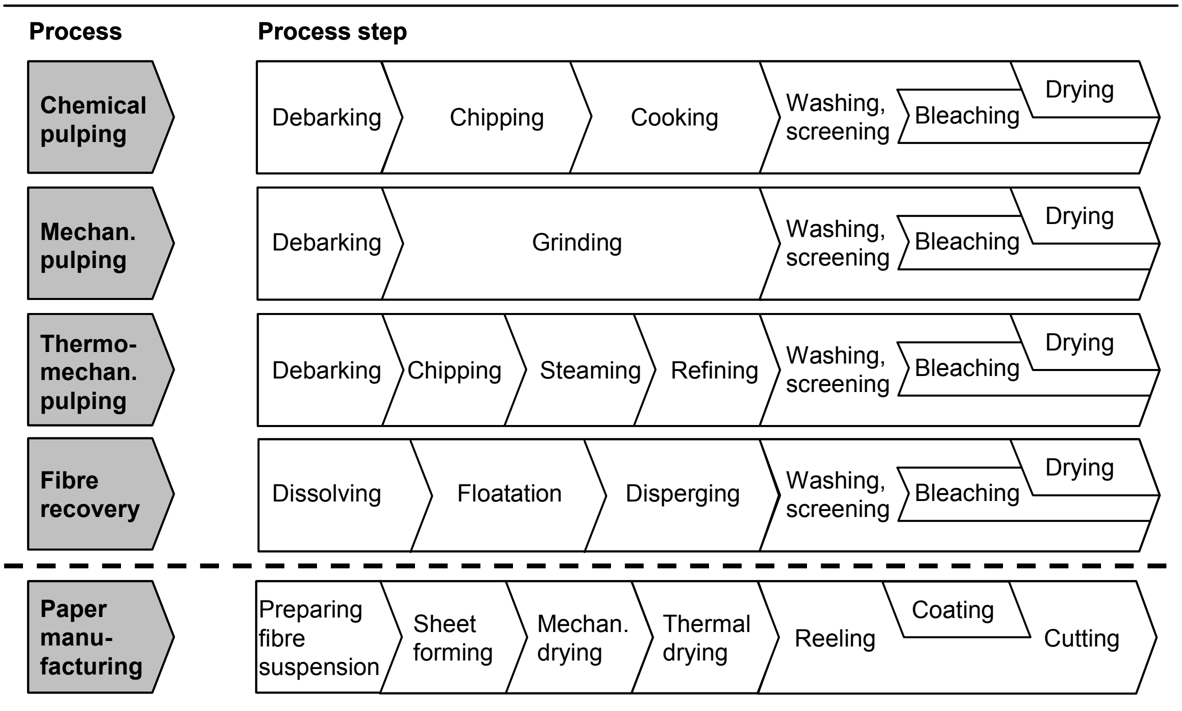

Fig. 18: Process and process steps of pulp and paper manufacturing (simplified)

Whereas the number of different processes varies significantly between pulp and paper manufacturing, the number of grades produced is comparable: it's virtually uncountable in both cases. Numerous systematics exist in parallel. Even within one publication different systematics in different tables can be used. As the harmonisation of systematics is not within the scope of this investigation, no effort will be devoted to this deficiency. In order to apply one consistent differentiation for the entire investigation, the systematics used in the CEPI Annual Statistics have been selected. Although it refers to process categories (looking at pulp), respectively grade categories (looking at paper), according to the aforementioned definitions, the term "processes" will subsequently be used for simplification.

The distribution of the European pulp production by process can be found in Fig. 19. Primary pulping (chemical, mechanical and thermo-mechanical pulping) and secondary pulping (i.e., fibre recovery from recovered paper) each account for half of the European pulp production.

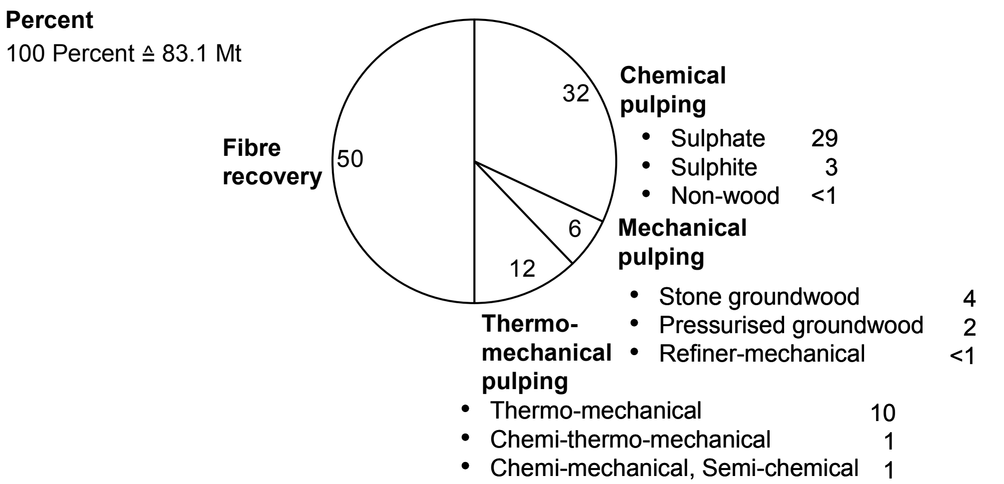

Fig. 19: Share of pulp production by process[1]

An overview of the relative weights of the paper manufacturing processes (grade categories) is provided in Fig. 20.

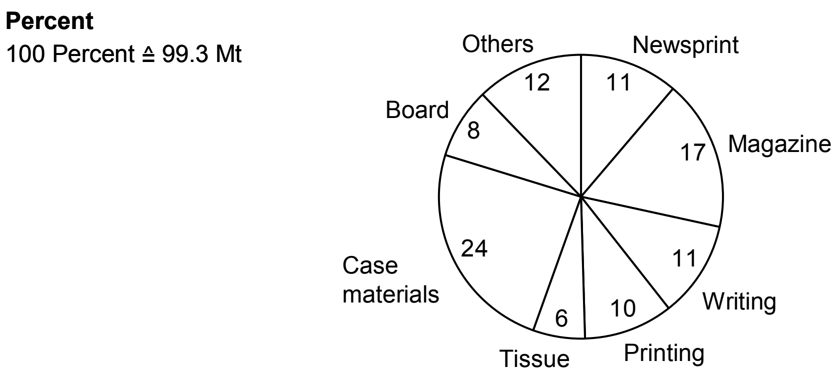

Fig. 20: Share of paper production by process[2]

The previous paragraphs have differentiated the pulp and paper manufacturing processes and grades with their respective weights; the following paragraphs will focus on total volumes. As Fig. 21 displays, the total paper and board production in CEPI countries has increased with

[1] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries 2005. Fibre recovery is calculated based on the utilisation of recovered paper and conversion factor (Hyvärinen, 2005). CEPI countries are EU15 countries without Greece and Luxembourg plus Norway, Switzerland, the Czech Republic, Hungary, Poland, and the Slovak Republic.

[2] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries 2005 reallocated to different grade systematics. Fibre recovery calculated based on utilisation of recovered paper and conversion factor (Hyvärinen, 2005).

moderate growth rates during the last years to about 100 million tons per year. Primary and secondary pulp production both range at about 41 million tons per year. The operating rates of the equipment have increased in small steps during the past decade but recently dropped again slightly to 88.0% for primary pulp, respectively 90.4% for paper.

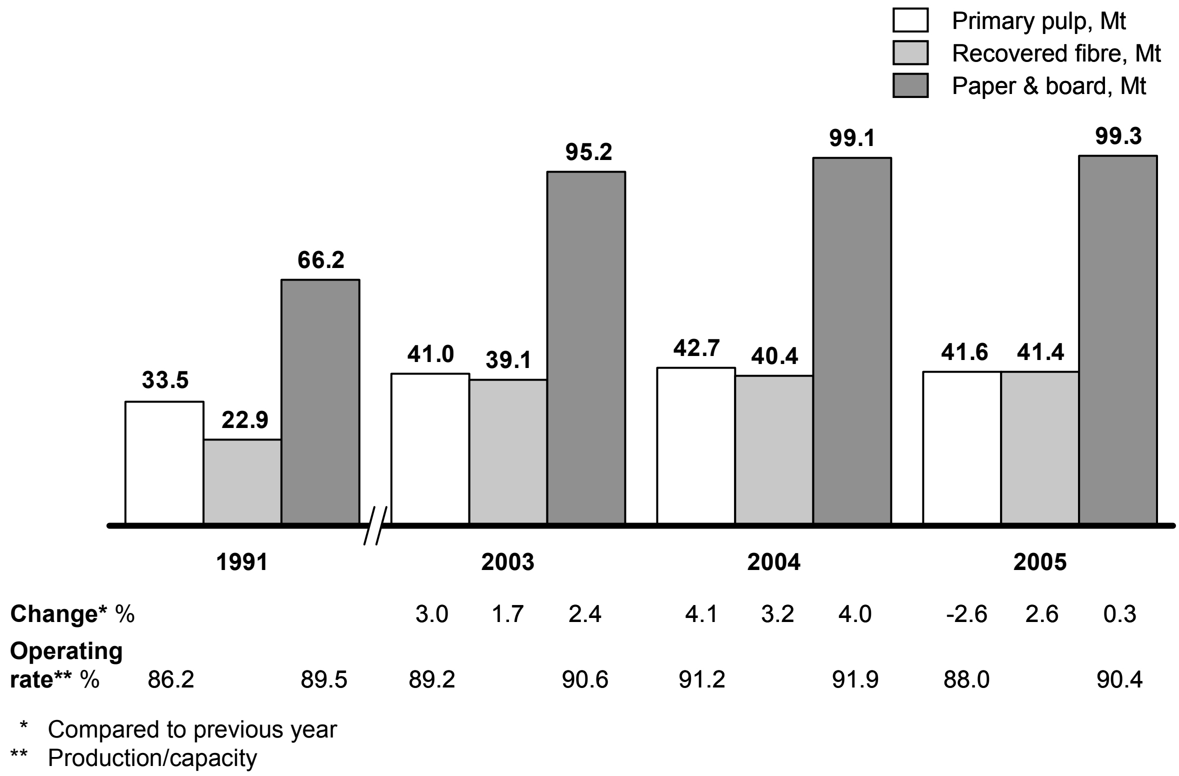

Fig. 21: Production and operating rates of pulp and paper mills in CEPI countries[1]

The distribution of the production capacities within Europe (see Fig. 22) reveals a clear ranking in all categories. Sweden and Finland dominate in the production capacity of chemical pulp. With more than eight million tons, each of them holds about a third of the Western European production capacity. The picture is similar in thermo-mechanical pulping, while Scandinavia's position in mechanical pulping is weaker. Germany and Italy follow Finland, Sweden is ranked 4. Referring to fibre recovery, the terms collection and utilisation of recovered paper, capacity, and actual fibre recovery need to be differentiated. In all of these categories, Scandinavia is of almost no relevance compared to the total CEPI volumes. Germany accounts for 28% of the utilisation, France, Italy, the UK, and Spain each have shares of between 10 and 13%, and all other countries constitute less than 5% each. In paper and board capacities, Germany again is in first rank of the Western European capacities with more than 21 million tons per year, followed by Finland with 15, Sweden with 12, and France with eleven million tons per year.

[1] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries. Fibre recovery calculated based on utilisation of recovered paper and conversion factor (Hyvärinen, 2005).

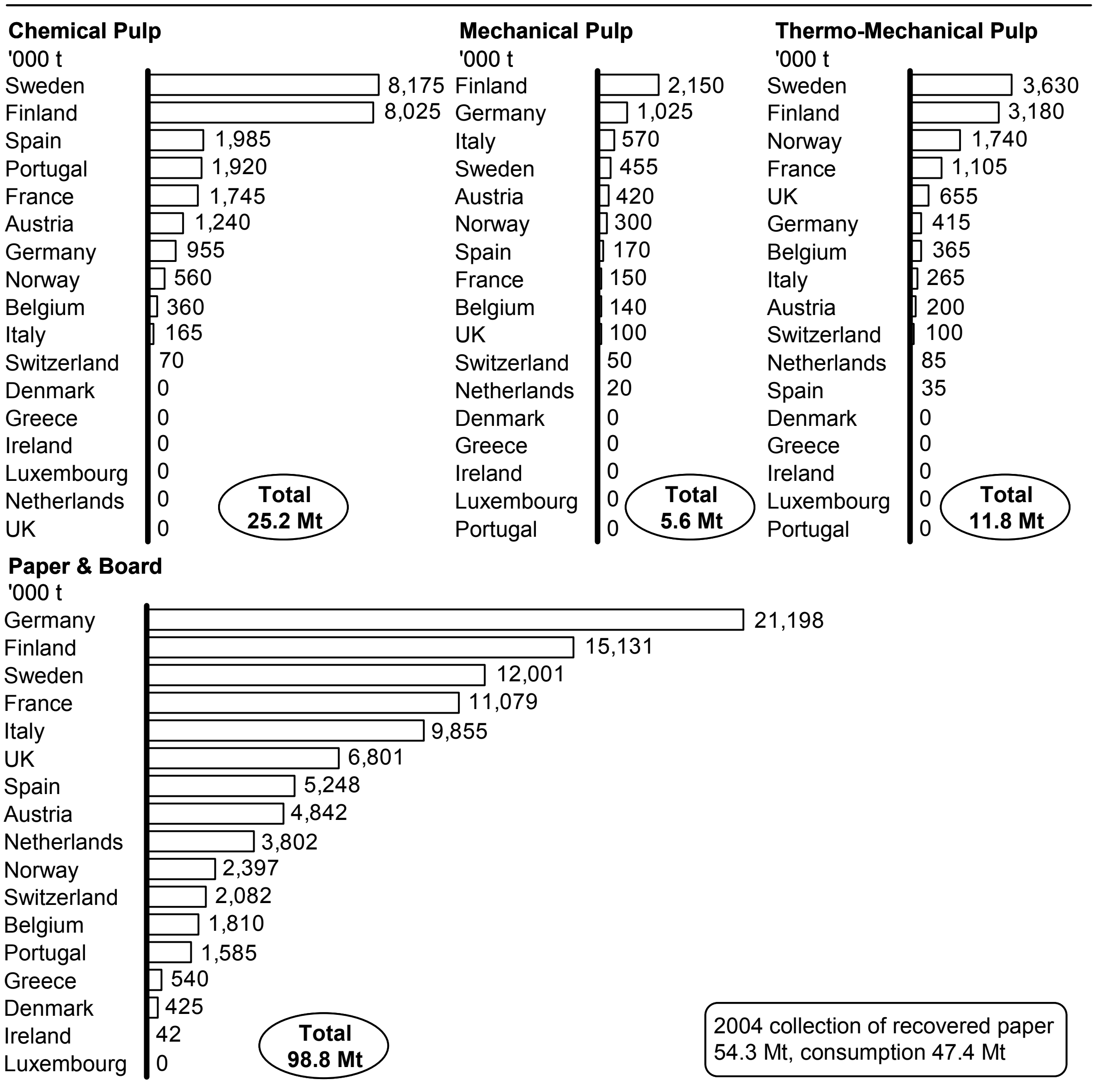

Fig. 22: Production capacity by process and country[1]

The importance of foreign trade with countries outside CEPI differs between pulp and paper. As the trade balance of primary pulp shows (see Fig. 23), about eight million tons of pulp are imported to CEPI countries. This would correspond to rank 3 in the production volume ranking of CEPI countries. The main supply comes from North and South America. Export is less than a fourth of the import volume and goes primarily to Asia.

[1] Capacity data according to NLK Database of Pulp & Paper Capacity Changes (NLK Associates, 2003) for December 2003. EU15 countries plus Norway and Switzerland are included. Chemical pulp comprises the NLK-categories "sulphate pulp", "sulphite pulp" and "non-wood-pulp", mechanical pulp comprises "stone groundwood" (SGW), "pressurized groundwood" (PGW) and "refiner mechanical pulp" (RMP), thermo-mechanical pulp comprises "thermo-mechanical pulp" (TMP), "chemi- thermo-mechanical pulp" (CTMP), "chemi-mechanical pulp" (CMP) and "semi-chemical pulp" (SCP). Data on paper recovery according to CEPI Annual Statistics 2004 (CEPI, 2005) for CEPI countries in 2004.

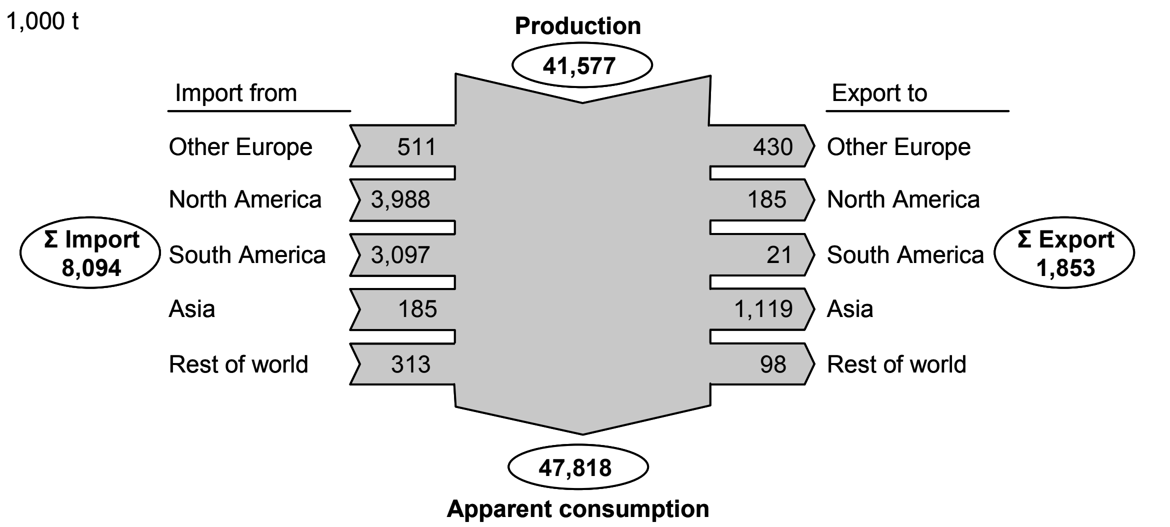

Fig. 23: CEPI's trade balance of primary pulp[1]

The import of recovered paper can be neglected, while a significant export volume of almost seven million tons shipped to Asia equals 13% of the collection volume in CEPI countries. For details, see Fig. 24.

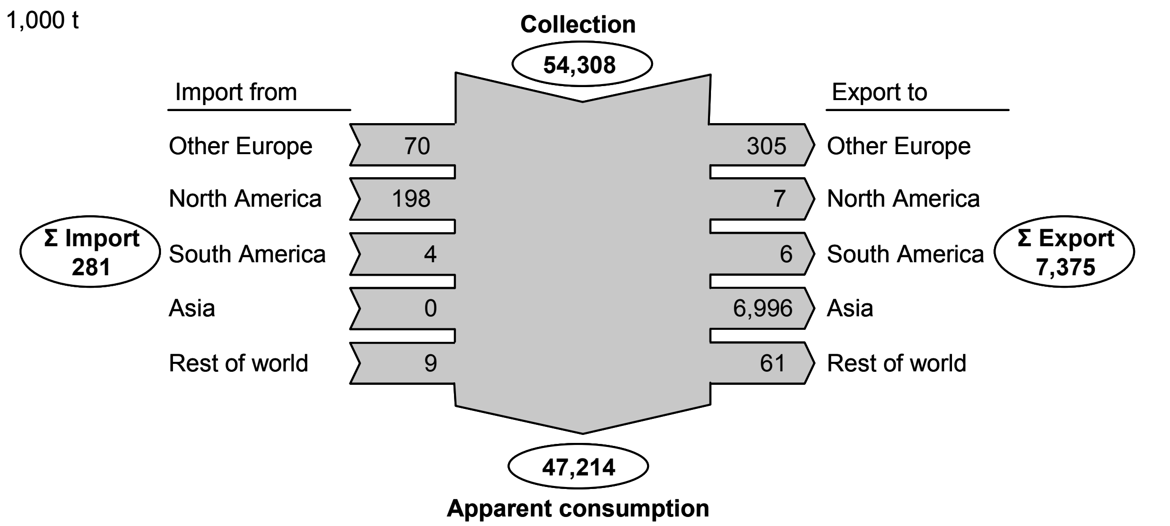

Fig. 24: CEPI's trade balance of recovered paper[2]

The trade in paper and board shows a similar picture. About four million tons of paper and board (corresponding to 5% of consumption in CEPI countries) are imported – primarily originating from North America and Eastern Europe. An export volume of nearly 15 million tons (15% of production) is primarily shipped to Asia (five million tons), Eastern Europe (four million tons), and North America (3 million tons).

[1] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries in 2005.
[2] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries in 2005.

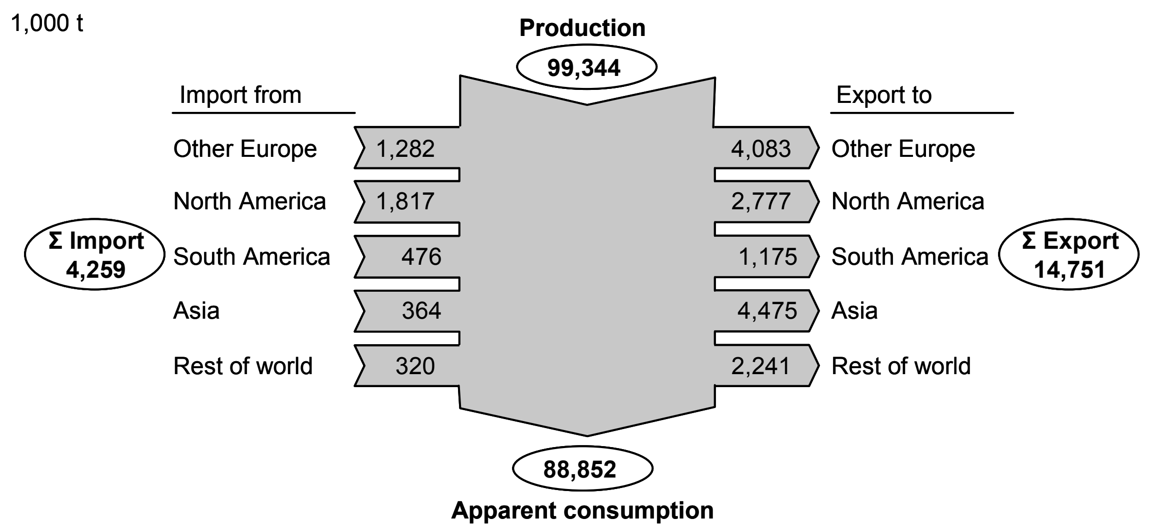

Fig. 25: CEPI's trade balance of paper & board[1]

A detailed assessment of the impact of emission trading requires the calculation of the relative effect on manufacturing costs, respectively on current market prices. The development of market prices of primary pulp grades is displayed in Fig. 26.

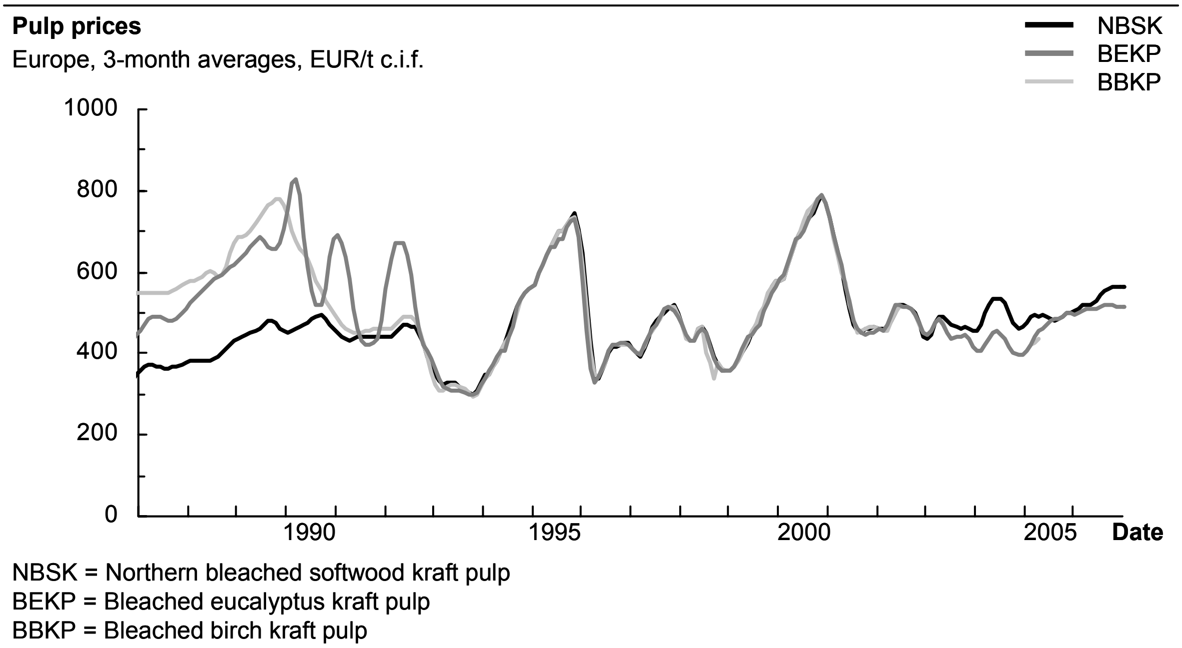

Fig. 26: Price development of major pulp grades[2]

The development in pulp prices reveals a significant cyclicality. Since 1985, the market prices for the major pulp grades have swung in a five-year cycle with sizable amplitude. There were

[1] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) for CEPI countries in 2005.
[2] Nominal prices according to RISI's Global Price History Database (RISI, 2007).

peaks in 84/85, 90, 95/96, and 00/01. However, the peak which could have been expected for 05/06 is hardly observable. Prices have increased since late 2004 but growth rates have only been moderate. As Fig. 26 shows, the price levels of softwood and hardwood kraft pulp (NBSK and BBKP) moved from about 400 EUR/t in 1998 to 900 EUR/t in 2000 and dropped again to 500 EUR/t which is in the order of magnitude of the long-term average of nominal prices. Furthermore, Fig. 26 reveals a very good correlation between the pulp grades displayed since early 1990. Good correlations can be found also for the development of prices in Europe and North America. Although a good correlation is neither a final proof for a linkage between the European and the North American pulp market nor for the existence of a competitive pricing mode, it is a valuable indicator for both assumptions.

The prices on the Western European paper market – major grades can be observed in Fig. 27 – demonstrate a less clear picture than the pulp prices.

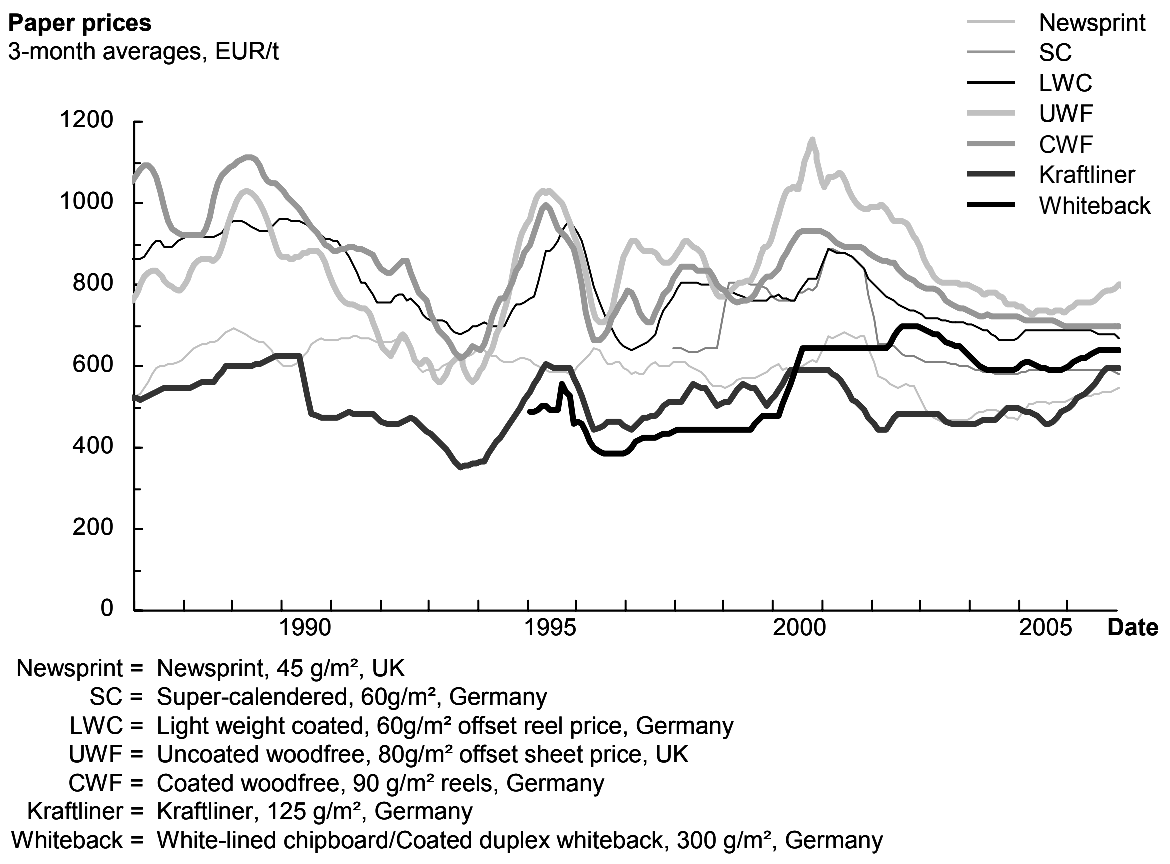

Fig. 27: Price development of major paper grades[1]

A certain cyclicality – parallel to the one noted at pulp – can be found at UWF (uncoated woodfree), CWF (coated woodfree), LWC (lightweight coated) and Kraftliner. The other grades do not seem to follow a certain pattern very strictly. This divergence in cyclicality

[1] Nominal prices according to RISI's Global Price History Database (RISI, 2007).

sometimes causes instances in which integrated pulp and paper producers sell their pulp to the market, while reducing the capacity utilisation of paper manufacturing. While the price relation between UWF, LWC, Newsprint, and Kraftliner has been fairly stable during the last decade, Whiteback (a board grade) has gained relatively to other grades.

The question, to which degree the pulp and paper industry can absorb potential increases in manufacturing costs originating from the introduction of emission trading, requires an examination of its profitability. Key indicators of the top 5 European pulp and paper manufacturers (ranked by capacity) are shown in Fig. 28.

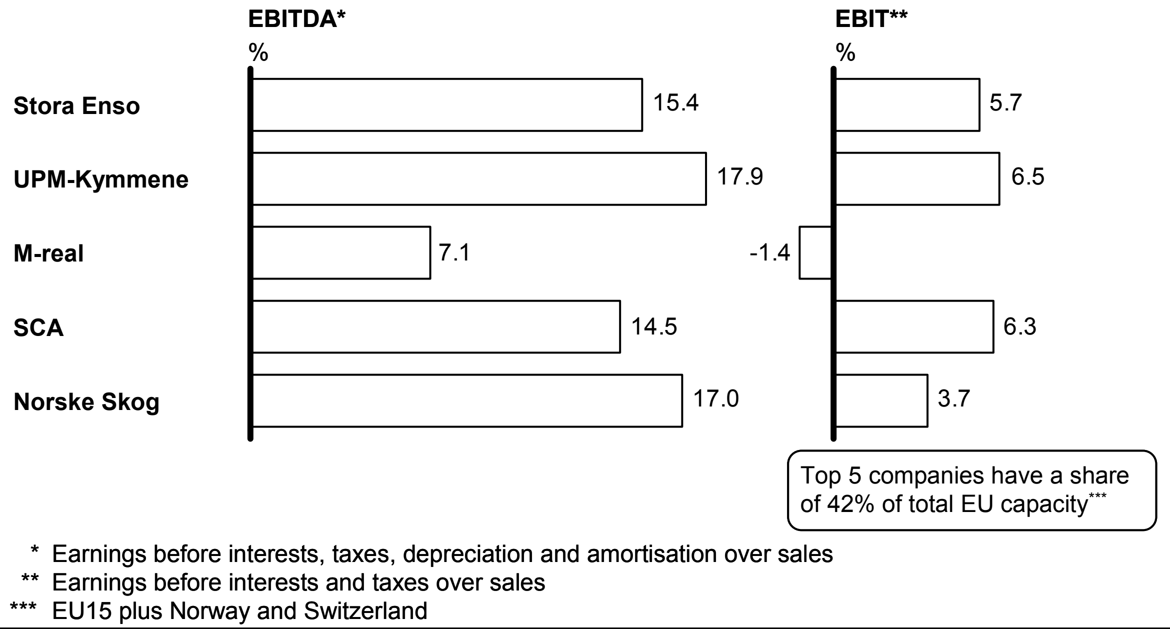

Fig. 28: Key financial indicators of top five European pulp and paper companies 2004[1]

In 2004, these five companies had EBITDA margins (earnings before interests, taxes, depreciation, and amortisation over sales) of between 7.1% and 17.9%. After deduction of depreciation, EBIT margins (earnings before interests and taxes over sales) of between -1.4% and 6.5% remained. The latter margin is the key indicator for long-term profitability. Any potential increase in manufacturing costs needs to be offset against EBIT. The five above-mentioned companies have a joint share of 42% of the pulp and paper manufacturing capacity in Western Europe. Their profitability can be regarded as representative for the majority of the next 45 companies in the European manufacturer ranking. Looking at the development of the indicators over time, a slight cyclicality can be observed, as noted above looking at pulp and paper prices. Profitability peaks occurred in 1989, 1995, and 2000. A downward trend in 2001, and especially in 2002, was followed by a consolidation starting in 2003 and continuing

[1] All indicators exclude non-recurring items. Data from annual reports 2004 (Stora Enso, 2005), (UPM, 2005), (m-real, 2005), (SCA, 2005), (Norske Skog, 2005), and NLK Database of Pulp & Paper Capacity Changes (NLK Associates, 2003).

in 2004. Thus, looking at the development of profitability over two decades, 2004 was close to, at most slightly (1.5 percentage points), below average.

At this point, any more detailed description of the European pulp and paper industry than given in the section above would take an unjustified share of this thesis. Besides the annual publications of the Confederation of European Paper Industries, which have been mentioned above, the relevant journals provide an up-to-date picture of current market developments in Europe.

2.1.3.2 Energy and emission – exposure to direct and indirect effects

As outlined in chapter 2.1.1.2 the gross financial effect of emission trading has a direct and an indirect component. A detailed breakdown of the exposure of the pulp and paper industry can be found in Fig. 29. All drivers are discussed in more detail in the following sections of this chapter.

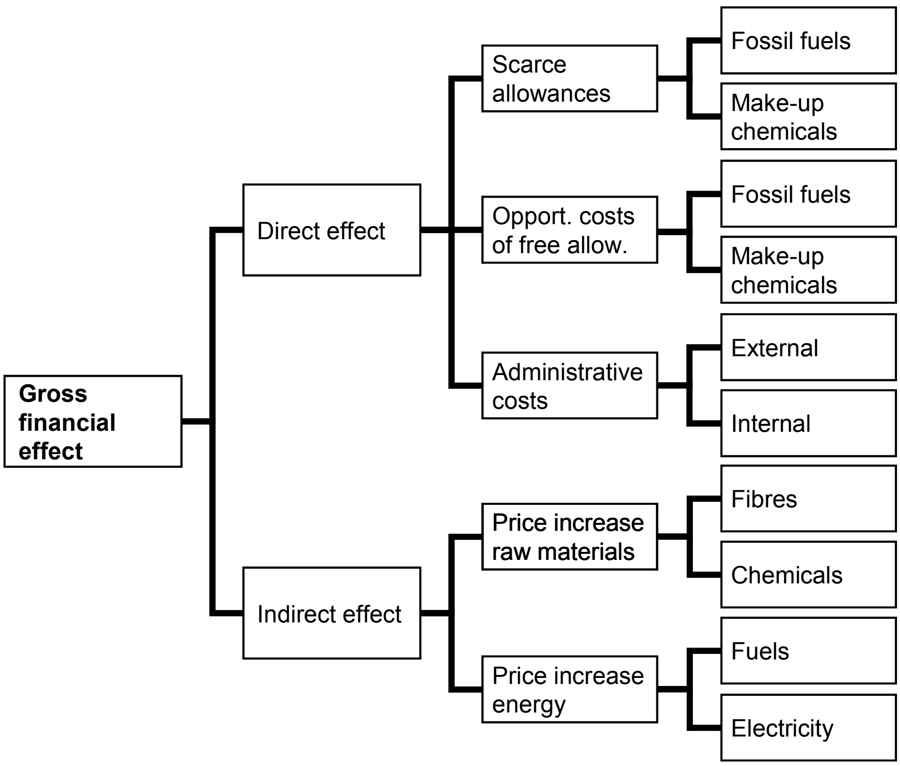

Fig. 29: Exposure of the pulp and paper industry to effects of emission trading

The direct as well as indirect effects of emission trading on pulp and paper manufacturing costs heavily depend on the energy intensity of the respective process. The specific consumption of thermal and electrical energy in pulp and paper manufacturing is illustrated in Fig. 30. Chemical pulping – especially if the manufacturing of market pulp requires drying of the pulp – and paper manufacturing have a significant consumption of thermal energy. In contrast the heat consumption of fibre recovery is very limited – in some cases actually zero. The heat balance of mechanical and thermo-mechanical pulping is even positive. Both processes require a remarkable amount of electrical energy for the defibration of the wood (chips) and transform it into thermal energy, 20-60% of which is recoverable in the form of steam or hot water.

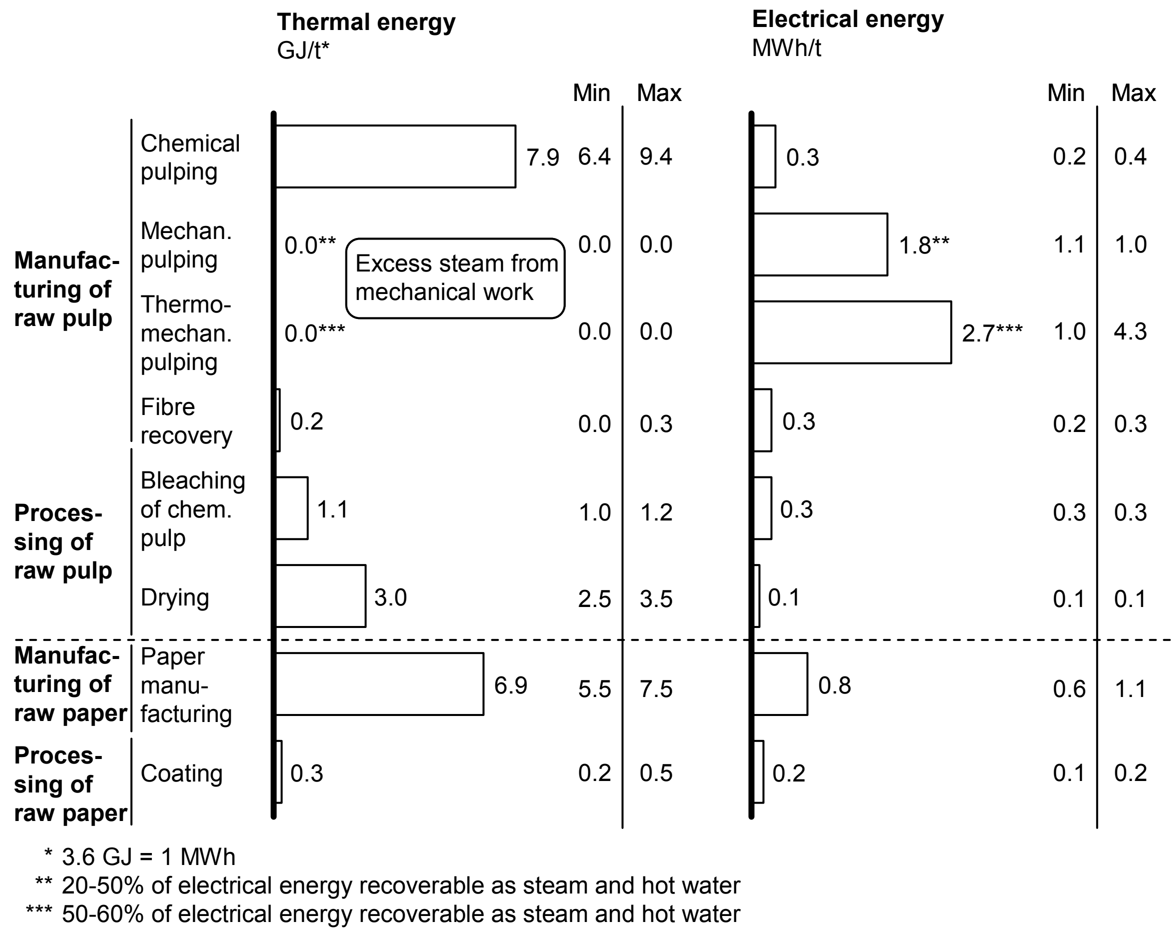

Fig. 30: Energy intensity of pulp and paper manufacturing processes[1]

Overall more than 85% of the thermal energy is consumed in the form of process steam. Most mills – especially the integrated mills with a more complex energy configuration – operate two grids of process steam: one of about 10 bar and a second one of about 3 bar steam pressure. Only a few mills get by with one pressure level. The remaining less than 15% (Teir et al., 2004) of thermal energy is consumed as direct heat (hot air) e.g., in the lime kiln of sulphate pulp mills (on average 1.9 GJ/t of sulphate pulp according to (STFI, 2000)) or in the drying hoods of paper mills.

[1] Data from EU Reference Document on Best Available Techniques in the Pulp and Paper Industry (Commission of the European Communities, 2001)

Looking at the supply of primary energy, fossil fuels and biomass are almost balanced. 50.8% of heat originates from fossil fuels, 49.2% from biomass. As Fig. 31 shows, natural gas, fuel oil, and coal are the three major fossil fuels used in pulp and paper manufacturing. Among them natural gas, the fossil fuel with the lowest emission factor (tons of CO_2 emission per GJ net calorific value), has a share of about three fourths, while the more CO_2-intensive fuel oil (heavy fuel oil (HFO) and light fuel oil (LFO)) and coal account for less than one fourth.

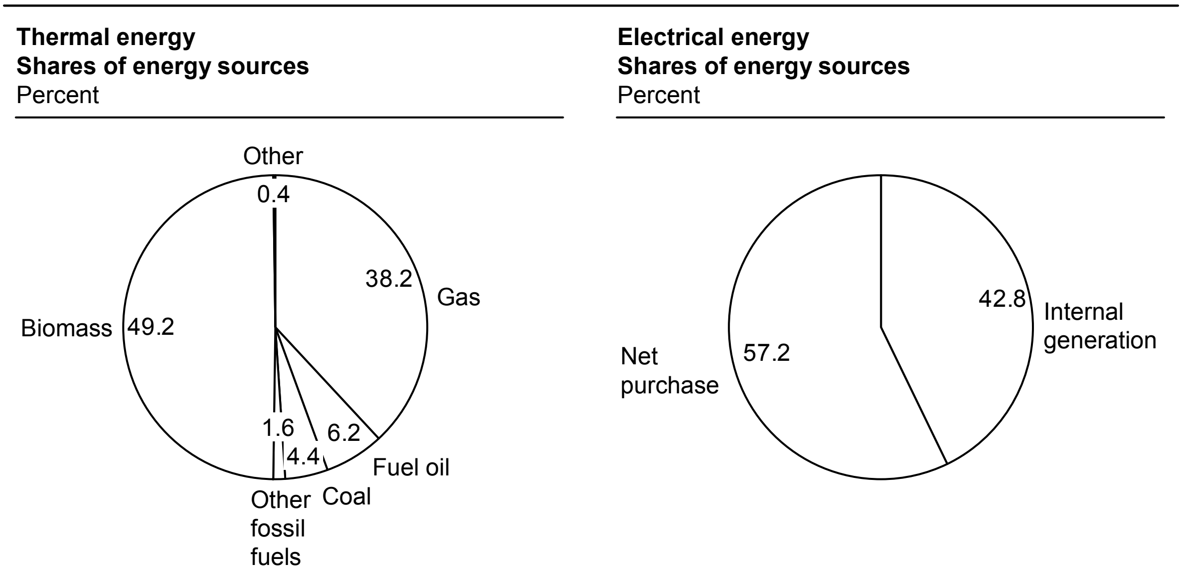

Fig. 31: Sources of thermal energy and electricity in the European pulp and paper industry[1]

In addition to these fossil fuels used as sources of thermal energy, make-up chemicals may cause additional CO_2 emissions and, thereby, direct costs of emission trading. The chemical recovery system of sulphate pulping comprises a sodium loop and a calcium loop, both closely linked to each other. To make up for sodium losses, typically some fresh sodium carbonate (Na_2CO_3) is added in the sodium loop. With one intermediate step, the CO_2 is transferred to the calcium loop and gets freed in the lime kiln. Although this emission is minor compared to the emission from combustion of fossil fuels used for heat generation, this fossil CO_2 originating from sodium carbonate is subject to the European emission trading scheme. In contrast with this additional "input", CO_2 can also be bound in a pulp or paper mill. If mills manufacture precipitated calcium carbonate (PCC, $CaCO_3$) from lime kiln stack gases, fossil CO_2 is fixed again and accordingly not counted as emission.

With emissions from fossil fuels and make-up chemicals, the drivers for the direct effects of scarce emission allowances and the opportunity costs of allowances received for free have been elucidated (see tree in Fig. 29). The administrative costs of emission trading are not

[1] Data according to CEPI Annual Statistics 2005 (CEPI, 2006b) referring to 2004. More detailed breakdowns can be found for individual countries, e.g., for Germany in the annual report of the Verband Deutscher Papierfabriken (VDP, 2005).

specific to pulp and paper manufacturing. The theoretical considerations in chapter 2.1.1.2 provide sufficient background. Thus, the next section covers the drivers of indirect costs. Here, the pulp and paper industry is exposed to price increases in raw materials and energy caused by emission trading. To assess the impact of price increases in fibre (wood, recovered paper, and pulp), chemicals, fuels and electricity, the cost structures of typical pulp and paper grades need to be understood. All other cost elements such as personnel, maintenance, depreciation and overhead are of no relevance when looking at the effects of emission trading. For pulp manufacturing, the grades TMP (thermo-mechanical pulp) and NBSK (northern bleached softwood kraft pulp) have been selected and are displayed in Fig. 32.

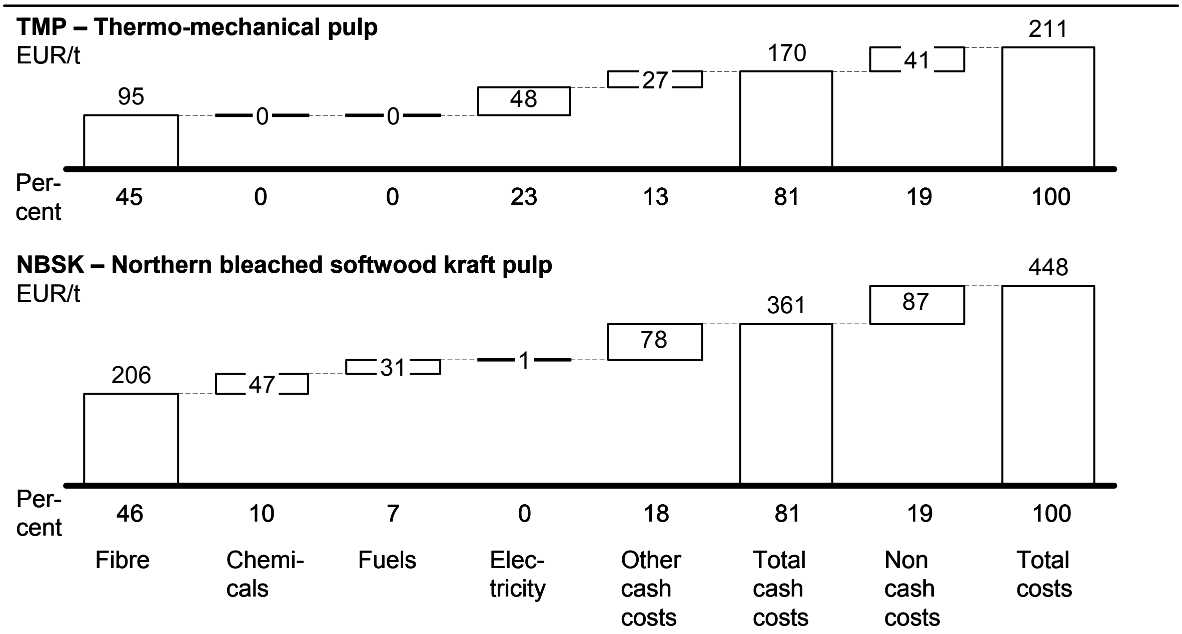

Fig. 32: Cost structures of major pulp grades (examples)[1]

While both grades, as typical representatives of mechanical respectively chemical pulp, have a 45% share of fibre costs on total costs in common, the shares of chemicals, fuels and electricity diverge fundamentally. TMP has basically no costs for chemicals and fuels but about 23% share of electricity costs, NBSK has significant costs for chemicals and fuels but no or even slightly negative costs for electricity. A TMP mill needs to purchase all electricity from the grid while a kraft pulp mill typically generates high pressure steam in the recovery boiler from burning black liquor (costs accounted here to fibre costs) and relaxes the steam with a back-pressure turbine down to conditions of process steam. In a state-of-the-art mill, the entire steam and electricity consumption is covered in this way. This explains the 40% share of internal electricity generation displayed in Fig. 31. Some steam and electricity can

[1] Cash cost data NBSK according to Paperloop's Cornerstone benchmarking (Paperloop, 2005). Cash cost data TMP according to Persson (2005). Add-on for non-cash cost comprising depreciation (10.2%), corporate (5%), and EBIT (4.2%), based on the average of the top 5 European pulp and paper companies (Stora Enso, 2005), (UPM, 2005), (m-real, 2005), (SCA, 2005), (Norske Skog, 2005).

even be sold (thus, potentially negative electricity costs).[1] Usually only a limited volume of external fuels is consumed (lime kiln).

The cost structures of paper grades differ less than those of pulp grades. Fig. 33 displays the cost breakdowns of newsprint and coated woodfree paper as examples. The costs of fibre (pulp) are the most significant of the four input factors with an indirect effect of emission trading. In both cases, chemicals, fuels, and electricity have shares between 2 and 18%. In the case of stand-alone paper mills, the steam is typically generated internally by combustion of different kinds of fossil fuels (e.g., natural gas, coal, oil), while the electricity is purchased from the grid. Cogeneration is rather an exception for a non-integrated paper mill.

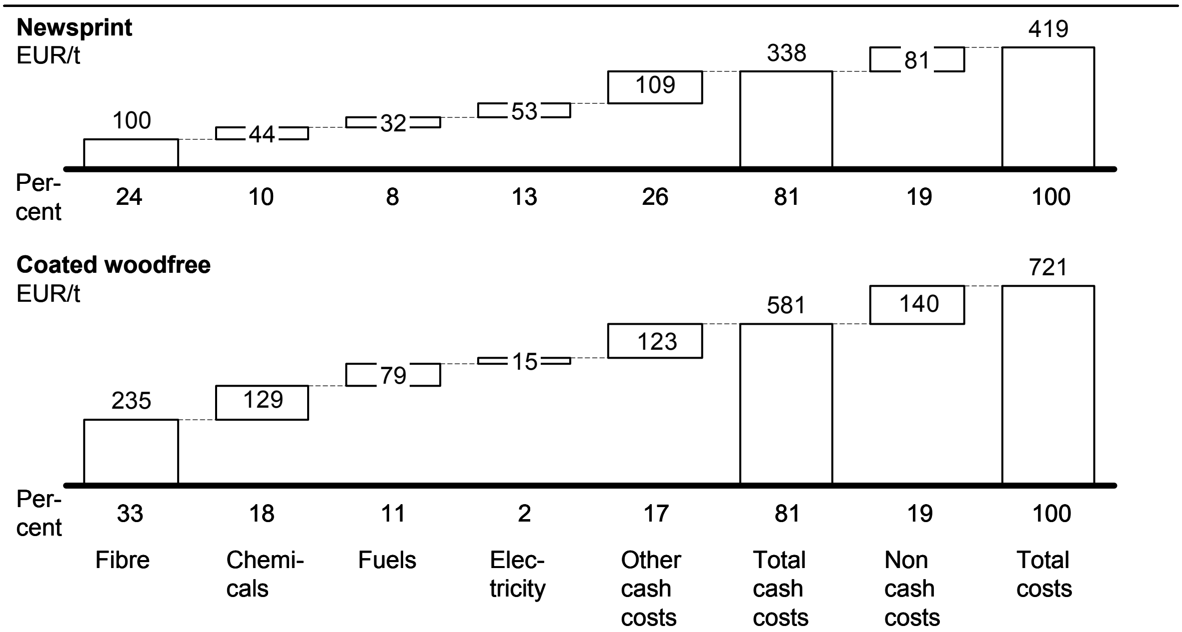

Fig. 33: Cost structures of major paper grades (examples)[2]

With the cost structures, the "lengths of the levers" for the effects of price changes in raw materials and energy have been introduced in the previous section of this chapter. In the following section, the price development i.e., the "amplitude of the levers" will be touched on.

The first lever of the indirect effect is the fibre price, i.e., the price of wood or recovered paper for manufacturing pulp respectively the price of pulp for manufacturing paper. Both prices may be affected by the introduction of emission trading. While this is obvious for the

[1] Very detailed calculations on the energy balances of sulphate pulp mills can be found in the "Final report KAM 1 Ecocyclic pulp mill" of several Scandinavian research institutions led by the STFI (2000).

[2] Cash cost data according to Paperloop's Cornerstone benchmarking (Paperloop, 2005). Add-on for non-cash cost comprising depreciation (10.2%), corporate (5%), and EBIT (4.2%), based on the average of the top 5 European pulp and paper companies (Stora Enso (2005), UPM-Kymmene (2005), m-real (2005), SCA (2005), Norske Skog (2005)).

pulp price (passing-on of the direct and indirect manufacturing cost increase originated by emission trading; according to chapter 2.1.1.2 to be classified as an indirect effect of the first order), the price increases in wood and potentially recovered paper, due to emission trading, require some explanation. They are indirect effects of the second order originating from the dual-nature of wood and recovered papers as raw materials and fuels. All fuels have different emission factors (tons of CO_2 emission per GJ net calorific value; zero in the case of bio-fuels). Thus, the same relative scarcity of emission allowances results in different direct costs of emission trading per energy content. Generating steam and electricity from coal is burdened with higher emission trading costs (emission allowances employed multiplied by allowance price) than generating from fuel oil, natural gas or especially bio-fuels. Hence, assuming substitutability of fuels, and an unchanged demand function for primary energy and regionally closed markets, the differences in the CO_2-burdens between all types of fossil fuels and bio-fuels should cause a price decline in fossil fuels and a price increase in bio-fuels. Theoretically, the prices of fossil fuels could even decline down to a level at which the sum of the new price plus costs caused by emission trading equal the former price level (whether this price decline is actually observable will be discussed a few paragraphs below). By contrast, the prices of bio-fuels may increase at the same time. Power plants formerly relying on fossil fuels may switch to bio-fuels such as wood. Besides the saved costs of replaced fossil fuels, the entire value of the emission allowances freed by this switch may be used to purchase these bio-fuels ("additional paying power"). This is irrespective of the share of allowances that have been received for free compared to the share of allowances that have been purchased. It is rather important for the price increase of wood whether it was a competitive fuel compared to fossil fuels already ahead of the introduction of emission trading or gained competitiveness primarily from the said introduction[1]. In the first case, the freed allowances entirely take effect on the wood price; in the second case, the allowances primarily provide competitiveness and only the excess allowances affect the wood price. A calculation published by the Finnish Forest Industries Federation illustrates the second case summarising (Finnish Forest Industries Federation, 2005, p. 1):

> *"The high price of emission allowances makes it uneconomical to use peat. If energy producers replace peat with emission-free bioenergy, they can sell the emission allowances they have received free-of-charge and use the income to secure wood for fuel use. The emission trading is increasing peat-burning power plants' ability to pay for timber. [...] At 20 €/tonne of CO_2, fibrewood starts to become fuel in Finland."*

Although the use of peat for electricity generation is specific for Finland and less relevant for other European countries, similar effects occur everywhere, where coal – almost as CO_2-

[1] Theoretically recovered paper should be affected in the same way as wood. However, two factors hinder the effect: (1) recovered paper is not entirely free of fossil CO_2 as fillers contain fossil calcium carbonate. (2) The substitutability is limited by a self-commitment of the European paper industry to achieve a certain recycling rate. Accordingly, material recycling prevails over thermal use.

burdened as peat – is replaced by wood[1]. Most lignite or hard coal-fired power plants allow co-burning of wood. Liquid and gaseous fossil fuels burned in other installations can be substituted rather in the mid and long term with the replacement of the existing power plants.

The development of German pulpwood prices within the seven-year period 2000-2006 is displayed in Fig. 34.

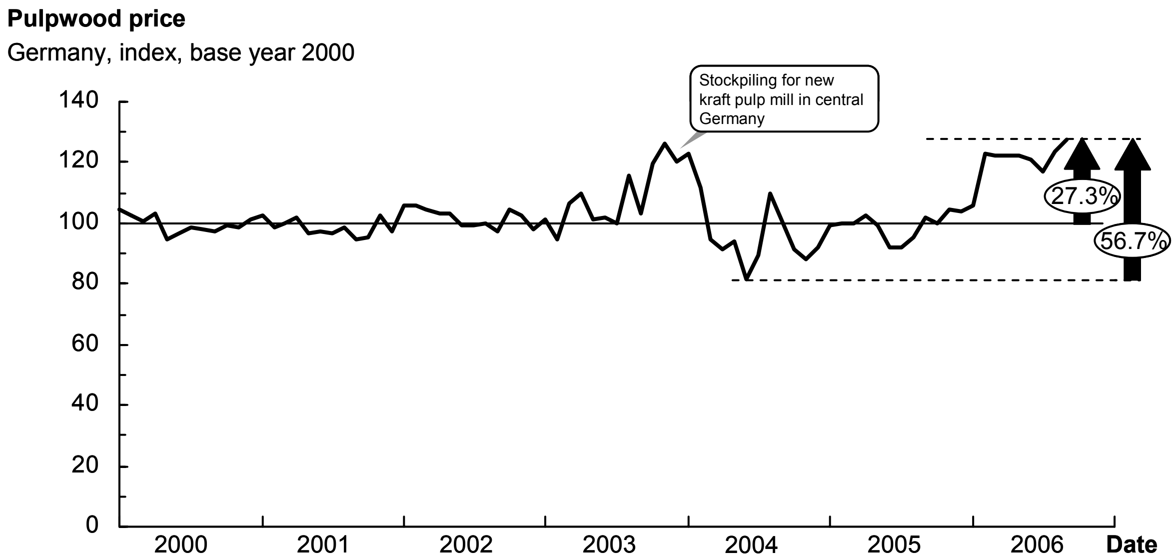

Fig. 34: Wood price development

After a relatively stable development of pulpwood prices in Germany between 2000 and mid 2003, prices reached a first peak in late 2003. One amongst several reasons for the peak was stockpiling by a major new kraft pulp mill in central Germany. At the time stockpiling was interrupted – though this is probably not the only reason – pulpwood prices levelled off and started to swing back to the former average price. However, the swing resulted in a continued price increase. Compared to the low mid 2004, German pulpwood price increased by 56.7% until autumn 2006. This is a level 27.3% above the 2000 average. Vorher (2007) reports even significantly higher price increases for certain segments. For late winter 2007, he quotes a German beech pulpwood price of about 48 EUR/m³, approximately 104% above the average of 1996-2005. Chips for chemical pulping have increased by even 158%, for TMP by 93%. Though, in spring 2007, the situation on the chip market levelled out somewhat. There is no doubt that numerous drivers influence pulpwood and chip prices. Some refer to physical use of wood, others to thermal use. Although most wood is still utilised as fibrous raw material

[1] The Czech Republic provides a valuable example: in 2003/2004, wood was a fully competitive fuel compared to coal – due to a misguided use of political instruments. Electricity generation from co-burning of wood in power plants was subsidised to the same amount as in pure biomass power plants (green bonus of 1,520 CZK/MWh (≈ 48 EUR/MWh)). As this was used intensively by the utility companies, wood prices boomed causing a shortage for the pulp and paper industry. In this case, the introduction of emission trading would have caused an additional wood price increase. However, in order to correct this misguidance, the green bonus for co-burning was reduced again (500 CZK/MWh (≈ 16 EUR/MWh)), which caused a wood price reduction.

for building products and pulp, its usability as fuel tends to gain share of the entire consumption. Here emission trading is one influencing factor, globally increasing prices of fossil fuels and RES promotion are others. Mantau (2006) calculated for Germany 2004 a share of 29.8% thermal use of available wood raw material. For 2005, he assumes even 37.5%, whereas 18.0% originate from industrial or municipal combustion installations and 19.5% from households. At least the 18.0% share of combustion installations should be influenced by emission trading according to the above-mentioned reasons.

The second lever for the indirect effect of emission trading is the price of chemicals used for pulp and paper manufacturing. Although chemical installations are not subject to emission trading via the industry-route (according to EU Directive 2003/87/EC only refineries are subject to emission trading), the chemical industry may be affected due to their energy installations and is affected by the electricity price increase. Thus, potential increases in chemicals prices can be classified as an indirect effect of second order.

The third lever for the indirect effect of emission trading is the price of fuels used for pulp and paper manufacturing. With regard to this lever, fossil fuels, internal bio-fuels – occurring as by-products in the processing of fibrous raw material – and external bio-fuels need to be differentiated.

As outlined above in the section on wood prices, theoretically the prices of fossil fuels should decrease to some degree with the introduction of emission trading. Assuming full substitutability of fuels, an unchanged demand function for primary energy, regionally closed markets, marginal replacement of fossil fuels by bio-fuels and competitive pricing for fossil fuels, the prices of fossil fuels should decline down to a level at which the sum of the new price plus costs caused by emission trading equal the former price level. In practice, however, it is hardly reasonable to assume the occurrence of this theoretical effect of second order (chapter 2.1.1.2). The assumptions of regionally closed markets and competitive pricing especially are not fulfilled. The prices for US Light Sweet Crude Oil and Australian Black Coal are not determined in the European Union. No special figures are required to demonstrate that the introduction of the European emission trading scheme in 2005 has not caused any decrease in prices for fossil primary energy. Thus, for all calculations made in this investigation, it is assumed that the prices of coal, oil, and gas are not affected by emission trading.

Another consideration is required referring to internal bio-fuels, such as e.g., bark, wood screening waste, black liquor or sludge. They occur as organic by-products in pulp and paper manufacturing, originating from the fibrous raw materials. As any change in the production ratio between the main product (e.g., pulp) and the by-product (e.g., black liquor) would cause changes in the main products properties and the value relation between the main product and the by-product strongly favours the main product, the occurrence of internal bio-fuels can be regarded as unchangeable. Typically, the internal bio-fuels are allocated zero out-of-pocket costs – fibre and additional processing costs are accounted to raw materials – but significant value due to their energy content. This value, in turn, which increased with the introduction of emission trading needs to be counted against the raw material costs. Thus, emission trading has no effect on the costs of internal bio-fuels. They are regarded as being and remaining zero.

This is different with external bio-fuels such as e.g., bark, sawdust, waste wood etc. These fuels gained value with the introduction of emission trading, according to the rationale outlined with the effect on raw material prices.

The fourth lever for the indirect effect of emission trading is the price of electricity. As foreseen ahead of the start of emission trading and observed since then, the electricity price is strongly affected by emission trading. The mechanics behind this have been introduced in chapter 2.1.2.4 looking at the development allowance prices. According to the definition in chapter 2.1.1.2 the electricity price increase causes an indirect effect of the first order. The associations of the energy intensive industries[1] expected this development already in spring 2004, when EU emission trading Directive 2003/87/EC was adopted but most national allocation plans are still unpublished. Gammelin and Hecking (2005) reported in the Financial Times Deutschland of August 19th 2005 about an internal RWE presentation which disclosed expectations of an additional profit of 300-350 million EUR caused by emission trading, based on 2005 allowance prices. Meanwhile, economists have calculated the so-called "windfall profits", i.e., the additional electricity costs German electricity consumers pay due to the introduction of emission trading, respectively the additional earnings of utility companies, to 5.7 billion EUR for 2005 and expected 10.6, respectively 10.3 billion EUR for the years 2007 and 2008 (Schlemmermeier and Schwintowski, 2006).

The actual development of the electricity prices in Central Europe and Scandinavia is shown in Fig. 35.

[1] See CEPI et al. (2004a), (2004b) and (2004c).

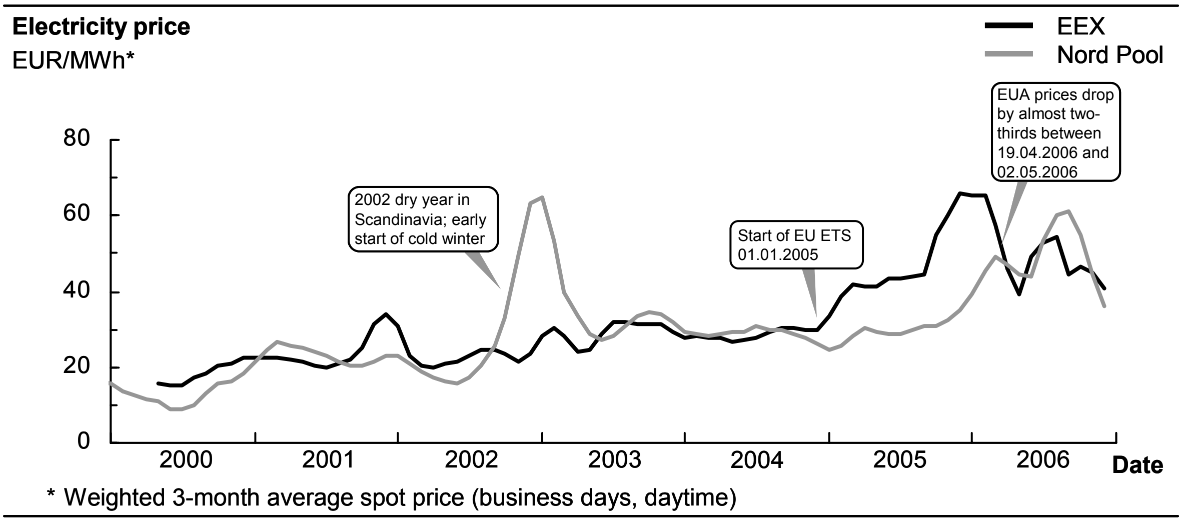

Fig. 35: Electricity price development[1]

On both markets, the electricity prices dropped with liberalisation in 1997-1999 (Sweden, Norway, Finland, Denmark), respectively 1998/99 (Germany). Since 2000, the prices have increased significantly, reaching and exceeding pre-liberalisation levels again. With about 50.87 EUR/MWh, the average EEX spot market electricity price 2006 was 176% higher than the respective average 2000. The 2006 average on the Nordic market, 48.58 EUR/MWh, was even 281% above the 2000 level. However, price increases between 2000 and 2006 are characterised by double-digit but yet somewhat moderate growth during the first few years and extraordinary price increases in 2005 and 2006. The EEX price grew on average by 11.5% between 2000 and 2004 and made a 61.3% jump in 2005 compared to 2004 and another 10.6% increase in 2006 compared to 2005. Disregarding a weather-induced peak in 2002/2003, the Scandinavian market developed similarly: double-digit but still a somewhat moderate increase between 2000 and even 2005 of 18.1% but a boost of 65.9% between 2005 and 2006. On both markets, price increases have several explanatory variables, e.g., market structures, global fuel price increases, and emission trading. Although the latter is surely not the only reason for price increases in 2005 and 2006, representatives of utility companies in 2005 primarily referred to emission trading reasoning for price increases[2]. The price decline in the Central European market is interesting following the two thirds price drop of emission allowances in April 2006. Here the graph in Fig. 35 even smoothes the real reaction to some degree, as it uses three-month average values. On the Scandinavian market, the effect was obviously much smaller. Though, this cannot be regarded as an indicator for the smaller influence of emission trading on electricity prices there.

Pulp and paper mills without internal electricity generation are fully exposed to this electricity price increase, unless hedging of the electricity price buffers the effect for a certain time. Mechanical or thermo-mechanical pulp mills especially are severely affected. In the TMP mill

[1] Data according to databases of EEX (2007a) and Nord Pool (2007)
[2] E.g., RWE's CEO Harry Roels in Platts Emissions Daily of August 12th 2005 (Anon., 2005c)

example in Fig. 32, electricity costs had a 23% share of total costs. A 70% electricity price increase means a 16% increase of total costs compared to an EBIT margin of 4.2%. In the long run, even a 20% electricity price increase would force the mill to stop operation if no other costs savings are realised or prices can be raised.

To summarise, the direct and indirect effects of emission trading on the European pulp and paper industry can be expected. Ahead of the actual investigation, all paper as well as chemical pulp mills seem to suffer most from the direct effect originating from scarce certificates for the combustion of fossil fuels, while mechanical and thermo-mechanical pulp mills tend to be most severely affected by a foreseeable increase in electricity prices.

2.2 Status of research – effects on the pulp and paper industry hardly investigated

The theoretical background of the political instrument of emission trading has been elucidated in detail in chapter 2.1.1.2. The most prominent mentors of emission trading are Coase (1960) and Dales (1968) in the 1960s. During the next three decades, nearly all economists looked at emission trading from the perspective of the national economy. Emission trading was one of the subjects in the dispute between Pigouvian-Interventionists and the Free-Market-Environmentalists.

Among the first one to look at emission trading focusing on the effects on a single industry sector were Brännlund et al. (1995) in the 1990s. As they had found out that the prevailing command-and-control environmental regulation systems affecting the Swedish pulp and paper industry are not cost-efficient, they started modelling the effect of regulation, respectively emission trading, on industry profits. Based on a model comprising biological oxygen demand (BOD), discharge of chlorinated compounds (AOX), and discharge of suspended solids (SS) for all Swedish pulp mills, they again proved the inefficiency of the existing regulation scheme. However, they were also not able to prove the efficiency of an (real, not only theoretical) emission trading scheme, as they realised problems originating from transaction costs, limited market liquidity, and – a special problem of waste water – potential differences in marginal damage costs. Another research group investigating the effects of emission trading on the pulp and paper industry were Ruth et al. (2000). With their long-term view, they found that investment incentives for the replacement of equipment accompanying emission trading schemes foster the speed of implementation significantly. Similar investigations were conducted during these years by other research groups looking at industry sectors as steel, cement, chemicals etc.

Although the above-mentioned publications of Brännlund et al. and Ruth et al. already focused on the pulp and paper industry, from today's point of view, they suffer a lack of concretion, i.e., they did not have a business study perspective. This is understandable as no emission trading scheme was in place in Europe yet. Thus, there was no real "urgency" to understand the specific implications for certain production processes or even individual plants. This changed with the adoption of the EU Green Paper on greenhouse gas emissions trading within the European Union on March 8th 2000 (Commission of the European Communities, 2000). This Green Paper triggered a discussion which has become broader since then. While the vast majority of publications from 2000 until 2003 still had a national economic perspective – most publications dealt with the actual design of the emission trading scheme and potential conflicts with other political instruments (see chapter 2.1.1) – the number of publications with a business study perspective also rose. However, at first most of them covered industry sectors other then pulp and paper. For the pulp and paper industry and the related scientific community, it obviously took until 2003 to discover the importance of emission trading. The first to offer insights on what the imminent European emission trading scheme would mean for pulp and paper companies were Point Carbon and RISI (2003). One year later, in 2004, numerous publications were issued, dedicated to the pulp and paper industry or at least covering this industry more thoroughly.

Today, two publications are available, quantifying the direct and indirect effects of emission trading on the European pulp and paper industry. The publications of Quirion and Hourcade (2004) as well as Reinaud (2005) both go beyond a pure quantification of the increase in manufacturing costs. Both apply price elasticities on the calculated cost increases to derive the effect on demand, respectively competitiveness.

For each out of twelve industries, Quirion and Hourcade calculate the effect of emission trading on the industries' competitiveness, measured in total turnover of the plants located in the EU. Their calculations are based on an allowance price of 20 EUR/t CO_2 and various price elasticities they have taken from literature. For the sector "paper, pulp, printing, and publishing" they apply numbers between -0.40 and -1.8[1]. With these numbers and considering the limited OECD market openness ratio for pulp and paper (12% compared to a 33% average of all manufacturing industries), they compute losses in turnover for this sector between 0.01% and 0.03% if allowances are auctioned and the receipt is not recycled to reduce labour taxes, respectively even a slight gain in turnover of 0.02%-0.05% if the receipt is recycled. In addition to these obviously small numbers, they highlight the fact that a 10% change in exchange rates has an effect of about 60 times this magnitude.

Reinaud (2005) also compares the effect on different industries. As a case example for the pulp and paper sector, she takes the paper grade newsprint. Systematically, she differentiates direct effects and indirect effects originating from utility companies' abilities to pass on opportunity costs. As she had investigated the electricity price effect in more detail before (Reinaud, 2003), she assumes on a solid theoretical foundation that an emission allowance

[1] Referring to Fouquin et al. (2001) -0.4 for exports outside the EU and -1.05 for imports into the EU, Erkel-Rousse and Mirza (2002): -1.5, GTAP (2002): -1.8

price of 15 EUR/t CO_2 leads to weighted average carbon costs for electricity generation in the EU of about 7.50 EUR/MWh – corresponding to an average carbon intensity of 0.500 t CO_2/MWh. However, she notes that the actual price increase may deviate from 7.50 EUR/MWh as it is subject to many other factors too. She assesses the treatment of emission trading in the electricity sector to be crucial for the international competitiveness of the European energy-intensive industries. Then, based on a price of 10 EUR/t CO_2 for emission allowances, Reinaud calculates an increase of total production costs for newsprint of 1.1%, respectively 1.6%, depending on whether 98% or 90% of the needed allowances are allocated for free.[1] She highlights the trade-off between maintaining market share versus maintaining profitability. For a constant market share – assuming that this means that prices need to be kept fixed – she calculates an approximate decrease in the operational margin (on product level) of 0.4 to 0.5 percentage points for mills located in the EU depending on whether 98% or 90% of the allowances needed are allocated for free. If alternatively the profitability margins (again on product level) are maintained, the cost increase needs to be reflected in a price increase of 0.7 to 0.8%. If this could be achieved in the market (against non-EU-players), a demand elasticity of -1.88 (referring to Marsh et al. (2003)) means a reduction in demand of 1.8%, respectively 2.3%, for the entire market.[2]

While Quirion and Hourcade as well as Reinaud try to quantify the entirety of the effects of emission trading on the pulp and paper industry in Europe, Starke (2004) rather focuses on the mechanisms of initial allowance allocation and discusses the economic implications for the pulp and paper sector only marginally. Most other authors concentrate on certain aspects as well and elaborate them in detail.

Definitely the aspect to which most attention has been paid is the increase in electricity prices. Among the first publications focusing on the electricity price effect were Koljonen and Savolainen (2004), who focus on the effects of emission trading on the electricity price in Finland. An in-depth analysis was published by Antila et al. (2004). They found that in normal hydrological years the electricity price on the Nordic market may increase by 4-16 EUR/MWh (about 7.60 EUR/MWh at 10 EUR/t CO_2) due to emission trading. This is in line with the numbers CEPI (2004a) stated in a press release referring to an unpublished Jaakko Pöyry study in spring 2004. CEPI concluded that mills located in the EU will have a serious competitive disadvantage compared to those located in non-Kyoto countries, that trade flows between the continents may change, and that the situation will even deteriorate after 2010. This conclusion absolutely accords with similar press releases from other associations of the

[1] See Table ES-1 respectively Table 32 and Table 33. Regrettably it is hard to follow the underlying calculations. Especially Tables 27 and 30 seem to display doubtful numbers for newsprint. Based on the disclosed assumptions and presuming an exchange rate of between 1.10 and 1.25 USD/EUR, the marginal direct cost increase should be in order of magnitude of 1.3% instead of 3.4% (Table 27) and the indirect cost increase about 2.6% instead of 1.1% (Table 30). This results in a 2.6%, respectively 2.7%, cost increase depending on whether 98% or 90% of the allowances needed are allocated for free.

[2] See Table 36 based on Table 35. Own calculations suggest a decrease in demand of 1.3%, respectively 1.5%.

energy-intensive industries highlighting that the most severe effects of emission trading could be expected from rising electricity prices (CEPI et al. (2004a), (2004b) and (2004c)). Similar attempts at regulatory management have been done by Kenneth Eriksson, the spokesman of the Swedish Forest Industry, who named expected electricity price increases resulting in additional costs of between one and four billion Swedish Crowns (approximately 100-400 million EUR) only for Sweden which is unacceptable (Holmström, 2004).

A second aspect of emission trading, again pulp and paper specific, is the increase in wood prices (see the introduction in chapter 2.1.3.2). Besides the already cited press release of the Finnish Forest Industries Federation (2005), Antila et al. (2004) and Koljonen and Savolainen (2004) attended to this issue. Antila et al. simulated the effects of emission trading on the competitiveness of fuels combining various models on the Scandinavian electricity market and a boiler database. They found that flows of fibrous raw material (wood chips etc.) may be redirected from physical use to combustion. Koljonen and Savolainen quantify this crucial point for the Finnish pulp industry: replacing peat with wood can become profitable at the allowance price level of 5-10 EUR/t CO_2. This can easily induce a scarcity of wood as a raw material for pulp mills – a point emphasized by Hannus (2004) too.

The third aspect, again specific to the pulp and paper industry, is the potential shift in the production of pulp and paper grades. It has been raised by Jokinen et al. (2004), who combined Jaakko Pöyry's "Periodic Table of Paper Grades" with thoughts about emission trading. Basically the energy and emission intensity of paper grades is introduced or at least stressed as a decision parameter for the production mix and production planning within a single mill or within a network of mills.

Another special aspect of the introduction of emission trading is the increase in uncertainty and risk – a topic not specific to the pulp and paper industry. The publications of Janssen (2001), McKinsey and Ecofys (2005), Hoffmann and Trautmann (2005) and Uhrig-Homburg and Wagner (2006) have taken up this point. Janssen was the first to disaggregate the risks inherent in developing JI and CDM projects. Although the focus of his thesis is on JI and CDM, numerous aspects can also be used to consider the risks of emission trading. In detail, he describes the limited options to insure against risks and the more applicable options to balance risks by diversification (portfolio theory). In a large-scale survey among European companies and associations of the directly and indirectly affected industries, McKinsey and Ecofys found, that, due to asset lifetimes in capital-intensive industries of between 20 to 60 years, the long-term uncertainty frightens the industry most strongly. Companies fear a reduction in the allocation for trade phase II if they reduce emissions intensively in the first period. Based on this publication, Hoffmann and Trautmann (2005) aim at introducing uncertainty as a third impact of emission trading besides direct and indirect costs. One means to hedge against some aspects of this uncertainty is introduced by Uhrig-Homburg and

Wagner (2006) who suggest creating derivatives of emission allowances as futures and forwards but also for more asymmetric, option-like instruments. The break between the allocation phases needs to be respected in the design of the instruments.

Administrative implications as a fifth aspect, not specific to the pulp and paper industry, are predominantly highlighted in publications by consulting and accounting firms. They offer their services in preparing the organisation, IT-infrastructure and accounting systems, certifying the emissions etc. Only limited space is admitted to this aspect in scientific publications. Only Antila et al. give an overview of which necessary administrative actions need to be taken. This comprises anchoring emission trading in the organisation, preparing reporting and licensing, and developing trading and risk management strategies.

The above-mentioned publications already provide some interesting insights into the effects of emission trading on the European pulp and paper industry. They try to quantify the effects on manufacturing costs and competitiveness and elucidate some aspects in detail. Nevertheless, numerous questions still remain unsolved or have only been superficially touched on. The subsequent chapter 2.3 defines the key questions this investigation is aiming to answer.

2.3 Problem and goal – changes in the political and economic environment require advice to affected companies and political decision makers

Although the entirety of existing investigations already provides interesting insights into the effects of emission trading on the European pulp and paper industry, three key questions remain as yet insufficiently answered:

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment?

Firstly, the question on the effect of emission trading on the manufacturing costs of pulp and paper has not yet been sufficiently answered. As displayed in more detail in chapter 2.1.3.2 above, only two investigations, those of Quirion and Hourcade (2004) and Reinaud (2005), provide a quantification. Each of the investigations looks at one pulp and paper related category, "paper, pulp, printing, and publishing" in the case of Quirion and Hourcade and "newsprint" in the case of Reinaud. Both categories are neither comparable nor able to draw a differentiated and representative picture for the whole European pulp and paper industry. Quirion and Hourcade do not differentiate any pulp and paper manufacturing processes or grades and even mingle pulp and paper manufacturing with printing and publishing. Reinaud picks one single paper grade accounting for about 11% of entire paper production and leaves out pulp manufacturing completely. Additionally, the results of their calculations differ by more than factor ten. This is absolutely unsatisfactory: a clear differentiation of the various pulp (see Fig. 18) and paper manufacturing processes (see Fig. 20) is needed. Additionally the direct and indirect effects on the manufacturing costs and their respective levers as displayed in Fig. 29 (from scarcity of emission allowances to price increases in energy and raw materials) need to be distinguished in these calculations. Scenarios should be created reflecting the range of potential amplitudes of the longest levers (presumably the allowance price and electricity price increase).

Secondly, the question on the implications of the presumable changes in manufacturing costs for profitability and competitiveness of the affected companies has also been insufficiently answered. Again the above-mentioned investigations of Quirion and Hourcade (2004) and Reinaud (2005) are the only ones aiming at giving answers to these questions. However, the links between manufacturing cost increase and loss in profitability seems to be of limited solidity. It is doubtful whether a 1.6% increase in manufacturing costs results in a loss of profit margin of only 0.5 percentage points. This suggests that the manufacturing costs of pulp and paper account for less than a third of the respective sales prices. As this is not the case, the interrelation between manufacturing cost increase and loss in profit margins requires a more intensive investigation. The same is needed regarding the effects on competitiveness, i.e., regarding the ability of companies affected by emission trading to sell their products on international markets (maintenance of profit margin vs. maintenance of market share). As both investigations provide profound starting points in this case, only an industry-specific deepening of the insights is required here.

Thirdly, the question regarding actions that can be taken by the companies to make the best of the changes in the political and economic environment deserves more attention. As the discussion of existing literature in chapter 2.1.3.2 above shows, some publications have focused on one or a few of the following points:

- Electricity price increase
- Wood price increase
- Shifting production mix
- Managing uncertainty and risk
- Handling administrative requirements

While electricity and wood price increases can be regarded as components of the effect on manufacturing costs (levers affected by emission trading), the other three points have the characteristic of actions to manage the requirements induced by the changes in the political and economic environment. This reveals that a compilation and subsequently thorough elaboration of lever-specific actions is required. Besides the lever-specifity, the compilation should differentiate "type" of action (i.e., whether the action requires a change in the technical configuration of the mill or is a "pure" management action) and "timing" or "duration" of action (i.e., short-term/operational vs. long-term/strategic). The investigation will reveal whether the potential actions are limited to the levers of electricity and wood prices or should have a broader scope including the levers of the direct effect of emission trading.

Giving reliable answers to the three key questions outlined at the beginning of this chapter is the goal of this investigation.

The superficial dimension of this goal is related to the scientific demand for profound answers to relevant questions that have not been answered sufficiently yet. However, this is only one dimension of the goal, as a pure "l'art pour l'art" would not have initiated this investigation.

Thus, the real or intrinsic dimension of this goal is to give recommendations to companies within the pulp and paper sector on how to cope with the changes in the political and economic environment that have come about with the introduction of emission trading. These recommendations should be as operational as possible and differentiated by lever, by "type" of action (i.e., change in the technical configuration vs. "pure" management action), and by "timing" or "duration" of action (i.e., short-term/operational vs. long-term/strategic).

Additionally, this investigation would have a positive side effect if it made obvious the impact of emission trading on the international competitiveness of pulp and paper manufacturing in Europe to all politicians who were and are involved in adopting the respective legislation on the EU and national level. This feedback on their recent work may help to safeguard both the reduction of greenhouse gas emissions by the means of emission trading and the international competitiveness of pulp and paper production in Europe. Further, this investigation may help to avoid the replication of mistakes in the EU's future emission trading scheme and in national allocation plans.

3. Methodology – inductive generalisation from a multiple case study

3.1 Approaching three key questions – theoretically and empirically

The three key questions to be answered by this investigation have been introduced in the previous chapter:

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment?

Methodologically, these three questions will be approached differently. Irrespective of the solid theoretical foundation that is necessary to answer all three questions, the first question will be investigated mainly empirically, while the second and third question will be approached theoretically using starting points from literature.

The first question is basically descriptive but may have an exploratory component too. The question "What is the effect…on…?" can to be broken down into a "What are the effects…on…?" and a quantification of the single effects. While the first of these two sub-questions bears an exploratory component, the quantification can be regarded as descriptive. The second key question of this investigation can be categorised as being descriptive too, while the third key question has a rather explanatory character. Although it does not explicitly ask for causes of certain phenomena, it requires an understanding of the causes when asking for recommendations.

The decision to answer the key questions empirically, respectively purely theoretically, inevitably results in the question of inductive or deductive building of theory (see Schumann (2000) and Diekmann (2003)). The approach to question one which initiated the entire empirical part of this investigation is purely inductive, i.e., the derivation of a general principle from specific examples. According to Müller-Böling and Klandt (1996), this procedure is the typical approach to build theory from empirical research, although it is criticised by the school of critical rationalists as not being formally logical. The criticism of induction can be traced back to David Hume in the 18^{th} century and, thus, is often cited as "Hume's Problem" (Meyer, 1979). It was accentuated again in Karl Popper's "Logik der Forschung" (1934, in English "The Logic of Scientific Discovery" 1959)). Popper strongly favours the deductive way of building theory. He suggests deducting conclusions (hypotheses) from a theoretical system. The system of hypotheses (i.e., the theory) – but not every single hypothesis – needs to be falsifiable empirically. As long as tests do not falsify a theory, it is preliminary adopted (falsificationism using confirmative testing). Falsificationism as a tenet in scientific theory has its philosophical backing in the concept of critical rationalism. Opposed to this concept, constructivism (sometimes referred to as positivism) aims at gaining recommendations in an inductive mode from empirical research (Raffée and Abel, 1979b). As both current concepts have given up the absoluteness claim of the foregoing concepts (classical rationalism and classical empirism, (Raffée and Abel, 1979a)) and basic considerations of falsificationism are applicable to the inductive approach too, induction has received wide acceptance for empirical research today. Thus, inductive theory building seems to be the appropriate approach to answer the first key question. Key questions two and three use deduction for theory building, i.e., using the conclusion from a general law and specific framing conditions for a specific case (Eichhorn, 1979) and, thus, are in line with all considerations of formal logic.

The empirical approach to the first key question suggests the formulation of hypotheses to be tested. According to Müller-Böling and Klandt (1996), these hypotheses can be derived in three ways: (1) from expert interviews and the intuition of the scientists, (2) from scientific publications – even if not explicitly formulated there – and (3) from empirical research, i.e., exploring by observation or fishing for correlation. The investigation to hand deploys both intensive utilisation of scientific literature (see chapter 2) and intuition to formulate preliminary hypotheses and expert interviews to sharpen or modify the preliminary hypotheses. Prior to these pre-tests, which are described in subsequent chapter 3.2 in more detail, the preliminary hypotheses for the first key question are the following:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters as according to manufacturing process, level of integration, energy mix etc.
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

As key questions two and three both are investigated with a deductive approach, it is not necessary to formulate respective hypotheses prior to the empirical research and to display them at this point. Hypotheses and theory with regard to both questions will be illustrated extensively in chapter 5.

3.2 Pre-testing of key questions and preliminary hypothesis

As mentioned in the previous chapter, a pre-test of the above-mentioned key questions and preliminary hypotheses was conducted upfront before the actual empirical research. This pre-test had a confirmative and an additional explorative objective, i.e., the testing of questions and hypotheses was accompanied by efforts to gain further hypotheses or – as a combination of both – to reshape or sharpen questions and hypotheses.

In accordance with the suggestions of Diekmann (2003), the pre-test was conducted as twelve qualitative expert interviews with representatives of several major pulp and paper manufacturers in Europe, representatives of the European and the German pulp and paper manufacturers associations, consultants, and scientists. Four of the interviews were conducted as personal interviews, eight as telephone interviews. Due to the bifocal intention of the interviews – the testing of questions and hypotheses as well as the exploration of new insights – the interviews were divided into two parts. At the beginning of each interview, questions and hypotheses were discussed based on a largely standardised letter – containing key questions and preliminary hypotheses in a slightly different format – that had been sent some days ahead of the interview. After these initial discussions, the interviewees were confronted with some charts about potential effects of emission trading on the pulp and paper industry. These charts were modified for each interview depending on the position/ background of the interviewee and the insights gained at the previous interviews. The charts triggered a discussion about various aspects of emission trading and its effect on the pulp and paper industry. Finally, the interviewees were explicitly asked to raise all relevant topics related to emission trading and the pulp and paper industry that had not been raised yet. The duration of the interviews ranged between ten and 40 minutes. Based on the pre-tests of the key questions and preliminary hypotheses and the subsequent open discussions in the interviews both questions, and hypotheses were reviewed.

All the interviewees confirmed the key questions as relevant for pulp and paper manufacturing in Europe. As the third question regarding potential actions is framed relatively broadly, it covers all recommendations referring to actions to look at. The "advantage" of broad formulation also applies to the three hypotheses on the first key question. All the interviewees confirmed hypotheses one ("…direct and indirect effects…") and two ("…magnitude of effects…"). The third hypothesis, regarding the interaction between emission trading and other current energy-related developments, was stressed by most interview partners. Green electricity and its subsidisation were mentioned in several interviews as "the other side of the coin" of emission trading. Energy and emission taxation were also mentioned by more than one interviewee. Another aspect mentioned was the promotion of cogeneration. However, due to the relatively broad formulation of the questions and preliminary hypotheses, all the remarks of the interviewees could be summed up under the existing word choice. Thus, the initial key questions and preliminary hypotheses remained unchanged for the subsequent empirical and theoretical investigation.

3.3 Research design – multiple case study

Subsequent to the initial formulation of key questions and hypotheses, the adequate logical linking between questions and hypotheses, on the one hand, and empirical data, on the other hand, needs to be chosen. Most authors of methodological literature refer to this logical linking as "research design" and differentiate "classical" quantitative and "more recent" qualitative research (e.g., Mayring (2002)).

According to this differentiation, the key questions and hypotheses defined required qualitative rather than quantitative research. The investigation was initiated in 2004, one year ahead of the actual start of the European emission trading scheme, in a time of severe changes in the respective legal situation. Thus, the pulp and paper industry had neither the experience with emission trading nor extensive or common awareness of the operational requirements and upcoming potential effects. The linkages had not been understood at this point of time and needed to be disclosed by this investigation. Under these conditions, quantitative research, basically testing correlations in empirical data, either available or gained in a specific survey, did not appear very promising. In contrast, qualitative research that has gained share in the empirical social research since the 1970s was appropriate in this situation, as it provides a much better understanding of these linkages (Mayring, 2002). Here, the terms quantitative and qualitative must not be misunderstood. They define whether a conclusion is drawn from statistical evidence or from a case-based and generalised line of argument. "Qualitative" does not exclude the use of numerical data, but they are not the only source of evidence. In this context, the existing investigation is based on qualitative evidence leveraging quantitative data for certain clarification.

The above-mentioned differentiation between quantitative and qualitative research is the most common aspect of describing a research design. Some authors, however, break down the term "research design" into two levels. A thoroughly elaborated concept is presented by Yin (2003b). He differentiates "research design" (in the narrow sense) comprising key questions, proposition of the study, units of analysis, logical linking (quantitative and qualitative), and criteria for interpreting the findings from "research strategy", choosing between case study, experiment, survey, history or analysis of archival records.

Referring to this second aspect, the existing investigation is a case study. For the same reasons as mentioned two paragraphs above, instruments such as field research, analysis of archival records, and also survey did not appeared to be a reasonable way of exploring answers to the key questions. The demand for an in-depth understanding of the effects of emission trading in its context of the current situation on energy markets and environmental political instruments requires a more detailed analysis of the linkages than the other instruments can provide.

This assessment is supported by Yin who regards case studies as the preferred research strategy (Yin, 2003b, p.1),

> *"when the focus is on a contemporary phenomenon within some real-life context".*

He underlines the superiority of case study research over surveys in complex situations addressing the validity issue of surveys. A question like "how much do you think you will be affected?" does not measure the effect but the subjective idea of the effect. This issue can be surpassed by a case study more easily. However, to overcome this potential issue and to meet all other quality criteria, each case study – whether theory (hypotheses[1]) testing or theory (hypotheses) building – theory (research design, research strategy) needs to be developed in advance as Yin stresses explicitly (Yin, 2003b, p. 28/29):

> *"For case studies, theory development as part of the design phase is essential, whether the ensuing case study's purpose is to develop or to test theory. [...] For this reason, theory development prior to the collection of any case study data is an essential step doing case studies."*

Whereas the characteristic as an exploratory, descriptive or explanatory case study is determined by the key questions to be answered, respectively by the hypotheses to be tested, the characteristics as single- or multiple- and holistic- (single unit of analysis within each case) or embedded- (multiple units of analysis within each case) case study need to be decided as a result of this theory building (Yin, 2003a) and (Eisenhardt, 1989). The existing investigation has been designed as an embedded-multiple-case study. In the subsequent chapter 3.4 the sample of cases investigated and the respective units of investigation will be introduced.

The last decision in the design phase of this investigation was to combine within-case analyses with a search for cross-case patterns. The latter approach, which was suggested by Eisenhardt (1989), provides the significant advantage of improved generalisability compared to pure within-case analyses.

3.4 Sample – generalisation through replication

All classical approaches of sampling originate from quantitative empirical research. Here, very high emphasis is placed on the method of sampling to provide the highest possible generalisability. It is achieved, if the distribution of all relevant variables in the realised sample corresponds to the distribution in the target population (Müller-Böling and Klandt, 1996). As numerous phenomena can deform the realised sample compared to the target population (Schumann, 2000), various methods of gaining samples have been elaborated over decades for different applications in quantitative empirical research. Diekmann systemises

[1] Different from other social scientists, Yin rarely uses the term "hypotheses". He prefers to use "theory" and "rival theory" (Yin, 2003a, p. 27).

random sampling in various practices, quota sampling, in various practices and arbitrary sampling (Diekmann, 2003), however the latter does not codify any procedures and is typically not regarded as valuable.

Whilst representative samples are mandatory for generalisability in quantitative research, the situation is different in qualitative research and in case studies. Yin summarizes the approach of generalisation used in case studies (Yin, 2003b, p. 32/33):

> *"A fatal flaw in doing case studies is to conceive of statistical generalization as the method of generalizing the results of the case study. [...] Under these circumstances, the mode of generalization is "analytic generalization", in which a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed. The empirical results may be considered yet more potent if two or more cases support the same theory but do not support an equally plausible, rival theory."*

The key aspect in generalising findings from case studies is replication, i.e., the continued testing of a theory case by case and method by method. Contradictions with literature foster the researcher to more creative theory building. Eisenhardt (1989) and also Yin differentiate direct replication from theoretical replication (Yin, 2003a, p. 145):

> *"In a direct replication, two or more cases are predicted to follow courses of events similar enough that they repeat or replicate each other's experience – in a conceptual, not literal, sense."*

Although direct replication compares findings of two or more cases, it should not be confused with statistical generalisation. It is only the same "cause-effect-conjunction" that is observed among the cases. This difference compared to sample logics becomes even more evident at theoretical replication. If the investigation comprises only one or multiple incomparable cases, the generalisation needs to be done by a logical line of arguments. Additional cases would have taken the same course, given the circumstances were similar.

Although the approach of generalisation in qualitative and case study research is totally different from the statistical generalisation used in quantitative research, the selection of the sample, i.e., of the cases to be investigated, is far from being arbitrary. Even more attention needs to be paid to the selection of the cases, as their number is essentially limited and the inductive generalisation through replication requires a tight line of argument. The researcher cannot hide weaknesses in the single case by using large samples. Eisenhardt stresses why the selection of cases – for theoretical not for statistical reasons – is of importance (Eisenhardt, 1989, p. 536/537):

> *"Selection of cases is an important aspect of building theory from case studies. As in hypothesis-testing research, the concept of a population is crucial, because the*

> *population defines the set of entities from which the research sample is to be drawn. [...] The cases may be chosen to replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types."*

Yin (2003a) agrees and suggests the following approach for selecting the cases: (1) listing all potential candidate cases, (2) collecting overview data on each candidate case and, finally, (3) selecting the actual cases from the candidate cases based on specific reasoning (e.g., exemplary cases, contrasting cases). According to Eisenhardt (1989), closure can be reached if a theoretical saturation occurs in adding new cases and iterating between data and theory.

In the existing investigation, the actual selection of the cases follows Yin's above sketched approach. The definition of the requirements for selecting the cases preceded the three steps listed. Within the restriction of an essentially limited number of cases, the selection needed to provide a good coverage of pulp and paper mills along three dimensions:

- Pulp and paper production processes
- Countries in Eastern and Western Europe
- Levels of integration between pulp and paper manufacturing

As a result of all the theoretical considerations which have been presented in the previous chapters, these three dimensions were presumed to be the strongest influencing factors on the effects to be investigated. The significant variation of the energy intensities of different pulp and paper manufacturing process (see chapter 2.1.3.2 and especially Fig. 30) strongly suggested that the direct and indirect effects of emission trading on these processes vary. Thus, ideally all of these processes – especially in pulp manufacturing – should be covered by at least one case in the investigation. A spread of the cases over several Eastern and Western European countries seemed to be essential, due to the prominent differences in national legislation regarding emission trading and other environmental political instruments and regarding the liberalisation of energy markets (see chapter 2.1.2.3). Finally, the coverage of integrated pulp and paper mills as well as of stand-alone pulp, respectively paper mills, seemed to be reasonable, as literature and pre-tests reported differences in the energy concept and synergies depending on the level of integration. The addition of further dimensions (types of boilers and turbines, age of installation etc.) as requirements for case selection might have been interesting. However, the inevitably increased number of cases would have exceeded the capacity of this investigation. Furthermore, it should be re-emphasised that the existing investigation is not designed as a (quantitative) multi-variance-analysis but as (qualitative) case study research. Thus, adding additional mandatory requirements would not have been reasonable.

The actual listing of all potential candidate cases (step 1 of the above-mentioned Yin approach) was made based on the NLK mill database (NLK Associates, 2003). The database comprises the production capacities of all pulp and paper mills in the EU15 countries plus Norway and Switzerland differentiated by process. The 2003 edition lists 737 paper mills (449 with an annual capacity of 50,000 tons or more), 94 chemical, and 113 mechanical pulp mills. Fibre recovery, however, is not included. A corresponding database for the Eastern European countries was not accessible. Hence, all initial queries – compilation of rough company and country data and rankings – were made in the NLK mill database, accepting that Eastern European mills were ignored in this first step. Based on this rough company data, a shortlist of large multinational companies was composed with the intention of meeting the above-mentioned criteria (processes, countries, level of integration) with a limited number of partners. It was assumed that these multinational companies would also have mills in Eastern Europe. Thus, the second requirement would also be met. Subsequently, detailed company profiles were composed for ten of these companies based on annual reports, company websites, and the Birkner directory of "Producers of Pulp, Mechanical Pulp, Paper and Board" (Birkner, 2002). Following a prioritisation, these companies were approached sequentially on corporate level (Vice Presidents, respectively Directors, responsible for emission trading, energy and/or energy). Thereby, the objectives of the investigation, the potential modes of cooperation and, finally, the pulp and paper mills relevant for the investigation were discussed in detail (step 2 of the above-mentioned Yin approach). As this process required more time than initially expected, general managers and the people responsible for energy and/or the environment at German pulp and paper mills were approached in parallel. Finally (step 3 of Yin's approach), the actual cases for the investigation were selected jointly with the people responsible on the corporate, respectively mill, level of the companies. The entire process from listing of candidate cases to signature of the last agreement of cooperation took from March to October 2004.

The actual "sample" – although this term rather refers to quantitative empirical research – consists of 22 pulp and paper mills in Central (Western and Eastern) Europe and Scandinavia. They account for 7.7% of the primary pulp production, for 4.0% of the secondary pulp production (fibre recovery), and 7.1% of paper production in the CEPI countries[1]. The average sizes of the investigated production lines are 253,000 t/a primary pulp, 235,000 t/a secondary pulp (recovered paper), and 371,000 t/a paper[2]. However, not only the overall coverage of production backs up a wide generalisability. The three above-mentioned requirements and even the additional "nice-to-have" criteria, such as e.g., types of boilers and turbines, are also fully covered. All the relevant pulp and paper production processes are represented properly as Fig. 36 shows. The uncovered processes or categories, accounting for

[1] Calculated based on CEPI Annual Statistics 2004 (CEPI, 2005) and 2005 (CEPI, 2006b). CEPI countries are EU15 without Greece and Luxembourg plus Norway, Switzerland, the Czech Republic, Hungary, Poland, and the Slovak Republic.

[2] In this context, the term "production line" refers to output of product belonging to one grade as defined in chapter 2.1.3.1. Where e.g., two paper machines in one mill produce the same grade, they have been regarded as an entity of one "line".

6% of pulp production, respectively 12% of paper production, can be neglected without limiting the generalisability of the findings.

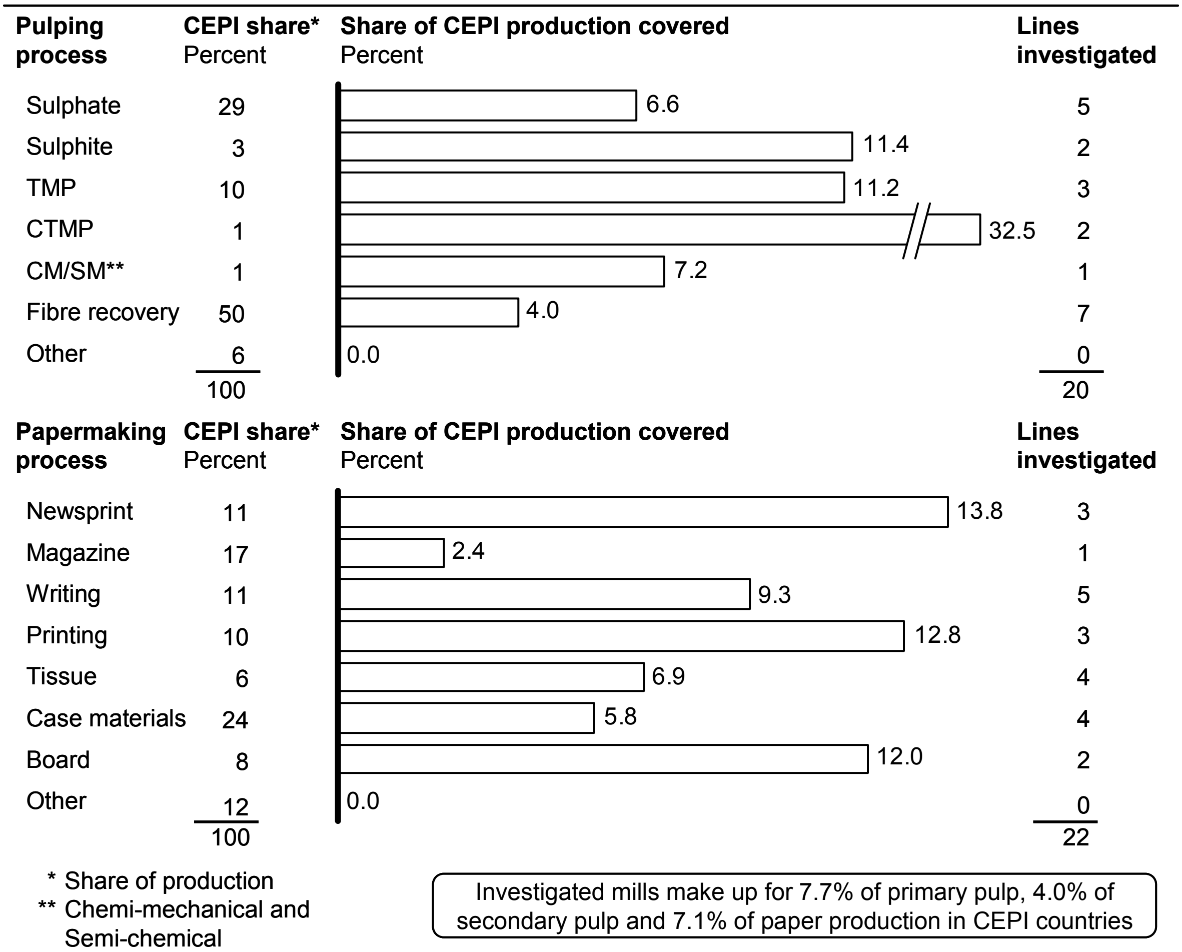

Fig. 36: Coverage of pulp and paper manufacturing processes in the investigation

The requirement of covering different Eastern and Western European is also met (see Fig. 37). Mills in nine Central European and Scandinavian countries have been included in the investigation. Five of these countries belong to the EU15; four of them joined the EU in 2004. With Sweden, Finland, and Germany, the top 3 paper and board and the top 2 pulp producing countries in Europe are represented. Austria and Belgium are both in the middle range of pulp and paper production in CEPI countries (see Fig. 22). Mills in France, Italy, UK, and Spain have been excluded from the investigation due to practicability reasons. Eastern Europe is represented by mills in Poland, the Czech Republic, the Slovak Republic, and Hungary, the four among the younger EU countries with the highest pulp and paper production.

The third of the above-mentioned mandatory criteria for selecting the cases is the level of integration between pulp and paper manufacturing. It is met perfectly too, as six of the 22 mills are stand-alone paper or board mills, five combine fibre recovery with paper or board manufacturing, four produce chemical pulp and paper or board, while the remaining seven mills combine paper or board production with thermo-mechanical pulping or more than one pulping process.

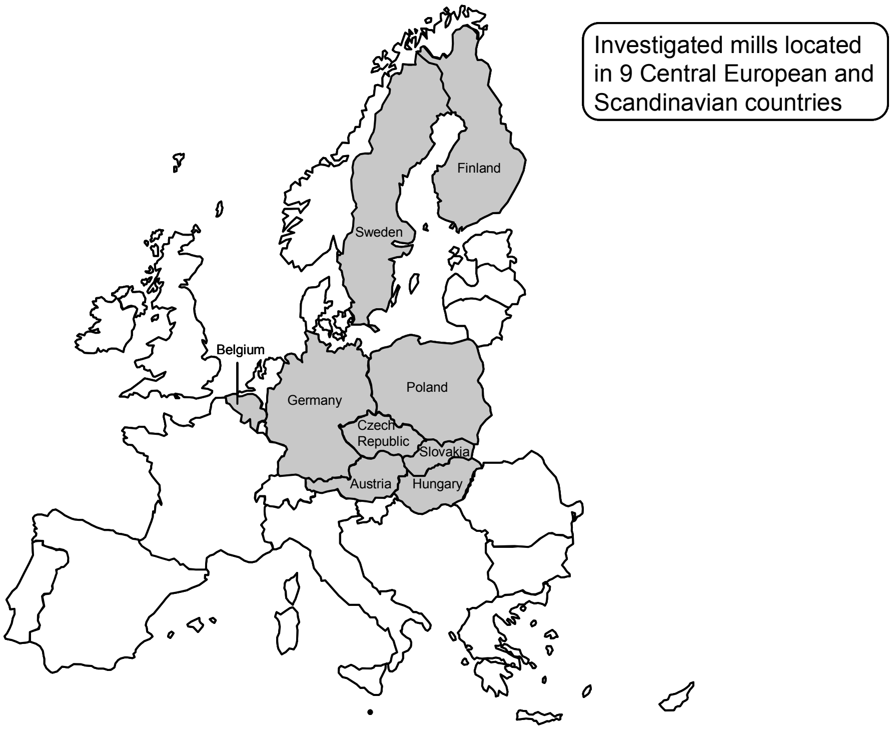

Fig. 37: Countries covered in the investigation

A summarising assessment reveals that the selected cases provide a good coverage of all relevant pulping and paper manufacturing processes, of the relevant countries, and of all levels of integration between pulp and paper manufacturing so that the findings should be easily generalisable for pulp and paper production in Europe using the replication approach.

3.5 Research methods – semi-structured interviews

In chapter 3.3 the research design of the existing investigation has been determined as an embedded-multiple-case study. Subsequently, the research methods of the investigation need to be described – divided into methods of data gathering, data processing, and data analysis.

With regard to qualitative research Diekmann (2003) as well as Müller-Böling and Klandt (1996) differentiate three techniques of data gathering:

- Interview
- Observation
- Content analysis

These three techniques can be differentiated by their temporal orientation: the content analysis is past-oriented, the observation present-oriented, and the interview allows all orientations between past and future. As the empirical part of the investigation began in autumn 2004, months ahead of the actual start of the European emission trading scheme, future orientation was required. Thus, interviews needed to be conducted. However, they were accompanied by content analysis, as the quantitative component of the investigation (modelling of effects) was dependent on production, energy, and emission data. This data – in reliable and consistent quality – typically can be taken from internal reports.

Ahead of the interviews and beside letters of recommendation from the contacts at corporate level, introductory information was sent to the interviewees at mill level. This material comprised a letter explaining the objectives of the investigation and the proposed mode of cooperation as agreed with the corporate contact. Additionally, the interviewees received an Excel-based form on energy and emission related data with a respective manual to familiarise themselves with the scope of the subsequent interview.

The actual interviews were conducted as personal meetings between November 2004 and March 2005. The interviewees, responsible for emission trading in the respective mills, typically managers for energy and/or environment, partially managers of accounting and/or controlling, and in some cases mill managers, were interviewed in the problem-centred mode (see Mayring (2002)). Thus, the interviews were conducted open, subject-oriented, and semi-structured. Nevertheless, all the interviews comprised three parts, respectively three modes, to answer the questions:

- Oral answers to oral questions
- Drawing of energy settings of the mill with large steam and electricity consumers, boilers, turbines etc.
- Provision of production, energy, and emission data of the mill in a standardised, Excel-based form or as existing reports

The interview guide (see Appendix 3) provided orientation for the interview but was released, when appropriate, to maintain openness and to ensure that the perspective of the interviewer would not dominate the interview. Whereas the questions in the interview guide primarily ask for descriptions, additional ad-hoc questions aimed at assessments of situations, developments, and options were attached depending on the initial answers. The duration of the interviews ranged from about two to five hours. In about half of the cases, the interviewee called in other management personnel of the mill if the questions surpassed his knowledge, respectively his organisational responsibility.

The past-oriented technique of content analysis needed to be applied if the interviewees were not able or willing to provide the required production, energy, and emission data in the standardised, Excel-based form (see Appendix 4) but gave access to existing mill reports. If this data needed to be extracted from existing reports subsequent to the interview, the interviewees were asked to check the compiled data ahead of any further processing.

Subsequent to the mill visits, the data gathered in the interviews was processed. Summarising protocols in a standardised format were made from handwritten notes on the oral answers. Thereby, the protocols were backed by memorised answers of the interviewees whenever the handwritten notes did not express the course of the interview to their full extent. All relevant cases of doubt were resolved with the interviewees in telephone calls or emails before completing the respective protocols. Although these loops would have been dispensable if the interviews had been recorded and transcribed, this procedure was not regarded as expedient. Presumably, recording would have limited the interviewees' willingness to answer some of the questions and to give personal assessments (openness, honesty). In order to ease the future readability of the protocols, notes of the legal situation (emission trading, energy, and environmental legislation) in the respective country were attached to the protocols where appropriate. The processing of the drawings resembled the processing of the notes. All the drawings were transferred into a standardised structure. The processing of the quantitative data was more difficult. Two main obstacles needed to be overcome: (1) the investigation looks at the effects of emission trading from a process/product centred perspective, while the mills typically regard heat and electricity generation as a central function. These differences in the perspectives required some effort to allocate energy and emissions to processes such as pulp and paper manufacturing. (2) More than half of the interviewees preferred to pass on various existing reports containing production, energy, and emission data instead of filling in the standardised Excel-form. Data gaps and inconsistencies needed to be approached in personal follow-ups. Some gaps, however, inevitably remained.

With regard to the actual data analysis protocols, drawings and quantitative data need to be differentiated again. Qualitative data was analysed using logical modelling and pattern matching (Yin, 2003b), i.e., empirically discovered patterns were compared with predictions from preceding theoretical considerations. Finally, a cross-case synthesis supports the generalisability of the findings. Referring to the quantitative data, a similar cross-case analysis was followed by extensive scenario calculations of the potential effects of emission trading.

3.6 Operationalisation – qualitative and quantitative variables

Following the detailed descriptions of research design and research methods, the chapter on methodology will be closed with some notes on the operationalisation of the variables in the investigation. As the crucial qualitative terms of key questions and hypotheses have been verbalised precisely in chapter 2.3, the following paragraphs focus on the quantitative aspects of the investigation. The Excel-based form, which was intended to gather all the production, energy, emission, and cost-related data required to calculate the monetary effects of emission trading, is described in more detail. Two versions of the form – PULP R1.6 and PAPER R1.6 – reflect the specifics of pulp, respectively paper manufacturing.

As indicated in the previous chapter 3.5, one major hurdle needed to be overcome in the differentiation between pulp and paper manufacturing in integrated mills. Whereas the mills typically regard the powerhouse as a central function, the investigation takes a process-, respectively product-centred perspective in order to allow better generalisability. Typically, energy consumption and direct costs are specifically accounted for the different processes or products manufactured in integrated mills, energy supplies (steam and electricity), however, emissions and indirect costs need to be allocated. In an integrated sulphate/case materials-mill for example, all sources of primary energy used for steam generation – including black liquor – are allocated to both pulp manufacturing and paper manufacturing. Thus, the data sets used for modelling (e.g., the TMP data set from mill A and the magazine paper data set from mill B) cannot be added up to construct any type of integrated mill. This calculatory combination is feasible with the existing model of course, but requires thorough handling with regard to the presumable energy setting.

In the case that only one central function supplied only one product, the allocation would be a limited effort. However, the existence of multiple products per central function (e.g., steam and electricity supplied by the powerhouse) and the interdependences of central functions (e.g., the powerhouse supplies electricity to the water treatment department) complicate the allocation. The first problem – multiple products from one central function – was solved by weighting the outputs with transfer prices (at equal margins). The second problem – interdependences between central functions – was solved using a simplification. Theoretically, an infinite iteration of allocating the central functions outputs to each other, respectively to pulp and paper manufacturing, would be required. Calculations based on various case examples have revealed, however, that one single iteration provides results of sufficient accuracy. The deviation from the "true" allocation after an infinite number of iterations is less than 1%, thus, not limiting the generalisability in a qualitative research design.
In contrast to the just-introduced hurdle of allocating central functions was the hurdle of setting boundaries. This hurdle, however, was much lower:

- Pulp manufacturing comprises all process steps from woodyard to pulp drying, respectively pumping the fibre suspension in the case of integrated production. In a chemical pulp mill, causticising and lime reburning, evaporation, and the chemical plant are included.
- Paper manufacturing comprises all process steps from the pulping section, respectively takeover of the fibre suspension in the case of integrated production, to finishing of paper packages.

More detailed definitions of the boundaries were provided to the interviewees in the manual sent with the forms ahead of the visits. Another boundary, however inform a temporal respect, is the base year of the investigation. All the actual data refers to 2004.
Irrespective of the above-mentioned differentiation between pulp and paper manufacturing, both versions of the form comprise the following six sections (see Appendix 4):
(1) Identification
(2) Fuel and chemicals input
(3) Emission
(4) Energy
(5) Manufacturing costs
(6) Potential CO_2 emission avoidance measures

Section 1 requires the entry of key mill data, the selection of production processes applied, the base year of subsequent data, and production volumes. Some of the entries in the first section (country, base year) determine the menus in the following sections.

In section 2, the sources of emissions (fuels and make-up chemicals in the case of chemical pulping) are selected from country-specific pull-down menus. These menus have been programmed based on country-specific lists of fuels (e.g., the list attached to the first German emission data gathering using the RISA-GEN software (ERM Lahmeyer et al., 2003)) and the manuals of the existing greenhouse gas inventories.[1] For all additional, not pre-defined fuels data can be entered manually.

Section 3 focuses on the CO_2 emissions. The emissions from fuels and make-up chemicals entered in section 2 are calculated automatically. Only certain exception', such as e.g. emission reductions through manufacturing of precipitated calcium carbonate (PCC) from exhaust gases, need to be considered separately.

In section 4, the energy setting of the mill is displayed quantitatively. Generation and consumption of direct heat (hot gas), steam, and electricity are broken down into detail.

Section 5 asks for the manufacturing costs. In order to allow an expedient modelling of the effect of emission trading, in-depth data is required on fibrous raw materials, utilities, and various direct effects of other environmental instruments such as energy and emission taxes. As a breakdown of the remaining elements of manufacturing costs is not required, many

[1] First guidelines for calculating greenhouse gas emissions were issued by the Intergovernmental Panel on Climate Change (IPCC) in 1997 (IPCC, 1997). Another calculation tool with general applicability was made available from the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) in 2004 (Ranganathan et al., 2004). A pulp and paper specific tool, based on the above mentioned standards, was developed for the International Council of Forest and Paper Associations (ICFPA) in 2003 (ICFPA, 2003).

participating mills used the option of summing up personnel, consumables, overhead expenses, depreciation etc. In addition to the actual cost figures which refer to the year 2004, the interviewees were asked to estimate the internal and external, one-time, and recurring administrative costs of emission trading.

Finally, section 6 looks at CO_2 emission avoidance measures that have been realised by the mills or are planned for the near future.

4. Results – pay attention to energy and fibre

4.1 Three questions, three hypotheses – results and conclusions

As outlined in chapter 3.1, the investigation aims to answer the following three key questions using different approaches.

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment?

The first question – which could be broken down into a "What are the effects…on…?" and a quantification of the single effects – will be investigated mainly based on empirical research, testing the three hypotheses gained from scientific literature and intuition, and pre-validated in the pre-tests:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters according to the manufacturing process, level of integration, energy mix etc.
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

The second and third key questions will be approached theoretically using starting points from literature and building up on the answers to key question one. Whereas the first two questions have an exploratory, respectively descriptive character, the latter is rather explanatory calling for recommendations. Thus, the first key question will be answered in chapter 4 – "Results – pay attention to energy and fibre", while the second and third key questions will be approached in the subsequent chapter 5 – "Implications and recommendations – take action". The structure of the existing chapter 4 will accommodate the first question, reflecting the subdivision into three hypotheses.

4.2 Effect on the manufacturing costs of pulp and paper industry

4.2.1 There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe

The existing hypothesis could be fully validated in the empirical research. There are several direct as well as indirect effects that the introduction of emission trading had on the manufacturing costs of pulp and paper in Europe. The theoretically derived breakdown of the direct and indirect effects presented in Fig. 29 (see page 68) has also been proved in almost all of its drivers:

All of the investigated mills showed CO_2-emissions from combustion of fossil fuels and some of them had additional emissions originating from the use of make-up chemicals. A few of the mills reduced their CO_2-emission through manufacturing precipitated calcium carbonate from the stack gases. According to the EU-wide legislation, which has been introduced in detail in chapter 2.1.2.2, all the mills need to cover their net emissions with emission allowances. National legislation and individual allocations determine mill by mill, how much of the emission is covered with allowances received for free, respectively how scarce the allocation is. As the quantification in subsequent chapter 4.2.2 will reveal, there are significant differences in the scarcity of the allocation.

All of the interviewed mill representatives reported administrative efforts associated with the introduction of emission trading and expected further efforts due to the obligation of annual emission reporting. The interviewees differentiated the internal and external administrative costs of emission trading. All of them reported on the management and accounting personnel capacity employed to report emissions, observe the allowance market, and maintain the mills emission balance with sales of purchases of allowances. Referring to the external costs of emission trading, they stated certification of annual emission reports, fees for national emission registries, fees for emission exchanges and brokers and, finally, consulting fees. Some of the interviewees were able to quantify these internal and external costs, while others abstained from doing so.

Going beyond the validation of the direct effects of emission trading, both major drivers of the indirect effects, i.e., price increases in energy and raw materials, have been proven. None of the mills was fully self-sufficient with regard to electrical energy; all of the interviewees expected electricity price increases. Most of them observed attentively the development of base load electricity prices on the European Energy Exchange (EEX) or in the Nord Pool market place (see Fig. 35 on page 77). The actual consumption of electricity from the grid, respectively the quantification of the electricity price effect, will be described in chapter 4.2.2.1.

The problem of increasing fibre prices, affecting the manufacturing costs of pulp and paper, as well as a raw material price increase and a price increase in external bio-fuels, was explicitly stressed by some of the interviewees. The examples from Finland and the Czech Republic in chapter 2.1.3.2 have been researched following hints from interviewees in both countries.

Hereby, all of the drivers for the direct and indirect effects of emission trading assumed from preparatory theoretical work and illustrated in Fig. 29 (see page 68) have been validated in the empirical work except one: the price increase in pulp and paper chemicals. None of the interviewees actively raised this issue. Nevertheless, the assumption of the existence of this effect will be maintained , as the press releases of pulp and paper chemical manufacturers refer to electricity prices and emission trading when announcing price increases (e.g., Eka Chemicals (2006)). The quantification of this effect in the subsequent chapter 4.2.2, however, needs to be done on an outside-in basis, i.e., without the utilisation of empirical data.

4.2.2 The magnitude of these effects differs by various parameters according to the manufacturing process, level of integration, energy mix etc.

This second hypothesis on the effects of emission trading on the manufacturing costs of pulp and paper requires significant attention. The hypothesis and the underlying demand for an in-depth quantification of the single effects, differentiated in the previous chapter, initiated the entire empirical part of the investigation. For each of the investigated mills, data sets of fifty or more data points covering all aspects of energy, emission, and manufacturing costs have been compiled. These data sets provide the starting point for advanced modelling of the direct and indirect effects along the basic logic introduced in Fig. 5 (see page 16) and detailed in Fig. 29 (see page 68). As each of these four steps – (1) description of energy and (2) cost structures, (3) derivation of scenarios, and (4) the display of the effects – requires significant attention, the chapter is subdivided accordingly to ensure good readability. The effects are subdivided according to the three scenarios chosen.

4.2.2.1 Energy structures

Any modelling of the effects sketched in Fig. 5 and Fig. 29 requires a significant number of input variables. The core data that needed to be gathered for each mill, respectively production line, were:

- CO_2-emissions by source (fuels, make-up chemicals)
- Allocation of emission allowances
- Administrative costs of emission trading
- Specifications and prices of fibrous raw materials, chemicals and fuels
- Consumption, supply and electricity costs
- Production volume and manufacturing costs

In addition to these core figures, numerous supportive back-up numbers (energy consumption and supply, prices and taxes for fuels and electricity, exchange rates etc.) were collected to allow better understanding of the energy and cost situation. The actual Excel-based data query form is in Appendix 4.

Although it would be interesting and feasible to present figures with all of this data – differentiated by manufacturing process, level of integration or country – at this point, it will not be presented. As outlined in detail in the methodology chapter (especially 3.4), case study research requires qualitative evidence and generalises analytically, not statistically. Thus, quantitative figures on energy and emission are reduced to a minimum in this chapter. Additional breakdowns would pretend quantitative evidence which is not the intention. Furthermore, the significance would be limited, as breakdowns inevitably create small subgroups (e.g., investigated CTMP lines in Sweden). Thus, the following paragraphs will comprise a textual description of the most relevant input parameter values.

(1) Energy consumption

The energy consumption needs to be differentiated into three types of energy: direct heat, steam, and electricity. Whereas all the investigated lines of pulp and paper manufacturing consume a significant amount of electricity and most lines – except some lines of fibre recovery – require steam, direct heat is consumed in only a few cases.

In pulp manufacturing direct heat, i.e., convective heat originating from the combustion of solid, liquid or gaseous fuels can be used for two purposes. All sulphate pulp mills require direct heat in the lime kiln for the calcium loop of the chemical recovery system. This process of reburning calcium carbonate to calcium oxide and CO_2 is specific for sulphate pulping. In the five investigated mills the respective heat demand ranged between 1.3 and 2.1 GJ/t pulp. The second – rather exceptional – purpose of using direct heat in pulp mills may be drying of pulp. As most mills use steam for heating the pulp dryers, only two mills were investigated using (solely) direct heat. Their direct heat consumption was 0.6, respectively 2.6 GJ/t pulp. Whereas typically only market pulp, i.e., pulp designated for sales to other paper mills, is dried, one of the investigated mills also observed advantages in drying the pulp designated for internal use. As drying reduces the fibres' capacity for water loading, less water needs to be evaporated in the paper machine, reducing the heat demand there and allowing a higher running speed if dried pulp is used. This energetic and economic assessment was obviously not shared by the other mills.

In paper manufacturing, direct heat can also be used for two purposes. Half of the investigated 22 lines of paper production use direct heat in addition to steam in the drying section of the paper machine. As the ratio between steam-heated drying and directly-heated drying is relatively flexible, the observed range of consumption was relatively wide. Tissue manufacturing, however, needs to be highlighted. Four investigated tissue lines consumed between 2.1 and 7.1 GJ/t paper, while seven lines producing other paper manufacturing processes consumed only 0.1 to 1.2 GJ of direct heat per ton of paper. The comparably high demand for direct energy in tissue manufacturing is caused by the Yankee-cylinders – a distinctive feature for tissue. Here, a significant (even prevailing) share of thermal energy is conveyed as direct heat. The second field of use for direct heat in paper manufacturing are gas heated infrared-dryers in coating machines. Naturally, this use is limited to printing and magazine paper and coated boards. Two of the investigated mills used 0.7, respectively 1.1 GJ, direct heat per ton of paper for coating.

Steam is the cheapest and, therefore, most common way to convey heat originating from combustion of fuels or – in a few cases – electricity to the fibres. Hence, it is used in all pulp and paper manufacturing processes – except some configurations of fibre recovery.

All processes of chemical pulping (sulphate, sulphite and respective derivatives) require significant amounts of heat in the digester with its surrounding equipment, in the bleaching section, in the evaporation section of the chemical recovery plant and – if available – in the pulp dryer. Whereas the heat for impregnation of the chips is conveyed essentially in the form of steam, the other demand for thermal energy is covered by steam instead of direct heat due to controllability and economic reasons (for an exception, see above). The steam demand of the seven investigated chemical pulp mills ranged between 3.1 and 14.6 GJ/t pulp, whereas the parameter values at the lower and the upper end were no outliers. For calculations, a value of 10 GJ/t should be assumed for the entire process (pulping, bleaching, and drying). It would be in line with the EU Reference Document.[1] A reliable reason for the widespread (e.g., different processes or levels of integration) could not be found as the requested breakdowns into different process steps did not provide comparable data. The steam balance of mechanical pulping processes is different from the balance of the chemical pulping processes. Though PGW (pressurized ground wood), RMP (refiner mechanical pulp), TMP and CTMP require steam to heat up and plastify the logs, respectively chips, (in four investigated mills the consumption ranged between 0.4 and 0.8 GJ/t pulp), the steam balances are net positive. Grinders and refiners transfer electrical energy to heat energy (steam and hot water). In three out of four investigated TMP and CTMP lines, the recovery of electrical energy ranged between 30 and 40% (1.9-4.1 GJ/t), while one mill was not able to recover energy. Again, the observed steam balances are in line with the EU Reference Document. Chemi-mechanical and semi-chemical pulping deserve only limited attention at this point. From theoretical considerations as well as from empirical observations, they range between chemical and mechanical pulping. Some more attention, in turn, should be paid to fibre recovery, as it accounts for almost half of European pulp production. The steam demand depends heavily on the configuration of the respective line. The existence of dispergers causes steam demand. Three out of the seven investigated lines required no steam, the remaining four lines, each of them recovering the fibres using dispergers, had steam consumption of between 0.3 and 0.8 GJ/t recovered fibre. These numbers are slightly higher than the EU reference numbers.

[1] EU Reference Document on Best Available Techniques in the Pulp and Paper Industry (Commission of the European Communities, 2001); see Fig. 30 in chapter 2.1.3.2.

Compared to the manifold differences in steam consumption between different pulping processes, the situation is much easier in paper, as all paper manufacturing processes are very similar. The single major steam consumer is the drying section of the paper machine. Solely subsequent on- or offline coating of the raw paper or board produced may cause a difference, although a significant share of the heat required in coating machines is usually conveyed by gas-heated infrared dryers. The steam consumption of the 21 investigated paper and board lines ranged between 3.8 and 8.5 GJ/t paper. In line with all theoretical considerations, newsprint seems to be rather at the lower end of the range, with board at the upper end. With increasing grammage/thickness and decreasing diffusibility of the paper or board, the specific energy for evaporation of water increases. An increased steam demand due to coating could not be observed in the lines of paper and board manufacturing investigated, as the requested breakdowns into different process steps did not provide comparable data.

Electricity is the third type of energy, consumed by all pulp and paper manufacturing processes. Basically, it is used to drive electrical engines for all types of mechanical work (e.g., chipping, defibration, and transportation); only a few Scandinavian mills also use it for heating purposes.

With regard to pulp manufacturing it is inevitable that chemical pulping, mechanical pulping, and fibre recovery need to be differentiated. In chemical pulping, the biggest consumers of electricity are the debarker and especially chipper engines. The subsequent process from digester to pulp drying requires a large number of smaller engines for transportation (pumps in the bleaching section, belts in the pulp dryer). The electricity consumption observed in the seven investigated chemical pulp mills range between 0.4 and 0.7 MWh/t pulp, numbers that are fully in line with the figures given in the EU Benchmark Document. From all theoretical considerations as well as from empirical data, the electricity consumption in mechanical pulp mills is significantly higher. Different from chemical pulping, the linkages between the single fibres are not weakened by cooking chemicals. Defibration is entirely based on mechanical work and heat. The electricity consumption of the four investigated TMP and CTMP lines ranged between 1.6 and 2.9 MWh/t, values rather at the lower end of what could be expected according to literature. As outlined some paragraphs above, three of the four mills recovered between 30 and 40% of the electrical energy in the form of steam and hot water. Referring to fibre recovery, the observed consumption (6 lines, 0.1-0.4 MWh/t) again corresponded to the EU Benchmark Documents data. Here, the consumption originates from smaller refiners and numerous pumps.

With regard to paper and board manufacturing, it has been stressed in the context of steam consumption earlier on that basically all paper and board grades are produced in one standard process. This is reflected in the electricity consumption. The variations between mills within one specific grade are bigger than the differences between the grades. Integration does not provide a real advantage for paper and board manufacturing: whereas the pulper in the case of market pulp supply consumes some additional electricity compared to integrated supply, the consumption in further wet end and drying section is equal. The effect of coating, in turn, is observable. Electricity consumption of 18 lines has been investigated. The parameter values range between 0.3 and 0.8 MWh/t with a cluster at 0.7 MWh/t, one single outlier is 1.4 MWh/t. Coating of magazine or printing paper, respectively board, increased the electricity demand by about 0.1 MWh/t.

The observations made looking at the consumption of direct heat, steam, and electricity in the production lines investigated can be summed up as follows:

- Figures are generally in line with what could be expected from literature
- Variations in the different consumption figures are relatively high
- Data gives indications but – as expected and intended – no statistical evidence for differences between different processes, grades, and levels of integration

(2) Energy supply

A description of the energy supply situation of the European pulp and paper industry, in general, and of the investigated mills, in particular, can take at least three perspectives. The first perspective focuses on the sources of primary energy, i.e., on the fuels and disregards the secondary energy (steam and electricity). The second perspective is rather equipment-oriented, i.e., it describes the machinery generating secondary energy from primary. The third perspective focuses on the operator, i.e., it differentiates internal generation and purchase. The subsequent remarks will address the primary energy perspective first and combine a description of equipment and operator (make or buy) afterwards. Beforehand, it needs to be stressed that figures of detailed breakdowns, such as, for example, "source of primary energy by level of integration", may be misleading. Where correlations exist, they are described verbally, but again: the investigation is not striving for statistical evidence.

Sources of primary energy are manifold – solid, liquid, and gaseous – fossil and bio-fuels. The distribution found in the empirical investigation and displayed in Fig. 38 strongly corresponds to the data published by CEPI (see Fig. 31, page 70). Liquid bio-fuels (black liquor from sulphate pulping, respectively red liquor from sulphite pulping) account for more than 40% of total primary energy supply. Solid bio-fuels (mainly bark and sawdust), sludges (from fibre recovery[1] and water treatment), and some bio-gases increase the share of bio-fuels to more than 55%. Half of the remaining fossil energy comes from natural gas, the remainder from coal, oil, and various fuels with negligible share.

[1] Although sludges from fibre recovery often contain some fossil carbon in the form of calcium carbonate, the energy originates from organic carbon only.

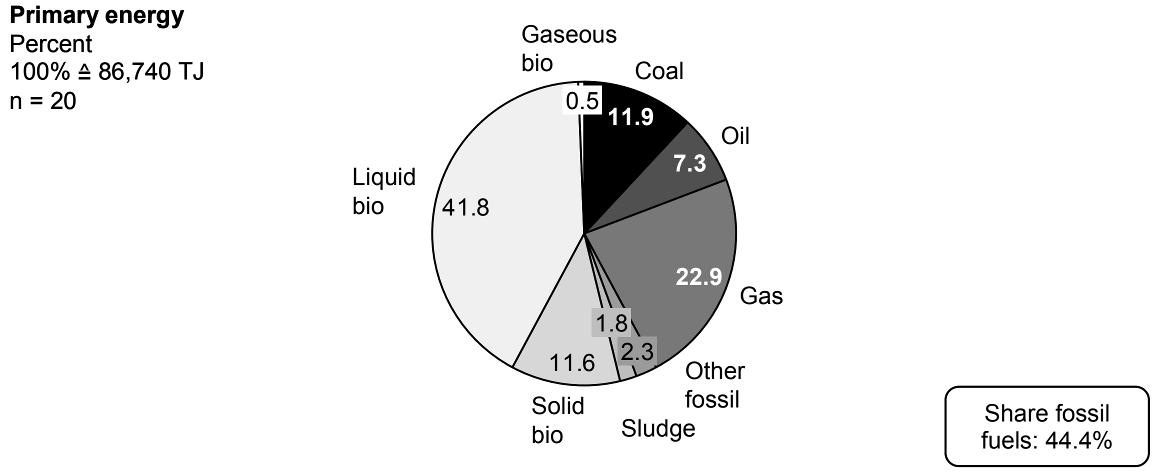

Fig. 38: Sources of primary energy for pulp and paper manufacturing

While the above-mentioned numbers refer to the entirety of all the mills investigated, individual mills are typically focused on a few sources of primary energy. Whereas the design of a stand-alone paper mill leaves some degree of freedom in selecting the fuels, they are rather pre-determined in pulp mills and integrated mills. In all chemical pulp mills, black liquor (respectively red liquor) is the primary fuel, as its combustion is required for recovery of chemicals. Typically, it accounts for about 50% of total primary energy. As bark and some sawdust accrue in the woodyard and some sludge originates from water treatment, these fuels are typically burned in a second boiler. Typically, these solid bio-fuels contribute about 10% to the primary energy supply. Emerging odorous bio-gases are burned rather for disposal than for energy utilisation. The remaining 40% of primary energy originates from fossil fuels – mainly coal, oil, and gas. As mechanical pulp mills have a very limited heat demand, a net excess of steam, and are typically integrated with a line of paper manufacturing (e.g, newsprint or magazine), the sources of primary energy are not pre-determined by the production process. Rather the local fuel supply situation, the year of construction and, of course, the potential combination with another line of (chemical) pulp manufacturing determine whether energy originates from coal, gas, oil or other fuels. Almost an equal degree of freedom exists in the case of fibre recovery. However, as about 20% of recovered paper input is extracted from the process in the form of sludges, other solid fuels (coal) are favoured as they require a similar type of boiler. For paper mills, generalising is more difficult. In fact, the share of bio-fuels in the primary energy supply is low, as basically no bio-fuels occur as by-products in paper manufacturing. Thus, stand-alone paper mills are typically dependent on fossil fuels; natural gas dominates, followed by coal and oil. For integrated mills, however, the above-mentioned consideration remains valid: the combinations with one or more lines of pulp production determine the energy settings.

Switching the perspective from the distribution of primary fuels to equipment and operator, direct heat, steam and electricity will be differentiated – corresponding to the description of energy consumption just given.

With regard to direct heat, the description is simple. Three applications of direct heat have been identified beforehand: lime kiln, pulp and paper dryers, and coating machinery. Lime reburning requires heat originating from liquid fuels, which are injected and burned as a fuel/air mixture. Thus, the predominant fuel used in lime kilns is oil in all specifications from HFO (heavy fuel oil) to LFO (light fuel oil). Some mills also utilise by-products gained during chemical recovery in sulphate pulping, such as turpentine or methanol. However, these bio-fuels do not make up for more than a third of the supply. Many coating machines and some pulp and paper dryers are equipped with gas heated infrared dryers. Another application of direct heat in paper drying is in the above-mentioned Yankee-cylinders, which is typical for tissue machinery. All of this equipment using direct heat for pulp and paper manufacturing is operated by the pulp and paper producer itself. Different to steam and electricity, direct heat is never purchased from or sold to other companies.

Due to the wider dissemination of steam as a heat medium and the much higher energy volumes conveyed, the supply of steam deserves more attention than direct heat. An overview of the steam supply in 21 investigated mills can be found in Fig. 39.

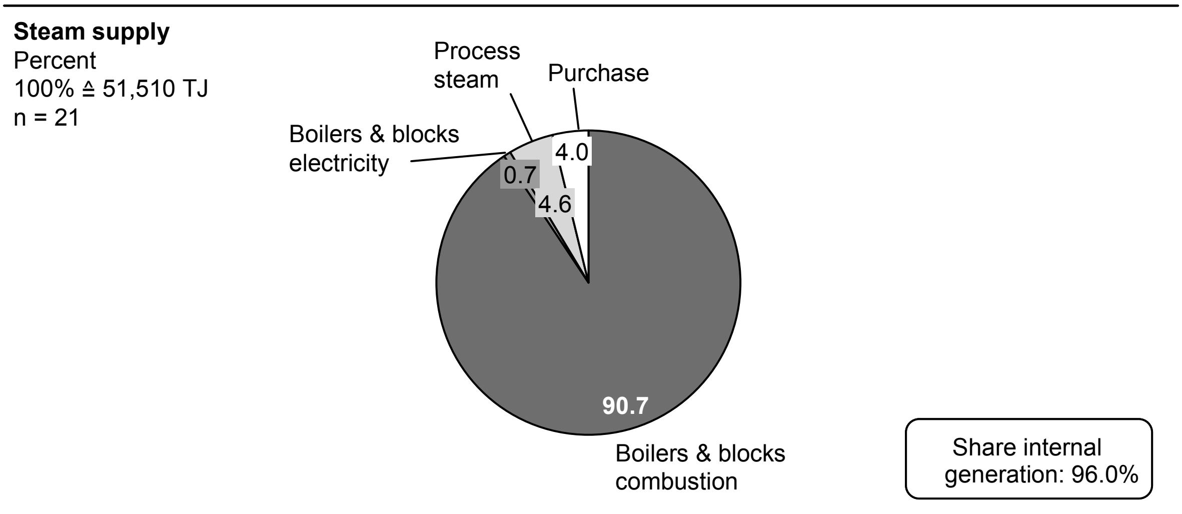

Fig. 39: Steam supply for pulp and paper manufacturing

Generation in combustion-heated boilers dominates with a share of over 90%, electricity-heated boilers accounting for less than 1% can be found in only a few Scandinavian mills, process steam (nearly 5%) occurs in mechanical pulp mills, and 4% of the steam is purchased from neighbouring power plants.

Again, chemical pulping needs to be differentiated from other pulping processes and paper manufacturing. As outlined above, black, respectively red liquor plays a dominant role. Beside the 50% share of entire primary energy, it contains the pulping chemicals which ought to be recovered to the highest possible degree. As recovery would be significantly interfered with if solid fuels were burned together with black or red liquor, at least two boilers are required in chemical pulp mills. One recovery boiler and one stoker-fired boiler can be regarded as the classical configuration since the 1960s: black or red liquor, odorous bio-gases, and sometimes oil – at least in start-up phases – are burned in a recovery boiler. Melted chemicals and ash precipitate as smelt on the furnace floor and are extracted to a dissolving tank for recovery. The heat of combustion generates high-temperature, high-pressure steam (typically 460-510°C, 60-90 bar). The stoker-fired boiler is used in parallel, burning all kinds of solid fuels, such as bark, sawdust, sludges or coal. Typically, it generates steam of the same condition. Although this is the classical configuration, only one of seven investigated chemical pulp mills was limited to these two boilers. One mill even had seven boilers, four had two or more boilers for solid materials, two mills had two or more recovery boilers. As none of the mills was younger than 30 years, the capacities of pulp production have been extended since initial start-up entailing several retrofits of the power houses. More and more stoker-fired boilers for solid fuels are supplemented or replaced by cleaner and more efficient fluidised bed boilers – BFB (bubbling fluidised bed) and CFB (circulating fluidised bed). Pulverised-coal-fired boilers are exceptions anyway, as they do not allow co-burning of the occurring solid bio-fuels (bark, sawdust, and sludge). The regular replacement of classical recovery boilers by black liquor gasification will, by contrast, still take more than a decade, even if the first application on an industrial scale started in 2004 and the electricity yield is significantly higher. Compared to steam generation in chemical pulp mills, the configurations in mechanical pulp mills are much easier. As they have limited steam consumption and even a positive steam balance (stone groundwood gets along without steam), only a single steam block would be required for the start-up phase and for increasing the temperature and pressure of the recovered process steam. Due to the prevailing integration of mechanical pulp mills however – all of the five investigated TMP and CTMP lines were integrated – the complementing lines usually determine the equipment for steam generation. When looking at fibre recovery, the situation is different again. Although the steam demand is low or zero, the occurrence of sludge suggests operation of a boiler for solid fuels. Otherwise, the sludge would need to be disposed of. As fibre recovery lines typically are younger than other pulp mills, CFB boilers are gaining share compared to stoker-fired boilers. Paper manufacturing, finally, has relatively high steam consumption and, thus, requires significant steam generation capacity. The required steam conditions, however, are moderate (often 180°C, 10 bar). Unless integrated with chemical pulp mills, all options for fuels, respectively boilers are feasible. In stand-alone paper mills and fibre recovery/paper combinations, stoker-fired or fluidised bed boilers operated with coal have been observed as well as steam generation subsequent to gas turbines. Two of the investigated mills covered the entire steam demand with purchases from neighbouring power plants. Steam blocks have been found in various mills too, but they have always been designed as support to or back-up for boilers.

Finally, the section on energy supply will be closed with a focus on electricity. An overview of the supply based on 18 investigated mills is given in Fig. 40. Again, the observed distribution is well in line with the numbers for the entire European pulp and paper industry published by CEPI (see Fig. 31, page 70): About one third of the electricity demand is covered by internal generation and two thirds are purchased. With almost 26% the generation in back-pressure turbines dominates the internal generation, gas turbines are the runner-ups with about 4%, condensing turbines and other types (e.g., small-scale hydro turbines) are rather negligible. Purchased electricity, in turn, is typically transferred via the public grid; only two out of 18 investigated mills are directly connected to neighbouring power plants.

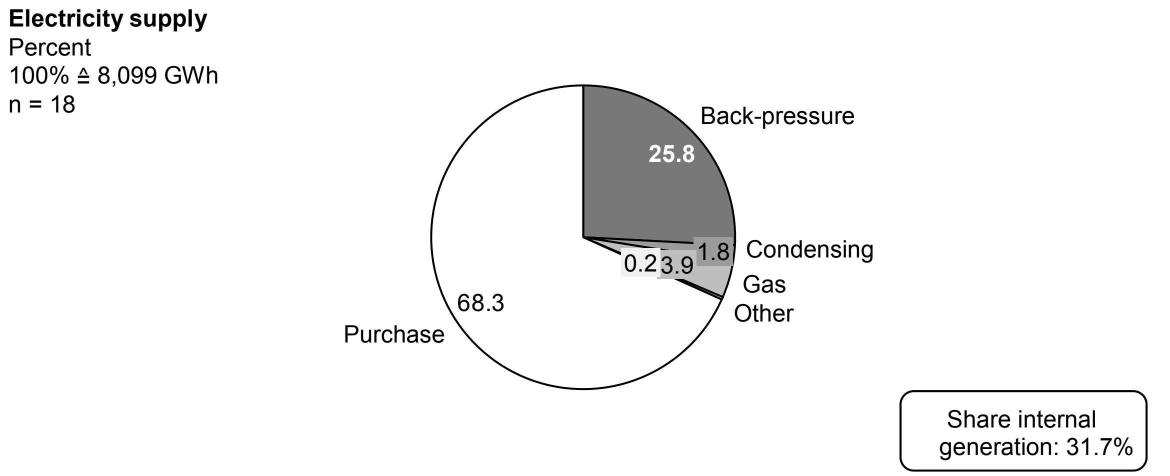

Fig. 40: Electricity supply for pulp and paper manufacturing

As the numbers in Fig. 40 show, internal electricity generation is closely linked to steam generation. Back-pressure and condensing turbines are both fed with high energetic primary steam of typically 460-510°C and 60-90 bar. Whereas back-pressure turbines release secondary or process steam used for various consumers in pulp and paper mills, condensing turbines relax steam down to atmospheric pressure, i.e., they release it as hot water. As pulp and paper manufacturing usually requires the operation of two process steam grids (typically 10 and 3 bar), back-pressure turbines – often allowing extraction (also called "bleeding") at intermediate pressure levels – are widespread in the pulp and paper industry. Less efficient condensing turbines can be regarded as phase-out models. Highly efficient cogeneration in combined gas/steam turbines, in turn, is gaining share.

Due to the close linkage between steam and electricity generation, chemical pulping needs to be differentiated from other pulping processes and paper manufacturing. Whereas in all other processes, steam generation can be designed according to the actual steam demand, the operation of recovery boilers almost inevitably results in the occurrence of high energetic steam. As all heat-consuming process steps in pulp and paper manufacturing require steam at much lower energy levels (at most 12 bar, 200°C), all chemical pulp mills relax the high energetic steam (primary) in back-pressure turbines gaining electricity. All seven investigated sulphate and sulphite mills operate at least one, most of them two or more. Due to efficiency reasons, condensing turbines, still in place in some mills, are used more as back-up than as main sources of internal electricity generation. For all other pulping processes and paper manufacturing, steam generation at process steam conditions would be sufficient. Nevertheless about half of the integrated mills producing mechanical pulp or recovered fibre and paper operate coal, sludge, oil or gas fired boilers and generate electricity from back-pressure turbines. Still rather an exception – but observed in two cases – is the combination of gas turbine and subsequent steam turbine which is highly energy-efficient and significantly subsidised in most European countries. Thus, the share of gas turbines will presumably increase in the European pulp and paper industry, especially in greenfield projects without chemical pulping and in mills which require a retrofit of their power house. Small hydro power turbines, that have been found in three of the 22 investigated mills, and other specialities are not in particular associated with any pulp manufacturing process. They have usually been built historically and nowadays contribute less than 5% to the mills' electricity supply. Although many utility and engineering companies offer operating boilers and turbines of pulp and paper mills on-site, only very few of the manufacturers are using this contracting service so far. In the case of integrated chemical pulp mills where the recovery boiler belongs to the core business, the split-up of steam and power supply causes severe difficulties and, even in less complex settings, pulp and paper producers often fear increasing dependency on utility companies. Due to the two-third share of purchase of electricity supply and significant increases in electricity prices, this fear is obviously not entirely unjustified. Most stand-alone paper mills and two of the investigated integrated mechanical pulp plus paper mills cover their entire electricity demand with purchases; the other mills cover the actual gaps between current demand and current internal generation. Here, direct purchases from neighbouring power plants are exceptions, the transfer via the public medium- or high-voltage grid (30 kV or 110 kV in most European countries) is the standard. Whether this electricity is purchased in a full-service-contract from the local grid operator or energy is sourced from any utility company and transferred via the regional and local grid depends on the liberalisation in the respective country and the companies' choice.

(3) Emission and allocation

The relation between direct CO_2-emissions and actual allocation of emission allowances is one of the key drivers of the direct effects of emission trading (see Fig. 29). Direct emissions originate from combustion of fossil fuels and make-up chemicals. On-site production of PCC can reduce the emissions (see chapter 2.1.3.2). The actual allocation of emissions allowances, in turn, depends on the respective national allocation plan and case-specific exceptions (see chapter 2.1.2.3).

As direct CO_2-emissions in pulp and paper manufacturing mainly depend on the direct and indirect consumptions of steam (indirect consumption via internal electricity generation) and direct heat, on the one hand, and the fuel mix, on the other hand, it would be rather difficult and misleading to name typical or average emissions by process. A summarizing view on the entirety of the investigated mills is indicated.

Whereas bio-fuels account for 55% of energy supply, natural gas, coal, and oil contribute respectively 23%, 12%, 7% (see Fig. 38 on page 108), the distribution of CO_2-emission looks different of course: 39% of the total CO_2-emissions originate from natural gas, almost 36% from coal, and 17% from oil. The remaining 8% are caused by other fossil fuels, such as peat, for example (see Fig. 41). Sludges, make-up chemicals, and PCC at best deserve a mention as "peculiarities": Looking at sludges, virgin fibre sludge and DIP sludge need to be differentiated. The latter typically contains fossil lime from fillers. If it is burned, calcium carbonate splits up into calcium oxide and fossil CO_2. Thus, mill-specific emission factors are required if DIP sludge or other components of recovered paper are burned. Likewise, emissions originating from make-up chemicals and emission savings due to manufacturing of PCC are limited. Looking at the total emissions of the investigated mills, make-up chemicals (mainly sodium carbonate used in sulphate pulp mills) account for 0.4%, while manufacturing of PCC saves 0.7%.

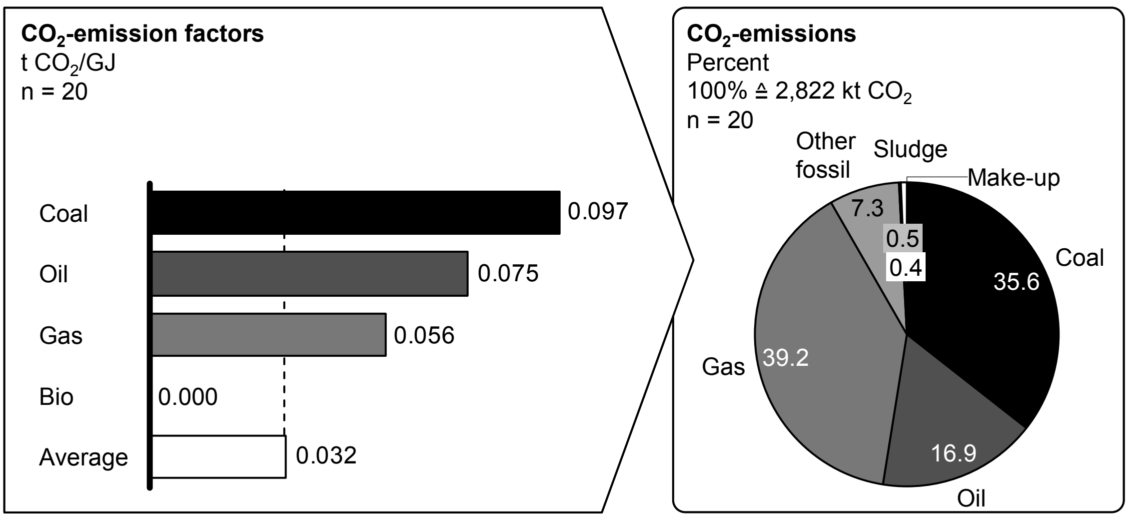

Fig. 41: CO_2-emission factors and emissions by source

Due to the above-mentioned considerations, a special caveat is required referring to the specific emissions. Subsequent numbers do not claim generalisability but provide the reader with an idea of the order of magnitude. The specific CO_2-emissions of 18 investigated pulp mills ranged between 0.00[1] and 0.55 t CO_2/t pulp with an unweighted average of 0.21 t CO_2/t. With regard to paper and board manufacturing, the numbers of 21 mills ranged between 0.00 and 0.76 t CO_2/t pulp with an unweighted average of 0.36 t CO_2/t.

As all emissions need to be covered by emission allowances, the allocation is the counterpart of the emissions described. Other than expected before the investigation, the overall balance considering the entirety of the mills investigated favours the allocation over the emissions: 2.9 Mt CO_2-emissions in the base year are outbalanced by an allocation of 3.5 Mt CO_2. Overall this means an overallocation of 21%. For the individual mills, however, the balances look different. They range from 17% scarcity to 79% overallocation. Four out of 17 mills have received fewer allowances than they would need to cover the emissions of the investigation's base year, while 13 mills have received more than required. In line with Tab. 2 (page 49) all the investigated mills with scarce allocations are located in Western Europe (Germany, Sweden), while all the investigated mills in Eastern Europe (Poland, the Czech Republic, Slovakia, Hungary) have received a significant overallocation. As differentiated in Fig. 29 (page 68), the major drivers for the direct effect of emission trading are the scarcity of emission allowances and the opportunity costs of the emission allowances received for free. Other than expected, scarcity is relevant for only four out of 17 investigated mills. The other 13 mills face opportunity costs of free certificates only and, furthermore, earn additional profit from sales of excess certificates. Costs of scarce allowances do not occur for them.

4.2.2.2 Cost structures

As with the energy structures described in the preceding chapter 4.2.2.1, the cost structures of pulp and paper manufacturing need to be understood prior to modelling and will be outlined in the following paragraphs. Raw materials – fibre and chemicals – as well as energy – fuels and electricity – deserve special attention.

(1) Fibrous raw materials
In upfront considerations, a potential fibre cost increase turned out to have a potentially significant indirect effect on the manufacturing costs of pulp and paper. The mechanisms behind this have been outlined in previous chapters (the dual nature of wood as fibrous raw material and fuel). Some of the interviewees also explicitly stressed this threat. Accordingly, detailed numbers on the consumption and costs of fibrous raw materials have been gathered for all mills. The subsequently displayed numbers provide the reader with an order of magnitude but cannot claim statistical generalisability.

[1] A specific emission of 0.00 t CO_2/t may occur if the process requires no steam supply (partially TMP, CTMP and fibre recovery) or if the steam required is purchased from a neighbouring power plant.

Looking at chemical pulping first, the specific consumption of six investigated mills ranged between 1.79 and 2.23 bdt/t, typical numbers when compared with statistics. At prices between 54 and 89 EUR/bdt, the mills had fibrous raw material costs between 121 and 183 EUR/t, whereas 183 EUR/t was rather an outlier, while the remaining costs ranged between 121 and 147 EUR/t. Due to comparable requirements to the raw material properties and yields (55-60%), significant differences between sulphate and sulphite pulping should not be expected and have not been observed. Semi-chemical pulp, in turn, should have slightly lower fibre costs, as the yield is typically higher compared to chemical pulps (70-90%). The fibre costs of (thermo-) mechanical pulps should be even lower as their yields are close to 100%. The consumption of recovered paper in six investigated lines of fibre recovery ranged between 1.11 and 1.34 t/t. Due to different qualities of consumed recovered paper, the purchase prices ranged between 63 and 90 EUR/t, resulting in fibrous raw material costs between 70 and 117 EUR/t.

Looking at paper and board manufacturing, the specific pulp consumption of 14 investigated mills ranged between 0.77 and 1.08 t/t causing specific costs of fibrous raw materials between 111 and 374 EUR/t. The wide range suggests a differentiation in paper manufacturing processes. Again, two of them will be highlighted. Five of the mills investigated produce writing paper, a category containing significant amounts of fillers. Accordingly, the specific consumptions of pulp (0.77 to 0.91 t/t) were at the lower end of the above-mentioned range. Four of these five mills paid average pulp prices of between 405 and 428 EUR/t resulting in total costs of fibrous raw materials between 316 and 381 EUR/t. One integrated Eastern European mills took advantage of significantly lower pulp prices, resulting in about 250 EUR/t total costs of fibrous raw materials. Comparably higher is the specific pulp consumption in the production of case materials. Due to strength requirements, the use of cheap fillers is tightly limited in this paper grade category. Accordingly, the specific consumption in four investigated lines ranged between 0.93 and 1.08 t/t, resulting in 111 to 191 EUR/t total costs of fibrous raw materials. Specific pulp consumption and costs of other paper and board manufacturing processes range between those of both the processes described.

(2) Chemicals

Like other sectors, the chemical industry faces cost increases due to emission trading. Although chemical installations are not directly – via the industry route – subject to the European emission trading scheme, the industry is affected due to their combustion installations and – even more severely – due to increasing electricity prices. As producers of chemicals pass on a significant share of their cost increase to their customers, pulp and paper manufacturers are affected too. To allow a quantification of the respective indirect effect on the manufacturing costs of pulp and paper, the specific chemicals costs needed to be researched.

In pulp manufacturing, dissolving chemicals such as sodium sulphate (Na_2SO_4) and calcium sulphite ($CaSO_3$) with respective make-up chemicals need to be differentiated from bleaching chemicals such as sodium hydroxide (NaOH), oxygen (O_2), ozone (O_3), hydrogenperoxide (H_2O_2) and chlorine dioxide (ClO_2). Thus, (semi-) chemical pulping and CTMP manufacturing can be separated from all (thermo-) mechanical processes of defibration. The specific costs of chemicals are significantly higher in these processes, compared to processes, which require chemicals for bleaching purposes only. In four investigated sulphite and sulphate lines, the specific costs for dissolving chemicals and bleaching chemicals ranged from 26 to 51 EUR/t, whereas costs in the sulphate mills were at the lower end, costs in the sulphite mills were at the upper end of the range. With specific chemicals costs of 10 and 18 EUR/t the investigated CTMP lines supported the assumption of lower chemical input due to basically thermo-mechanical defibration. Finally, in the fibre recovery lines, the costs of chemicals for floatation and bleaching ranged in the same order of magnitude. In two mills, costs of 12, respectively 14 EUR/t, have been observed.

The most relevant chemicals for paper manufacturing are fillers such as clay ($Al_2Si_2O_5(OH)_4$), natural and precipitated calcium carbonate ($CaCO_3$) and talc ($Mg_3Si_4O_{10}(OH)_2$), and pigments such as titanium dioxide (TiO_2) and starch ($(C_6H_{10}O_5)_n$). Whereas coated papers (magazine, printing) have mineral contents of between 20 and 50%, uncoated papers (especially newsprint and case materials) have very low mineral contents (see Laufmann (1998)). This is of course, reflected in the specific chemicals costs. Five investigated lines of writing paper had chemicals costs between 61 and 96 EUR/t, while costs in three lines of case material ranged between 8 and 37 EUR/t.

(3) Fuels

Specific fuel costs of pulp and paper are driven by the respective consumption of steam and direct heat, the fuel mix, and fuel prices. Detailed descriptions of consumption and supply – overall and differentiated by process – have been given in preceding chapter 4.2.2.1 paragraphs (1) and (2). Thus, only the price component remains to be considered before an overall perspective of specific fuels costs can be taken. The price can be broken down into net fuels costs (including shipment), on the one hand, and energy, respectively emission taxes, on the other hand. Looking at purchased fuels, the net cost component does not cause difficulties as the respective costs can be gathered from accounting systems. With regard to internally supplied fuels (bark, black liquor, sludges etc.), the situation is different. As these fuels do not cause out-of-pocket expenses, usually no prices are deposited in the accounting systems. Transfer prices – typically based on the energy content – can be calculated, but are subject to wide valuation scopes. Only one out of seven investigated chemical pulp mills had a defined transfer price for black liquor, but none of the mills recovering fibres from recovered paper was able to quantify the value of sludge. Energy and emission taxes of fuels are the second price component to look at. While emission taxes are an exception in Europe – considering the nine countries investigated, only Sweden has such a tax system – energy taxes are have a wide spread due to the respective EU legislation[1]. The EU defines minimum levels for energy and electricity taxes, although the member states can decide to levy higher taxes. Furthermore, nominal and real taxes need to be differentiated as numerous exemptions exist[2]. For this investigation, the real tax payment is considered as relevant. A comparison of energy taxes and emission trading will follow in chapter 4.2.3.

Due to the above-mentioned difficulties, the specific gross fuel costs were available only in a limited number of cases. Thus again, no statistical generalisability can be claimed. Nevertheless, some typical numbers will be listed to provide the reader with an idea of the right order of magnitude of fuel costs in pulp and paper manufacturing.

The only chemical pulp mill with existing transfer prices for black liquor and other internal fuels had specific gross fuel costs of 77 EUR/t. The fuel costs of the remaining six investigated chemical pulp mills – excluding internal fuels – ranged between 10 and 43 EUR/t. As liquid and solid internal fuels typically have a significant share of the primary energy supply in chemical pulp mills, their true fuel costs should end up in the same order of magnitude as displayed for the first mill mentioned. TMP and CTMP mills, in turn, have very limited heat demand and, thus, comparably low fuels costs. This assessment is supported by the investigated TMP and CTMP mills with internal steam generation. Two mills showed specific fuel costs of 1, respectively 2, EUR/t (neglecting the combustion of small volumes of internal sludges.) Looking at fibre recovery, the situation is similar. As the heat demand emerges from disperger and pulp dryer only, mills which are not equipped with these features have zero fuel costs. In the remaining four investigated fibre recovery lines, the specific fuel costs ranged between 1 and 4 EUR/t, although the value of burned sludge needs to be added in all cases.

Compared to the wide spread of specific fuel costs in pulp manufacturing, the costs in paper manufacturing fluctuate rather moderately. Within the limited spread, newsprint should be at the lower end, due to its comparably lower steam demand, and tissue should be at the upper end, due to the expensive gas-fired heating of Yankee-cylinders. As only six of the 22 investigated paper mills were able to quantify their entire specific fuel costs, these assumptions could only be conditionally supported. The specific costs ranged between 26 and 63 EUR/t. If the numbers of nine further mills, which could provide thorough quantifications of external fuels costs only, are investigated carefully and estimates for internally supplied fuels are added, their total specific fuel costs likewise end up at about 20 to 60 EUR/t.

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[1] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity (Council of the European Union, 2003), see chapter 2.1.2.2.

[2] See the German example regarding settlement of energy taxes and pension insurance in chapter 2.1.2.3.

(4) Electricity

About two thirds of the electricity consumption of the European pulp and paper industry is covered by purchases. The numbers published by CEPI (see Fig. 31 on page 70) have been validated empirically in this investigation. Details can be found in Fig. 40 in the preceding chapter 4.2.2.1. While the purchased volumes have been touched on beforehand, the focus of the following section is on the price of electricity. It can be broken down into five components:

- Energy costs
- Grid fees
- Taxes on energy and emissions
- Fees for promotion of generation from RES (renewable energy sources)
- Fees for promotion of CHP (combined heat and power generation)

Depending on the national legislation and the resulting competition in the electricity markets within the EU member states, the magnitude of the overall electricity costs and their above-mentioned drivers vary significantly. Liberalisation has been implemented to different degrees and with quite different results for generation and grid in the single countries. Energy taxes are in place in entire Western Europe – some countries have chosen to apply EU minimum taxes, others levy higher rates and define exceptions – while electricity customers in Eastern Europe are benefiting from a transition period. RES and CHP are also promoted in different ways and with different effects on electricity costs. The subsequent figures, although originating from a limited number of mills each[1], influenced to some degree by differences in consumption patterns, grid levels and purchasing power, give a good indication of the variations between the nine countries investigated.

The actual energy costs of the electricity price were relatively equal across the Scandinavian, Central, and Eastern European countries if two outliers (the Czech Republic at the lower end and Hungary at the upper end) are disregarded. The 2004 power prices ranged between 22.52 and 28.11 EUR/MWh. Scandinavia (Sweden and Finland) was at the lower end of the range, but the difference compared to Central and Eastern Europe was only about 2-3 EUR/MWh.

Other than actual energy costs, the grid fees vary significantly across the investigated mills, even if voltage levels are taken into account. If all fixed and variable grid costs are divided by the supply from the grid, the numbers range between 1.75 EUR/MWh for a mill in Finland to 19.98 EUR/MWh for a mill in the Slovak Republic. Grid fees in all other countries are almost equally distributed within this range. Again, the Scandinavian countries are at the lower end of the range.

[1] This, however, should not be a distorting problem, as grid fees, taxes, and fees for the promotion of RES and CHP are regulated. Thus, they are equal for all mills with the same consumption patterns and access to the same grid level in the country (or region).

In 2004, electricity consumers in Poland, Slovakia and the Czech Republic were still benefiting from the transition phase toward energy taxes. In all other countries, taxes were paid, although real taxes were typically lower than nominal taxes. The lower end of the range was marked by a mill in Belgium with 0.30 EUR/MWh, most countries were below 1.00 EUR/MWh, and the highest real taxes were paid in Finland (4.40 EUR/MWh).

Fees for the promotion of RES and CHP were missing entirely in the Eastern European countries except the Czech Republic. Sweden and Poland have mandatory systems of green certificates; Finland has a voluntary system but finances promotion of RES and CHP recycling through energy taxes. Mills in other countries can benefit from international green certificate systems, but have no direct costs in purchased electricity. In Germany and Austria, the fees actually paid for RES and CHP were 4.71 EUR/MWh, respectively 5.16 EUR/MWh, but the fees in the Czech Republic were about 1.24 EUR/MWh.

The summation of the five components results in the effective costs of purchased electricity. While the actual energy costs were relatively equal across the Scandinavian, Central, and Eastern European countries, the total costs of purchased electricity deviate markedly. In Sweden and Finland, the average effective costs were 26.81, respectively 30.36, EUR/MWh. The mills in Central and Eastern Europe, which were not subject to certain special supply situations, paid between 41.83 EUR/MWh and 48.09 EUR/MWh. The average costs for a German mill were 43.58 EUR/MWh. With 53.29 EUR/MWh, the mills in Hungary paid more than twice as much as the Swedish mills – a severe burden for all electricity-intense processes.

(5) Administrative costs

A thorough quantification of all the direct and indirect effects of emission trading requires not only the gathering of actual cost data for raw materials and energy but also an approximation of administrative costs. Here, of course, no actual data from the base years could be used. Thus, the interviewees were asked for estimates. As outlined in chapter 4.2.1, all of the mill representatives interviewed reported administrative efforts associated with the introduction of emission trading and expected further efforts due to the obligation of annual emission reporting. Moreover, they differentiated internal and external administrative costs. They assumed that the magnitude of these costs primarily depend on the complexity of the mill's energy supply situation, i.e., on the number of combustion installations and variety of fuels, while the number of pulp and paper production lines and the respective production volumes were assumed to have only limited relevance. However, an in-depth quantification proved to be difficult. About half of the interviewees abstained from estimating these internal and external costs entirely, while estimates provided by the other half seem to be of limited construct validity. For upfront as well as for recurring costs, numbers between a few thousand and 150,000 EUR per mill were stated. It was obvious that most interviewees had no substantiated idea of upfront and recurring annual costs or provided consciously exaggeratedly high numbers. This problem was solved by applying equal default numbers for all mills (see chapter 4.2.2.4.2.1).

4.2.2.3 Scenarios

As outlined explicitly in chapter 4.1 (see page 101), the investigation aims to answer three key questions regarding the effects of emission trading on the pulp and paper industry and its options to benefit from inherent upside potentials and minimise downsides. The quantification, reflecting the second hypothesis and the subject of the existing chapter 4.2.2, uses a model according to the mechanics displayed in Fig. 29 (page 68). It requires both mill-specific input variables and the definition of general scenario variables. While the first (energy consumption and supply, fuel mix, fibrous and raw materials input etc.) has been described in the previous section, the latter will be the focus of the following paragraphs.

Seven scenario variables or groups of scenario variables need to be defined to allow modelling of all the direct and indirect effects of emission trading contained in Fig. 29 (page 68):

(1) Price emission allowances
Drivers for and development of emission allowance prices have been extensively discussed in chapter 2.1.2.4. Since the actual launch of the European emission trading scheme, prices moved within a range of 6.62 EUR/t CO_2 (January 14th 2005) and 32.58 EUR/t CO_2 (April 19th 2006) in 2005 and 2006. Only very recently, in January 2007, prices of 2007 EUAs fell below the former bottom level. However, 2008 and 2009 EUAs are still quoted at 11.80 EUR/t CO_2 and appear to have bottomed out. For the scenario, parameter values between 5 and 40 EUR/t CO_2 will be assumed. 5 EUR/t CO_2 is the very low end of all recent projections (see Tab. 3 on page 59). Actual prices have not fallen below this level during the last two years with the exception of a very recent decline in 2007 EUA prices. Future prices will presumably be significantly higher. The European allowance market will become scarcer – reduced allocations in the phase II vs. growing economies – and even project-based allowances (ERUs and CERs from JI and CDM project) will have a lower price limit and transaction costs. 40 EUR/t $CO_{2,}$ in turn, is at the very high end of all recent projections. So far, prices have never exceeded 33 EUR/ t CO_2 – at current energy prices a ceiling mechanism seems to take effect if the 30 EUR/ t CO_2 level is reached. While another 10 EUR/ t CO_2 are conceivable during the next few years (with rising oil and gas prices but constant coal prices), prices above 40 EUR/t CO_2 are highly improbable. At comparably limited trade volumes, increasing volumes of project-based allowances have a price ceiling.

(2) Degree of free allocation

Apart from the price of emission allowances, the costs of scarce allowances and opportunity costs of allowances received for free both depend on the relation between allowances allocated free of charge and actual CO_2-emissions. Before the company perspective is taken, some words need to be said about the macro-allocation, i.e., about the allocation principles on a national level. Here governments have some degrees of freedom but one obligation. The degrees of freedom refer to the total allocation volume and the actual allocation mechanism. They can choose between grandfathering – potentially considering various special effects (early action, growth, new entrants etc.) – benchmarking, and auctioning. Furthermore, they can treat different sectors in different ways. In the case of grandfathering, for example, a different fulfilment factor could be applied to the energy sector and the pulp and paper industry. Irrespective of these degrees of freedom, one obligation is binding: EU Directive 2003/87/EC[1] decrees that at least 95% of the certificates need to be allocated for free in phase I and 90% in phase II. As Tab. 1 (see page 47) illustrates, only four countries have used the option of auctioning and 21 countries have allocated all certificates for free. Switching to the company perspective, it becomes obvious that these 90 or 95% do not determine the degree of free allocation for a mill. It is rather determined by the industry-specific fulfilment factor or benchmark, development of production and specific emissions. Whether 5 or 10% of a national allocation is auctioned is far less relevant than the decision whether a fulfilment factor for the respective sector is 0.98 or 0.85. Thus, an orientation to the Kyoto targets is more appropriate. With Council Decision 2002/358/CE[2], the European Community has obliged itself to meet the Kyoto target of 8% emission reduction by 2010 compared to 1990. As a consequence of the associated burden-sharing agreement, the member states have individual emission targets of between 79% and 127% compared to the 1990 emission levels. In addition to these differences in the target levels, economies and emissions have developed differently in the enlarged EU since 1990. Thus, in 2003 the deviations from the 2010-Kyoto target ranged between +24% (Austria) and -58% (Lithuania). The EU15's emissions were 4.7% above target, the accession countries' emissions 25.2% below target[3]. Assuming that the pulp and paper industries have developed as the economies and should bear the same burden as all other sectors, the degrees of free allowance allocation could be derived directly from these numbers. In this case, mills in Western Europe could receive 95.3% of the allowances required in the base year of this investigation, mills in Eastern Europe even 125.2%. A country-specific differentiation of free allocations, as well as disproportionate contributions of the pulp and paper industry compared to other sectors, is also conceivable for the scenarios.

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Parliament and Council of the European Union, 2003c)

[2] Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder (Council of the European Union, 2002)

[3] Report COM(2005) 655 from the Commission Progress towards achieving the Community's Kyoto target (Commission of the European Communities, 2005c)

Last but not least, the actual allocations according to the national allocation plans (2005-2007) are valuable as they reflect the effective exposure.

(3) Price increase fibrous raw materials
Wood and recovered paper, respectively pulp, are the fibrous raw materials for pulp, respectively paper, production. As outlined in detail in chapter 2.1.3.2, the prices of these input factors may increase significantly as a result of emission trading. Wood and recovered paper have a dual nature as fibrous raw materials and CO_2-free fuels; pulp manufacturing is directly and indirectly affected by emission trading and cost increases could be passed on. The potential price increases are scenario variables in the model.

Wood and recovered paper are – or could be – substitutes for solid fossil fuels such as coal and peat. Most combustion installations designed for coal- or peat-firing can be operated with wood and recovered paper too, as the examples from Finland and the Czech Republic illustrate impressively (see chapter 2.1.3.2). Both wood and recovered paper are attributed with very low emission factors – zero in the case of wood, on average 0.0007 t CO_2/GJ in the case of recovered paper[1] – whereas the average CO_2-load of coal is 0.096 t CO_2/GJ, of peat even 0.106 t CO_2/GJ. Considering few prerequisites (see chapter 2.1.3.2 again), the liberated allowances – about two per ton of coal – significantly increase utility companies' paying power for wood and recovered paper.

Looking at wood first, three cases need to be differentiated for the parameter values of the scenario variables. (1) If wood had been a competitive fuel compared to coal and peat already ahead of emission trading, the difference in specific emissions would be fully reflected in the wood price (increase about 35 EUR/bdt at 20 EUR/t CO_2 allowance price). (2) If even the additional paying power, due to liberation from emission allowances, does not make wood a competitive fuel compared to coal and peat, the prices will remain constant (increase 0 EUR/bdt). (3) If the additional paying power makes wood competitive compared to coal and peat, the prices will increase moderately (increase between 0 and 35 EUR/bdt at 20 EUR/t CO_2 allowance price).

Basically the same consideration applies to recovered paper. However, one caveat is required: the EU and European pulp and paper industry have agreed upon a self-commitment obliging the industry to ensure a recycling rate of paper and board products of at least 56% by 2005 (CEPI and ERPA, 2000). Meanwhile, the first self-commitment has been replaced by a new target for 2010: 66% recycling of paper and board consumed in Europe (CEPI and ERPA,

[1] Due to fossil carbon in fillers. Calculation based on filler market data provided by Laufmann (1998), FAO statistics on paper production (FAO, 2006), and calorific values published by the Vienna University of Technology (Hofbauer, 2006).

2006). Accordingly, material recycling generally prevails over thermal use[1]. Although theoretically already a small share of thermal use could be price-setting for the entirety of recovered paper, a somewhat moderate execution of the above-mentioned additional paying power should be assumed. Otherwise, the self-commitment would probably be replaced by a stricter political instrument – potentially prohibiting thermal use entirely.

Looking at paper production, the price increase in the input factor pulp strongly depends on the producers' ability to pass on direct and indirect cost increases. Although the internal and external pulp supply could be differentiated theoretically, both sources should be treated equally; transfer prices should be in compliance with market prices. Thus, again two polar cases and all parameter values in between are possible. (1) If pulp prices are determined by non-European suppliers, they remain constant after introduction of emission trading. (2) If pulp prices are determined by European producers, who are all affected to about the same degree by emission trading, and pricing is based on marginal manufacturing costs, the cost increases are fully passed on. (3) If the prerequisites of neither afore-mentioned case are fulfilled, some of the cost increase will be passed on and pulp prices will increase moderately.

(4) Price increase chemicals

Chemicals are an important cost factor in pulp and paper manufacturing. In 19 of 25 investigated production lines, they accounted for 6-13% of total manufacturing costs. Thus, chemical price increases significantly affect costs and the profitability of pulp and paper manufacturing. As outlined in more detail in chapter 4.2.2.2 paragraph (2), the production of chemicals is often affected directly and indirectly by emission trading. Direct effects originate from combustion installations of the chemical industry, whereas indirect effects arise from electricity price increases. According to official German statistics (Statistisches Bundesamt of the Federal Republic of Germany, 2006), energy costs have shares of between 5% and 20% of the total manufacturing costs of different pulp and paper chemicals. Thereof, purchased electricity accounts for 3% (pigments) to 14% (lime). Considering that direct effects on chemicals are minor compared to indirect effects – an assumption that is supported by many rationales – and that cost increases are passed on to customers, electricity price increases may cause price increases in pulp and paper chemicals of up to 6%. For the parameter values of the scenario variables, the share of electricity costs and the ability to pass on cost increases will be varied.

[1] The self-commitment obliges the industry not to make extensive use of the degrees of freedom EU Directive 2001/77/EC (European Parliament and Council of the European Union, 2001) allows. Its definition of biomass, whose combustion is promoted, implicitly also includes recovered paper, whereas some subsidiary national legislations, in turn, explicitly exclude recovered paper (e.g., German Biomass Regulation (Biomasseverordnung, (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2001))). In case of a full switch-over in the European waste treatment strategies from the prevalence of physical to the prevalence of thermal utilisation, the prices of recovered paper would increase significantly, of course. This, however, appears highly unlikely.

(5) Price increase fuels
As illustrated in Fig. 29 and extensively discussed in chapter 2.1.3.2 fuel price increases may be an indirect effect of emission trading on the pulp and paper industry. Again, fossil fuels need to be differentiated from bio-fuels.

From theoretical considerations, the prices of fossil fuels should decline somewhat with the introduction of emission trading. Due to numerous arguments listed in chapter 2.1.3.2 however, this effect will not be observable in practice. Thus, for all calculations, prices of fossil fuels are kept constant.

Another differentiation is required when looking at bio-fuels. Occurring liquid and gaseous bio-fuels and sludges can be summed up in one group. They accrue as by-products in pulp and paper manufacturing and are typically neither purchased nor sold but burned internally. Although they have an – even significant – value as fuels, they do not cause any out-of-pocket costs. These costs are fully allocated to the fibrous raw materials. Thus, liquid and gaseous bio-fuels and sludges can be neglected when thinking about fuel price increases. The situation of solid bio-fuels is different. A part of these accrue as by-products too; some solid bio-fuels, however, are purchased just for energetic use. This share is subject to the same price increase in fibrous raw materials, as noted in paragraph (3) above. Again, two polar cases and all parameter values in between are possible.

(6) CO_2-intensity electricity generation
The emission intensity of electricity generation and the ability to price in opportunity costs of emission allowances received for free are the two most relevant drivers for electricity prices. While the ability to pass on opportunity costs strongly depends on the – rather intangible – competition intensity on the electricity markets, the CO_2-intensity is quite fact-based. Due to the grid structures, the Scandinavian electricity market (Nordel) and the continental European market (UCTE, Union for the Coordination of Transmission of Electricity) need to be differentiated. The average CO_2-intensities for coal, oil, and gas are well known by country, respectively market, (Reinaud, 2003). Solely the price-setting marginal power plants in the merit orders may be subject to debate – here we return to competition intensity again. For the utility companies, it makes a noticeable difference whether a clean gas turbine or a comparably dirty hard coal-fired power plant sets the price, i.e., whether opportunity costs for emissions of 0.35 or 0.85 t CO_2/MWh are priced in. Regrettably, the definition of the price-setting marginal power plant bears some difficulties as total consumption varies during the course of a day and the merit orders are rather fragmented at the upper end. Although Antila and Pulkkinen (2004) identify coal-fired power plants as price-setting for the Nordic and the central European market, both gas and oil are relatively close and may be price-setting too at times. Beside the three values of coal, oil, and gas the average emission intensities of the

Nordel, respectively UCTE market, – considering also wind, hydro, and nuclear – are conceivable as parameter values for the scenario variables.

(7) Degree of pricing in marginal allowances in electricity prices

The last but highly important scenario variable is the degree to which the costs of a marginal allowance can be priced in into electricity prices (for the pricing mechanism, see chapter 2.1.2.4). This degree strongly depends on the competition intensity in the electricity markets, a determinant which is not very tangible. At the end of 2006, actual baseload electricity prices had come down to about 40 EUR/MWh, according to the EEX quotation, respectively 33 EUR/MWh on the Nordic market, after peaks close to 70 EUR/MWh in both November 2005 and August 2006. Actual price developments can be found in chapter 2.1.3.2. Utility companies justify the price increase primarily due to increased fuel costs and the introduction of emission trading. The fuel cost effect unquestionably exists as the Europe Brent Spot Price has increased by almost half since 2004[1] and fuel costs dominate the short-run marginal costs of the price-setting power plants. Regrettably, the exact split into the fuel component and the emission trading component is not feasible without knowing the utility companies' calculations. Applying reasonable assumptions for emission intensity of the marginal power plant and its share of fuel costs on short-run marginal costs, however, the effect of emission trading can be estimated. Depending on the assumptions, between 30 and 100% of the marginal allowance is priced in.[2]

In the paragraphs above, seven scenario variables from (1) price of emission allowances to (7) degree of pricing in marginal allowances in electricity prices have been outlined with their polar cases of potential parameter values. Theoretically, solely polar cases and one or two intermediate values per parameter would allow more than a hundred different scenarios. Due to existing unilateral and mutual dependencies between parameters, however, the actual number can be reduced significantly without leaving out important settings. Three scenarios – "best case", "most likely", and "worst case" – can be regarded as a best compromise between reflecting the entirety of the future economic environment' potential settings, calculability, and interpretability. The illustration of modelling results will inevitably evoke the question whether the European pulp and paper industry could operate under the conditions of the "worst-case" scenario. There are good reasons to argue that it could not. Nevertheless, the results are described in chapters 4.2.2.4 ("most-likely" scenario), 4.2.2.5 ("best-case" scenario), and 4.2.2.6 ("worst-case" scenario), while further reaching conclusions are not drawn until chapter 5.

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[1] According to the US Energy Information Administration the European Brent Spot Price increased from 38.27 USD/barrel (30.81 EUR/barrel) on average in 2004 to about 55 USD/barrel (42 EUR/barrel) early 2007 (EIA, 2007).

[2] This is in line with the "preliminary evaluation" the German Federal Cartel Office made for the electricity prices RWE charged its industrial customers in 2005 (Bundeskartellamt of the Federal Republic of Germany, 2006).

The summary of the three scenario cases can be found in Tab. 4, rationales for the single parameter values follow at the beginning of each subsequent chapter (4.2.2.4-4.2.2.6).

Scenario variable	**Unit**	**Best case**	**Most likely**	**Worst case**
Price emission allowances	EUR/t CO_2	5.00	20.00	40.00
Degree of free allocation	%	max (actual[1], 100)	actual	min (actual[1], Kyoto[2], 100)
Price increase in fibrous raw materials				
Softwood	EUR/bdt	0.00	18.26	73.05
Hardwood	EUR/bdt	0.00	17.33	69.33
Recovered paper	EUR/t	0.00	0.00	33.55
Pulp	EUR/t	0.00	50% pass on[3]	100% pass on[3]
Price increase in chemicals				
Pulp chemicals	%	0.0	1.4	3.7
Paper chemicals	%	0.0	2.1	5.6
Price increase in fuels				
Fossil fuels	EUR/GJ	0.00	0.00	0.00
Sludges	EUR/GJ	0.00	0.00	0.00
Solid bio-fuels	EUR/GJ	0.00	0.96[4]	3.84[5]
Liquid and gaseous bio-fuels	EUR/GJ	0.00	0.00	0.00
CO_2-intensity electricity generation				
UCTE countries	t CO_2/ MWh	0.371	0.861	0.861
Nordel countries	t CO_2/ MWh	0.332	0.966	0.966
Degree of pricing in marginal allowances in electricity prices	%	50	75	100

[1] Average annual allocation for 2005-2007
[2] Allocation required to meet national Kyoto target
[3] 50% respectively 100% pass on of average manufacturing cost increase of all pulp lines investigated (differentiated by process)
[4] Effective 0.24, as only 25% of solid bio-fuels are specifically purchased for energetic use
[5] Effective 1.92, as only 50% of solid bio-fuels are specifically purchased for energetic use

Tab. 4: Parameter values of scenario variables

4.2.2.4 Effects under "most-likely" scenario

In chapter 4, the results of the empirical part of the investigation are displayed. The first hypothesis on the initial key question (see page 101) has been validated in chapter 4.2.1: there are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe. The second hypothesis, referring to the magnitude of these effects, is the subject of the current chapter 4.2.2. Energy and cost structures have been described in chapters 4.2.2.1, respectively 4.2.2.2, and scenarios for modelling defined in chapter 4.2.2.3. Thus, chapter 4.2.2.4 is targeted at illustrating the actual effects on manufacturing costs under the "most-likely" scenario. An overview of "typical values" for these effects can be found in Tab. 5, Tab. 6, and Tab. 7 (pages 144-146), whereas note shouldbe taken of the introductory remarks. The mechanics presented in Fig. 5 (see page 16) and levers differentiated in Fig. 29 (see page 68) provide the structure for the display. As pointed out beforehand, a display oriented at manufacturing processes, levels of integration or countries would be feasible alternatively but were not too meaningful. Case study research provides qualitative instead of quantitative evidence. Thus, all noteworthy specifics of the processes etc. are highlighted within the lever-oriented structure. The quantifications for "best-case" and "worst-case" scenarios follow in chapters 4.2.2.5 and 4.2.2.6.

4.2.2.4.1 Summary "most-likely" scenario parameters

The scenario "most likely" combines the parameter values of all seven groups of scenario variables which have the highest occurrence probability within a perspective of two to three years (2005-2007). Of course, the afore-mentioned conditions of individual justifiability and the consideration of dependencies are met.

(1) Price emission allowances
The allowance price of 20 EUR/t CO_2 is close to the centre of justifiable parameter values and used as a base case in many recently published model calculations on emission trading. It is slightly above the current market price level of 15-18 EUR/t CO_2 but e.g., fully in line with the recent phase II price forecast of Dresdner Kleinwort of 19.50 EUR/t CO_2 (Patel and Schumacher, 2007).

(2) Degree of free allocation
In the "mostlikely" scenario, each mill received exactly as many allowances as actually allocated for the first emission trading phase (2005-2007).

(3) Price increase fibrous raw materials
Softwood and hardwood gain competitiveness as fuels compared to coal and peat with the introduction of emission trading. Thus, the differences in specific emissions are partially (assumption: 50%) reflected in price increases. Considering an allowance price of 20 EUR/t CO_2 given emission factors and calorific values result in price increases of about 18 EUR/bdt of wood. Thermal use of recovered paper is still hindered by the industry's self-commitment. Pulp manufacturers face direct as well as indirect cost increases but are limited by non-European producers in their attempts to pass on cost increases. Thus, in all pulp grades (only) 50% of the manufacturing cost increase is passed on to paper manufacturers.

(4) Price increase chemicals
As purchase of electricity is an important cost factor of chemicals and electricity prices increase significantly in the "most-likely" scenario, the manufacturing costs of pulp and paper chemicals also increase. As European producers compete with non-EU imports, they only manage to pass on 50% of their cost increase, resulting in a price increase of 1.4% for pulp chemicals, respectively 2.1% for paper chemicals.

(5) Price increase fuels
The prices of fossil fuels presumably remain unaffected by emission trading. Sludges, as well as liquid and gaseous bio-fuels accrue internally only and are neither purchased nor sold. Solid bio-fuels, however, gain competitiveness as fuels compared to coal and peat with the introduction of emission trading (see above). Thus, the differences in specific emissions are partially (assumption: 50%) reflected in price increases of about 1 EUR/GJ. 25% of these

solid bio-fuels are purchased specifically for energetic use, the remaining 75% occur as by-products in the woodyard (bark, sawdust etc.).

(6) CO_2-intensity electricity generation
In the "most-likely" scenario, coal-fired power plants set the electricity price. Thus, the CO_2-intensities are 0.861 t CO_2/MWh for the UCTE countries, respectively 0.966 t CO_2/MWh for the Nordel countries.

(7) Degree of pricing in marginal allowances in electricity prices
In the "most-likely" scenario, the competition between the utility companies is limited. They manage to pass on 75% of the cost of the marginal allowance to the customers. Although the pass-on percentage is above the 25% ceiling German Cartel Office proposed in the RWE case, it is assumed that the ceiling does not take effect.

4.2.2.4.2 Gross effect "most-likely" scenario

4.2.2.4.2.1 Direct effect

The direct effect of emission trading has three main levers: costs of scarce emission allowances, opportunity costs of allowances received for free, and administrative costs which are covered in the following sections.

(1) Scarce emission allowances
According to the theory of emission trading (see 2.1.1.2), the scarcity of emission allowances is the key driver for emission reduction. All other direct and indirect effects are – accepted – side effects. Scarcity of allowances occurs if the actual CO_2-emissions from fuels and make-up chemicals lessened by emission savings from PPC manufacturing exceed the allocation of emission allowances. In the case of an overallocation, the effect is negative, i.e., the mill can make additional profit from selling unused allowances. However, one caveat is required at this point: other than in the extensive theoretical background of emission trading in chapter 2.1.1.2, identified but not yet implemented CO_2-savings measures have not been taken into account in the existing calculation of the effect of scarce emission allowances. Hardly any mill management was in the position to provide and quantify respective measures. Thus, it has been decided to leave besides the few identified and quantifiable measures in the calculation in order to maintain the highest possible generalisability. Accordingly, the calculated direct effect and subsequent gross and out-of-pocket effects need to be interpreted as "business-as-usual", i.e., prior to all the actions described in chapter 5.2.

For each mill, the effect of scarce emission allowances emissions originating from fuels depends on direct heat, steam, and electricity consumption and the respective fuel mix. The energy structures observed have been described in detail in chapter 4.2.2.1. In contrast with emissions, the allocation and allowance price are the two scenario variables influencing the effect of scarce emission allowances. Thus, the different scenarios need to be considered when quantifying the effect of scarce emission allowances.

The "most-likely" scenario is calculated with the actual allocation of emission allowances for the phase 2005-2007 and an allowance price of 20 EUR/t CO_2. Looking at pulp manufacturing, the effect of scarce emission allowances ranges from 0.64 EUR/t cost increase to 7.46 EUR/t cost decrease. Considering paper manufacturing, the range is 0.54 EUR/t cost increase to 10.19 EUR/t decrease.

Synthesising the results of the calculations, three drivers are cardinal for the effect of scarce emission allowances referring to fuels. (1) The higher the consumption of internally generated direct heat, steam, and electricity is, the more severe the effect of scarce allowances is – either as a cost increase or decrease. Thus, chemical pulping is affected significantly more than all other pulping processes; board and tissue face higher exposure than the other paper grades. (2) The higher the share of fuels with high emission factors in the fuel mix, the more severe the effects of scarce allowances are. Mills burning coal or peat are more vulnerable to this effect than mills relying on gas or bio-fuels. (3) The location of the mill finally decides whether the effect is positive (manufacturing cost increase) or negative (manufacturing cost decrease). The actual allocation for the phase 2005-2007 is long for all the mills investigated in Eastern Europe, while some of the mills in the EU15 countries are up to 17% scarce of allowances. Thus, while Eastern European mills benefit, Western European mills rather suffer from the effect of scarce emission allowances. Overall, the effect of scarce allocation for fuels bears up- and downsides, strongly depending on the mills' energy configuration and location.

From an all-embracing industry perspective, the scarcity effects arising from make-up chemicals and PCC manufacturing are "peculiarities" compared to the effect outlined above arising from fuels. Make-up chemicals are limited to sulphate pulp mills and even there they account for only a few percent of the total emissions. Accordingly, the effect is minor. Depending on the location (see above), the manufacturing costs of sulphate pulp increase or decrease by a few Cents per tonne. The overall relevance of PCC manufacturing is similar, as only a few mills produce PCC from exhaust gases. Accordingly, the scarce allowance effect of the respective emission saving can be neglected when looking at the entirety of the mills, while it is of relevance for the mills with PCC manufacturing. In one of the mills investigated, almost 30% of the emissions were saved by PCC manufacturing.

(2) Opportunity costs of free allowances

Theoretically, the opportunity costs of allowances received for free are an item in transit for cost accounting. A separate description is valuable, however, as their treatment by utility companies shows. A differentiation into a fuel-induced effect and a make-up chemical-induced effect can be dispensed with without losing accuracy. The effect of make-up, anyway limited to sulphate pulp mills, is always oriented in the same direction as the fuel effect and has a magnitude of less than 5% of the fuel effect. Though, one final clarification of the term opportunity costs is required before beginning the quantification based on different scenarios. In the case of a scarce allocation, the opportunity costs refer to the total number of allowances received for free. In the case of an overallocation, in turn, only the required allocation causes opportunity costs, while the excess allocation can to be regarded as negative scarce allocation. The latter is not required for operation of the installation and, thus, cannot cause opportunity costs.

The "most-likely" scenario is calculated with the actual allocation of emission allowances for the phase 2005-2007 and an allowance price of 20 EUR/t CO_2. Looking at pulp manufacturing, the opportunity costs range between 6.65 and 10.92 EUR/t in the investigated chemical pulp lines, between 0.00 and 0.49 EUR/t in TMP and CTMP lines, and between 0.00 and 3.09 EUR/t in fibre recovery (as noted above, many TMP/CTMP lines and some lines of fibre recovery do not consume external heat). The paper mills investigated show a range of 1.55-15.24 EUR/t based on 19 lines, i.e., excluding those with external steam supply.

As allowances received for free and scarce allowances are complementary, the drivers of the opportunity cost effect are basically the same as for the effect of scarce allowances. Given that the allocation of emission allowances is based on historic emissions (grandfathering), (1) high consumption of internally generated direct heat, steam, and electricity and (2) high shares of fossil fuels with high emission factors in the fuel mix promote high opportunity costs of allowances received for free. Thus again, chemical pulping and board as well as tissue manufacturing – especially in stand-alone mills with coal-fired steam generation – face relatively high cost increases. Compared to the effect of scarce emission allowances, the location of the mill (3) loses a bit of its dominance as a determining factor. Even for the mills located in Eastern Europe, the cap of 100% allocation takes effect in calculating the opportunity costs.

(3) Administrative costs

As described in chapter 4.2.2.2 paragraph (5), most of the interviewees had problems in quantifying upfront and recurring administrative costs of emission trading. About half of the interviewees abstained from estimating these internal and external costs. The others provided estimates ranging from 0.01 to 0.64 EUR/t. These numbers are obviously of very limited construct validity. Some interviewees had no substantiated idea of these costs, others potentially provided consciously exaggeratedly high numbers. Four lines were not charged with administrative costs, as they have no emissions (external supply of steam and electricity).

Thus, an outside-in estimate helps gain a reliable idea of the order of magnitude. Assuming upfront administrative costs of 50,000 EUR for the entire mill, 25,000 EUR recurring costs, and an annual production of 300,000 t of all products, the specific upfront costs are 0.17 EUR/t and the specific recurring costs 0.08 EUR/t. The real administrative costs for pulp and paper manufacturing ought to be within a range of minus 50% to plus 100% of these outside-in estimates.

(4) Total direct effect

The total direct effect of emission trading on the manufacturing costs of pulp and paper consists of the costs of scarce emission allowances, the opportunity costs of emission allowances received for free, and administrative costs (see Fig. 29 page 68). As all three levers have been described in the previous paragraphs, the presentation of the total direct effect may be somewhat condensed. Due to the missing, respectively vague, estimates on administrative costs made by the interviewees, the following quantification resorts to the outside-in estimates.

As noted above, the "most-likely" scenario is calculated with the actual allocations for the phase 2005-2007 and an allowance price of 20 EUR/t CO_2. According to this scenario, the investigated chemical pulping lines bear gross direct costs of emission trading of 2.19-11.28 EUR/t (1.1-3.1% of manufacturing costs based on seven lines), mainly driven by the opportunity costs of allowance received for free. The effect on TMP and CTMP manufacturing is still moderate. Heat and steam demand are very limited, in some lines actually zero. Furthermore, some of these mills do not operate their own boilers but cover their entire steam demand with purchases. Thus, the direct effect of emission trading is limited in these processes. The costs of three investigated lines increase 0.31-0.78 EUR/t (0.1-0.4%), a fourth line benefits from external steam supply. Fibre recovery lies in between chemical pulping and TMP respectively CTMP if steam is required for the disperger. In five investigated lines with internal steam supply, the direct effect ranges from 0.35 to 2.66 EUR/t (0.4-1.7%), whereas the comparably high effect on the most severely affected lines originates from fibre drying for sale as market pulp. Looking at paper manufacturing, the spread in cost increases becomes relatively wide. While the least affected mill with internal steam generation faces a cost increase of 0.79 EUR/t (0.1%), the costs of the most severely affected mill increase by 15.49 EUR/t (respectively 5.0% of manufacturing costs). Variance primarily originates from energy intensity and fuel mix.

The afore-mentioned numbers are listed to provide the reader with the realistic orders of magnitude they should expect for the total direct effect of emission trading on the various pulping processes and paper manufacturing. Though, as already stressed beforehand, they do not pretend statistical generalisability. As in all qualitative research, generalisability can only be reached analytically. Thus, the following paragraphs aim at synthesising the mechanics behind the direct effect.

Looking at pulp manufacturing, the direct effect of emission trading on manufacturing costs is significant in chemical pulping (2-3% in the "most-likely" scenario), moderate in fibre recovery (1-2%), and comparably minor in all mechanical, thermo-mechanical and chemi-thermo-mechanical pulping processes (less than 1%). Looking at paper manufacturing, the effect varies significantly. Some mills are affected severely (up to 5%), others only marginally (less than 1%). General influencing factors are, first of all, energy concept and country. While mills generating steam and electricity internally may be affected severely, mills purchasing all energy are hardly vulnerable to the direct effect. Mills located in Eastern Europe tend to benefit from a sufficient or long allocation, while mills located in Western Europe rather suffer scarcity of allowances. Beyond these general drivers, however, a differentiation of the pulping processes and paper manufacturing is required.

In chemical pulping, the largest share of the direct effect originates from the opportunity costs of allowances received for free. Scarce emission allowances and administrative costs rather play a subordinate role. Accordingly, the individual energy intensity of the production and the mix of fuels, besides from black liquor, determine the direct effect. Nevertheless, the country as the main driver for the allocation must not be disregarded.

The mechanical, thermo-mechanical, and chemi-thermo-mechanical pulping processes function with comparably limited amounts of direct heat and steam. In many cases, the process steam generated from mechanical work is even sufficient to meet demand. Accordingly, emissions from combustion of fuels are very limited too. Thus, neither the opportunity costs of allowances received for free nor scarce allowances play an important role here. Administrative costs – if a combustion installation exists – account for a significant share of the limited direct effect.

The situation is somewhat similar in fibre recovery. Some lines function without any heat or steam, others, operating a disperger for fibre treatment, have a steam demand that is limited compared to chemical pulping or paper manufacturing. Nevertheless, the opportunity costs of allowances received for free dominate the direct cost effect. Thus again, the individual energy intensity of the production and the mix of fuels drive the cost increase.

Paper manufacturing requires significant amounts of steam in the drying section. Newsprint typically has the lowest, board the highest demand. Additional direct heat may be used in the drying section too (Yankee cylinder for tissue manufacturing) and in coating machines (printing and magazine paper). Thus, CO_2-emissions can be relatively high, especially if steam is generated from coal or other fossil fuels in stand-alone paper mills. Accordingly, the opportunity costs of allowances received for free and costs of scarce allowances dominate the direct effect of emission trading. Administrative costs contribute rather marginally to the manufacturing cost increase.

4.2.2.4.2.2 Indirect effect

The indirect effect of emission trading has two main levers: the price increase in raw materials – comprising fibrous raw materials and chemicals – and the price increase in energy – comprising fuels and electricity which are described in the following sections.

(1) Price increase raw materials
(a) Fibrous raw materials
Looking at fibrous raw materials, wood and recovered paper need to be differentiated from pulp. Whereas prices of wood and recovered paper may increase due to their dual nature as raw material and fuel (see chapter 2.1.3.2), pulp prices may rise if manufacturers manage to pass on their manufacturing cost increases.

As noted above, in the "most-likely" scenario, wood and recovered paper are considered as becoming competitive fuels compared to coal and peat through emission trading. However, thermal use of recovered paper is still hindered by the industy's self-commitment. Hence, the prices of wood increase by approximately 18 EUR/bdt depending on calorific values, while the price of recovered paper remains constant. According to the specific fibre consumption of the different pulping processes, the manufacturing costs of pulp increase significantly. In the investigated chemical pulp mills (specific consumption ranges between 1.79 and 2.23 bdt/t, see chapter 4.2.2.2 paragraph (1)), the effect on manufacturing costs is 32.68-38.93 EUR/t (or 8.2-19.2% of manufacturing costs). Due to the significantly higher yield in TMP and CTMP manufacturing (the same applies to all mechanical pulping processes), the cost increase in these processes is about 17 EUR/t (ca. 8%). In fibre recovery, the manufacturing costs remain unaffected.

As outlined above, the potential fibre price effect on the manufacturing costs of paper originates from the pulp manufacturers' ability to pass on their cost increases. Although an in-depth discussion of the pass-on capability will not follow until chapter 5.2.7 (see action (96)), a scenario-based quantification of the fibre cost effect on paper can already be given. Thereby, each scenario refers to two drivers: (1) the manufacturing cost increases of the investigated and specifically relevant pulping lines calculated, based on the same scenario assumptions, and (2) the assumed pass-on-capabilities.

In the "most-likely" scenario, the manufacturing costs of pulp increase significantly and the producers manage to pass on 50% of the cost increase to paper producers. A significant share of the pulp cost increase originates from rising fibre prices. Solely recovered fibre almost remains unaffected, as recovered paper, the raw material of recovered fibre must not be used thermally and, thus, does not increase in price. Accordingly, the fibre price effect on the manufacturing costs of paper strongly depends on the pulp mix used. Papers consisting entirely of recovered fibre (and fillers) remain almost entirely unaffected by a fibre cost increase, while papers containing a high share of primary pulp face significant fibre cost increases. This theoretical pattern was fully validated by the results of the model. Four investigated paper and board lines, using solely recovered fibre, face cost increases in fibrous raw materials between 0.67-0.78 EUR/t (0.1-0.3%). The remaining ten lines, each primarily using primary pulp, have to bear fibre cost increases of 10.65-19.12 EUR/t (1.9-5.8% of manufacturing costs). If – to test the sensitivity towards this factor – 100% of the cost increase could be passed on by the pulp manufacturers, the manufacturing costs of paper would increase twice as high (21.30-38.23 EUR/t or 3.7-11.7%).

(b) Chemicals

According to Fig. 29 (see page 68), the second indirect effect of emission trading originating from raw materials is the price increase in chemicals. As outlined in detail in chapter 4.2.2.2 paragraph (2) and quantified in chapter 4.2.2.3 paragraph (4) the manufacturing costs of pulp and paper chemicals will increase with the introduction of emission trading. Increasing electricity costs are the primary driver.

As noted above, in the "most-likely" scenario, electricity prices increase significantly and chemicals producers manage to pass on 50% of their cost increase. Accordingly, the prices of pulp chemicals increase by 1.4% and the prices of paper chemicals by 2.1%. As a result, the manufacturing costs of pulp and paper are also affected moderately. Looking at the pulp manufacturing processes first, chemical pulping is affected the most, of course. In six lines investigated, the cost increase ranges between 0.27 and 0.71 EUR/t (respectively 0.1-0.2% of manufacturing costs) if one outlier (0.04 EUR/t) is factored out. Whereas mechanical and thermo-mechanical pulping should by definition not be affected, CTMP has to bear a cost increase of about half the magnitude of chemical pulping. In two investigated CTMP lines, the effect is 0.14 respectively 0.25 EUR/t (0.1%). In fibre recovery, finally, the use of chemicals and the corresponding cost increase depend on the process, respectively on the use of the secondary fibre. If the fibre is used for graphical applications without a preparatory coating of the paper or board, it should be de-inked with the respective chemicals. Otherwise, the use of chemicals can be neglected. Accordingly, some of the mills investigated face manufacturing cost increases of 0.17-0.20 EUR/t (0.1%), while others are not affected. Looking at paper manufacturing, the effect of chemical price increases in the "most-likely" scenario is somewhat more severe but overall still moderate. In 14 investigated mills, it ranges from 0.17 to 2.02 EUR/t (0.0-0.3% of manufacturing costs). Significant differences between paper manufacturing processes cannot be observed, although coated and wet stable papers should be affected slightly more than, for example, newsprint, due to generally higher chemical costs.

(2) Price increase energy

(a) Fuels

The potential fuel price increase resulting from emission trading has been discussed extensively in chapter 2.1.3.2. In chapter 4.2.2.3 paragraph (5), it has been argued why potential effects from fossil fuels, sludges, liquid, and gaseous bio-fuels should not be considered in the scenario-based quantifications. Only price increases in solid bio-fuels are regarded as variables in this respect.

The "most-likely" scenario is based on an allowance price of 20 EUR/t CO_2, a "moderate" price increase in solid bio-fuels (only half of the potential paying power arising from freeing allowances when replacing coal is considered as a price increase) and a 25% share of solid bio-fuels that are specifically purchased for energetic use. Looking at pulp manufacturing, the respective increase in manufacturing costs reaches up to 0.85 EUR/t. Thereby, chemical pulp mills can be differentiated from the other pulping processes. Steam consumption is higher than in the other processes and almost all mills operate a boiler for combustion of solid fuels, as bark and sawdust occur as by-products in the woodyard. Looking at the other pulping processes, in mechanical, thermo-mechanical, and chemi-thermo-mechanical pulping as well as in fibre recovery, steam consumption is very limited and boilers for solid fuels are not essential. – Accordingly, the investigated chemical pulp lines face a higher manufacturing cost increase than the other lines. Six out of seven chemical pulp lines bear cost increases of 0.13-0.85 EUR/t (0.0-0.3% of manufacturing costs), one mill does not operate a respective boiler. In nine investigated TMP, CTMP, and fibre recovery lines, the effect ranges between 0.00 and 0.13 EUR/t. The effect observed in the investigated lines of paper manufacturing, finally, has a higher variance again. 13 out of 20 lines are not affected by a price increase in solid bio-fuels, in the remaining seven lines the additional costs range from 0.05 to 1.14 EUR/t.

(b) Electricity

All theoretical considerations discussed in chapter 2.1.3.2 and illustrated in Fig. 29 (page 68) make it obvious that increasing electricity prices may significantly affect the manufacturing costs of pulp and paper. Again, three scenarios have been calculated, whereas the continental European (UCTE) and the Scandinavian electricity market (Nordel) have been differentiated.

In the "most-likely" scenario, electricity prices increase by 12.92 EUR/MWh (UCTE) respectively 14.49 EUR/MWh (Nordel). Grid fees, taxes on energy and emissions, and all fees for promotion of RES and CHP are kept constant. Accordingly, the manufacturing costs of the investigated chemical pulp mills increase by 1.59-8.47 EUR/t (0.6-2.0% of manufacturing costs), while TMP and CTMP lines have to bear 18.55-37.79 EUR/t (9.3-13.3%), and fibre recovery becomes 0.57-3.23 EUR/t (0.7-1.7%) more expensive. Looking at 18 investigated lines of paper manufacturing, costs increase by 1.62-10.35 EUR/t (0.3-1.6%) due to rising electricity prises. Considering the drivers of these numbers – basically specific electricity consumption and share of external supply – the calculated electricity price effects appear fully generalisable.

(3) Total indirect effect

As shown in Fig. 29 (page 68) and quantified in detail in the paragraphs above, the total indirect effect of emission trading on the manufacturing costs of pulp and paper has four levers: the price increase of raw materials – broken down into fibrous raw materials and chemicals – and the price increase of energy – broken down into fuels and electricity.

In the "most-likely" scenario, all four of the above-mentioned levers take effect. Looking at pulp manufacturing first, the relative manufacturing cost increase is comparable for all processes investigated, although absolute cost increases and their determining levers differ. The six investigated chemical pulp lines face manufacturing cost increases owing to indirect effects of between 35.04 and 46.76 EUR/t (9.1-20.5% of manufacturing costs). The increase is primarily driven by rising fibre prices. This lever accounts for 8.2-19.2% of the manufacturing cost increase or 81% of the indirect effect. Chemicals, fuels, and electricity play a comparably minor role here. The weights of the four levers in mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulping processes are different, although specific and even absolute cost increases are approximately in the same order of magnitude. In two investigated CTMP lines, the indirect effect accounts for 36.62, respectively 39.83 EUR/t (18.3% each). Other than in chemical pulping, where the effect is primarily induced by the fibre cost increase, the contributions of the fibre price increase and electricity price increase both account for about the same in these processes. The effects of chemicals and fuels can again almost be neglected. About the same indirect effect can be expected for TMP and mechanical pulping. Looking at fibre recovery, a significantly lower indirect effect can be observed. In five of the investigated lines, the indirect effect accounts for a manufacturing cost increase of 0.59-3.40 EUR/t (0.7-1.8% of manufacturing costs). The consumption of chemicals and solid bio-fuels is low or even zero, the specific electricity demand is limited, and the prices of recovered paper remain unchanged in the "most-likely" scenario, assuming, that the thermal use of recovered paper remains prohibited. Finally, the manufacturing cost increase of paper depends significantly on the mix of pulps used and the ability of pulp manufacturers to pass on their cost increase. The manufacturing costs of paper made from recovered fibre are by far less affected than those of paper made from primary pulp. The above-mentioned indirect effects on different pulping processes are the primary reason for this. Assuming a 50% pass-on, costs of the four investigated paper lines using solely recovery fibre increase by 2.82-7.82 EUR/t (0.7-1.6%) due to the indirect effect, while the remaining lines using primary pulp face cost increases of 13.51 and 28.92 EUR/t (2.6-7.7%). Here, about 57-81% of the indirect effect originates from the fibre cost lever, the remainder is mainly dominated by increasing electricity costs (9-34%). Chemical and fuel cost increases play a minor role. Accordingly, the cost increase would be significantly higher if more than 50% of the pulp manufacturing cost increase could be passed on. In the case of full pass-on, the costs of paper manufacturing would rise by 24.16-48.04 EUR/t (4.4-13.5% of manufacturing costs). Thus, the ability to pass on the cost increase will be in the focus of chapter 5.2.7.

4.2.2.4.2.3 Total gross effect

The mechanics behind the total gross effect of emission trading is visualised best in Fig. 5 on page 16. It comprises all direct and indirect effects which have been described, quantified, and discussed before, while the value of allowances received for free and potential recovery from a price increase have not yet been deducted. As it is influenced by all the afore-mentioned levers, a detailed discussion of the mechanics behind each value is not reasonable. In case the reader wants to dive deeper into what drives each single value, they ought to look back at the lever-oriented description in chapters 4.2.2.4.2.1 and 4.2.2.4.2.2.

Already in the "most-likely" scenario, the gross cost effect is comparably severe. The six chemical pulp mills investigated are burdened with an additional 37.24-56.05 EUR/t (11.4-22.5% of manufacturing costs). In all the mills, 78-93% of the increase originates from indirect effects, solely 67-88% can be traced back to the fibre cost increase. The contributions of all other levers are comparably minor.

In mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp lines, the gross effect is in the same order of magnitude. In two investigated CTMP lines, costs increase by 37.39, respectively 40.14 EUR/t (18.4, respectively 18.7% of manufacturing costs). The gross effect is primarily (>95%) caused by its indirect levers. Increasing electricity costs account for 50-60% of the effect, 40-50% originates from increasing wood prices. Chemicals, fuels, and all directly acting levers can be almost neglected. Although no fully analysable data sets exist from TMP and mechanical pulp lines, the same should be expected there.

In fibre recovery, the gross effect ranges between 0.93 and 5.55 EUR/t (1.1-2.9%). Due to the comparably small effect, the share of direct and indirect components is non-uniform. While in the mills without steam consumption, the indirect effect (electricity price increase) dominates, the opportunity costs of allowances received for free occur in the other mills.

In paper manufacturing, the supply of fibrous raw material takes a prominent role. Although it is only one among various direct and indirect levers of the gross effect, two respective differentiations will be made under the "most-likely" scenario. It turns out that increasing pulp prices may have a severe effect on paper manufacturing. The first differentiation refers to the pulp mix used. Mills using particularly primary pulp will be differentiated from mills relying solely on recovered fibre. The second differentiation within this scenario refers to the pulp manufacturers' ability to pass on their cost increases. Whereas a 50% pass-on is the basic assumption for the "most-likely" scenario, the sensitivity towards this lever will be described showing the results of a 100% pass-on.

Looking at the ten mills using significant shares of primary pulp and assuming a 50% pass-on first, the gross effect ranges from 19.90 to 41.36 EUR/t (or 3.3-8.6% of manufacturing costs). 68-97% of the gross effect originates from the indirect effect; solely 46-74% can be traced to increasing pulp prices, another 9-33% to electricity. The price increase in chemicals contributes 1-7% of the gross effect and solid bio-fuels 0-3%. Switching to a 100% pass-on, the gross effect increases to 30.55-60.48 EUR/t (5.5-14.4%). As the differences solely originate from the pulp lever, its share rises to 63-85%. Without this lever (0% pass-on), the gross effect on the manufacturing costs of these mills would only be 5.10-22.25 EUR/t.

Looking finally at the four investigated mills primarily relying on recovered fibre, the gross effect ranges between 9.17 and 22.30 EUR/t (2.1-6.2% of manufacturing costs) under the assumption of 50% pass-on of the pulp cost increase. In this group, the picture is less uniform. The direct effect, especially driven by the opportunity costs of allowances received for free, makes up 41-82% of the gross effect. The indirect effect is dominated by the increasing electricity prices which account for 11-45% of the gross effect. The fibre cost increase, in turn, does not play a significant role at these mills. Under the assumption of 50% pass-on, it contributes 3-8% to the gross effect, about as much as the chemical price increase (2-8%). Even a 100% pass-on of the manufacturing cost increase in recovered fibre does not push the fibre cost lever to a noticeable share (7-14%).

4.2.2.4.3 Net effect "most-likely" scenario

As displayed in Fig. 5 (see page 16), the net financial effect of emission trading on pulp and paper manufacturing is calculated from the gross effect by deduction of the opportunity value of emission allowances received for free and recovery from passing on a share of the remaining out-of pocket effect which is described in the following sections.

4.2.2.4.3.1 Opportunity value of emission allowances received for free

The opportunity value of emission allowances received for free mirrors the respective opportunity costs. For each mill, both effects are of the same magnitude, but act in opposite directions. Thus, a detailed display of the results of the model is dispensable with. The reader will find a description and discussion of the respective levers and drivers in chapter 4.2.2.4.2.1 paragraph (2) (page 129).

4.2.2.4.3.2 Out-of-pocket effect

The most important quantification within chapter 4 is the subsequent description and evaluation of the out-of-pocket effect of emission trading on the manufacturing costs of pulp and paper[1]. It is the basis for all the considerations and decisions about passing on cost increases in the form of price increases. While the subsequent pass-on ability and net effect are hard to quantify due to the need for – questionable – assumptions which will not be discussed in detail until chapter 5, the out-of-pocket effect is still logically stringent within the known three scenarios.

A detailed decomposition into the various direct and indirect drivers is dispensable with at this point. It would be redundant – the relative weights of the levers remain unchanged compared to the display of the gross effect – and, moreover, counterintuitive. Due to the overallocation in some mills, the positive and negative levers balance out to some degree, causing some levers to account for more than 100% of the out-of-pocket effect.

Under the "most-likely" scenario, the out-of-pocket cost effect is severe for most pulping processes and many paper mills, therefore many differentiations are required.

In the six investigated chemical pulp mills, the out-of-pocket effect ranges from 27.99 to 47.65 EUR/t (or 8.9 to 19.0% of manufacturing costs). The opportunity values of the free allowances contribute significantly to the limitation of the out-of-pocket effect, as they make up 15-25% of the gross cost increase, respectively 18-33% of the remaining out-of-pocket cost increase.

The out-of-pocket effect on the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp lines is in the same order of magnitude. In two investigated CTMP lines, it is 36.91, respectively 39.97 EUR/t (18.3 respectively 18.4% of manufacturing costs). Comparing these numbers with the gross effect, it instantly becomes evident that the opportunity value of free allowances does not play a role here, owing to the very limited demand for heat or external steam in these processes. Although no fully analysable data sets exist from TMP and mechanical pulp lines, approximately the same out-of-pocket cost increase should be expected there.

In the investigated fibre recovery lines, the out-of-pocket effect is comparably minor. The consumption of steam and electricity is limited and the waste paper price remains unaffected in the "most-likely" scenario. Accordingly, the results of the model range from 0.48 to 3.72 EUR/t (or 0.6-2.0% of manufacturing costs).

[1] In this respect, all internal administrative costs are also regarded as out-of-pocket costs. See caveat in footnote on page 16.

Finally, looking at paper manufacturing, the mills again need to be differentiated by their fibre mix. Whereas the cost increase in primary pulp is quite severe, recovered fibre remains rather moderately affected in the "most-likely" scenario (see above). Accordingly, paper mills depending on primary pulp have to bear higher cost increases than those relying primarily on recovered fibre.

Starting with the ten mills using significant share of primary pulp and assuming a 50% pass-on of pulp cost increase first, the out-of-pocket effect ranges from 10.91 to 29.28 EUR/t (or 1.7-5.5% of manufacturing costs). As in chemical pulping, the opportunity values of the free allowances significantly contribute to the limitation of the out-of-pocket effect, as they account for 5-57% of the gross cost increase, respectively 6-132% of the remaining out-of-pocket cost increase. Switching to a 100% pass-on, the out-of-pocket effect increases to 25.41-48.40 EUR/t (3.9-10.6% of manufacturing costs). Without the fibre cost lever (0% pass-on), the out-of-pocket effect on the manufacturing costs of these mills would be -3.60 to +11.23 EUR/t only (-1.0 to +1.9% of manufacturing costs).

At the four investigated paper lines primarily relying on recovered fibre, the out-of-pocket effect under the "most-likely" scenario is much smaller of course. Assuming a 50% pass-on, it ranges between 1.83 and 8.61 EUR/t (0.4-1.3% of manufacturing costs). The reductions through the opportunity values of free allowances are huge, basically due to the low base. The limited contribution of the fibre cost lever can be seen at the results of 100% pass-on: the out-of-pocket effect increases only very moderately to 2.54-9.38 EUR/t.

4.2.2.4.3.3 Recovery from price increase

As outlined before and shown in Fig. 5 (page 16), the net financial effect of emission trading on the manufacturing of pulp and paper is calculated from the gross effect by deduction of the opportunity value of emission allowances received for free and the recovery from passing on a share of the remaining out-of-pocket effect. The latter has been quantified for all the lines investigated in the previous chapter. Accordingly, pulp and paper manufacturers' capability to pass on a share of the out-of-pocket manufacturing cost increase they face is the key parameter to look at.

Other than the out-of-pocket effect, this ability is hard to quantify. Even very basic price theory makes it evident that the sales volume is a result of the sales price. Depending on demand elasticity, the sales volume decreases to a greater or lesser extent with an increasing sales price. Thus, less sold product units contribute to coverage of the fixed costs. The overall profit of the company is affected, whether positively or negatively depends on the specific circumstances (elasticity, share of fixed costs etc.). Quirion and Hourcade (2004) as well as Reinaud (2005) discuss the effects of price increases applying various demand elasticities ranging between -0.40 and -1.88 referring to earlier publications[1] (see chapter 2.2). Obviously, their considerations are questionable in at least three aspects. (1) Nearly all of them lack a differentiation of product groups but refer to "pulp, paper, printing and publishing" as an entity or pick only one example. (2) The assumed demand elasticities vary significantly, whereas the polar cases require a completely different pricing strategy. (3) Considerations assume a joint pricing decision by the entire industry but neglect the fact that each company may act differently. Thus, they hardly help in determining an "optimal" pass-on percentage.

Due to the aforementioned difficulties, the subsequent quantification of the net effect accepts a "temporary" simplification assuming a 50% pass-on capability across all product categories. The discussion of pricing aspects in chapter 5.2.7 will be much more differentiating.

4.2.2.4.3.4 Total net effect

The net financial effect of emission trading marks the reduction of earnings per unit of product, respectively the target for cost savings measures required to maintain the original level of earnings. However, the volume effect – higher prices typically mean less units of product contributing to coverage of the fixed costs - is factored out here. It will be one of the subjects in chapter 5. The other caveat referring to the subsequent quantification of the net financial effect of emission trading has also been named above: a pass-on capability of 50% is assumed and manufacturer and customer each bear half of the cost increase. In practice, this value is definitely not appropriate for each single pulp or paper category, as chapter 5 will reveal. However, it provides an indication of what the net effect could be. Whoever "knows" or assumes a pass-on-capability different from 50% can easily calculate the respective net effect based on the out-of-pocket cost increase described in chapter 4.2.2.4.3.2. In addition, in order to help assess the sensitivity, the effect of 10% higher or lower pass-on capabilities is described. A breakdown of how much each single direct or indirect lever contributes to the net effect is dispensable with. Chapter 4.2.2.4.2.3 on the total gross effect provides detailed insights in this respect.

Under the "most-likely" scenario, an understanding of the net financial effect of emission trading requires a differentiation of pulp and paper manufacturing processes. Looking at the six investigated chemical pulp mills first, earnings are reduced, respectively cost savings need to be achieved of between 13.99 and 23.83 EUR/t (or 4.5-9.5% of manufacturing costs). A 10% higher or lower pass-on capability accounts for 2.80-4.77 EUR/t (0.9-1.9% of manufacturing costs). In the two investigated CTMP lines, the specific net effect on earnings is 18.45, respectively 19.98 EUR/t (9.2% of manufacturing costs each), whereas a 10% higher

[1] According to Fouquin et al. (2001), a demand elasticity of -0.4 should be applied for exports outside the EU, while imports change by -1.05,. Erkel-Rousse and Mirza (2002) calculate with a demand elasticity of -1.5 for pulp and paper, the GTAP model (2002) applies -1.8. Marsh et al. (2003), consider -1.88 for newsprint.

or lower pass-on capability accounts for 3.69, respectively 4.00 EUR/t (1.8% each). Although no entirely complete data sets of TMP and mechanical pulp mills exist, a net effect in the same order of magnitude should be expected. Energy consumption and supply structures, fibre demand, and other relevant drivers are typically largely comparable. In turn, the net effect on fibre recovery – the last of the investigated pulping processes – not comparable. It is very moderate under the "most-likely" scenario. Assuming a 50% pass-on, the effect on earnings, respectively the requirement for cost savings, ranges from 0.24 to 1.86 EUR/t (0.3-1.0% of manufacturing costs). An additional 10% pass-on capability is 0.05-0.37 EUR/t (0.1-0.2% of manufacturing costs). Finally looking at paper manufacturing, the afore-mentioned differentiation into mills, primarily relying on recovered fibre, and mills, using significant shares of primary pulp, is again required. While the group of four investigated mills primarily relying on recovered fibre faces a net effect of 0.92-4.30 EUR/t (0.2-0.7% of manufacturing costs), the ten remaining pulping lines with significant use of primary pulp have to bear an earnings reduction or to implement savings measures of 5.45-14.64 EUR/t (0.8-2.7% of manufacturing costs). For the first group, an additional 10% pass-on accounts for 0.18-0.86 EUR/t (0.0-0.1%), for the latter group 1.09-2.93 EUR/t (0.2-0.5%).

All the detailed quantifications of the financial effects of emission trading on the various pulping and paper manufacturing processes under the "most-likely" scenario find closure in a recapitulating overview. In contrast with all the figures presented in chapter 4.2.2.4, which indicate ranges of effects observed at individual investigated mills, the subsequent tables Tab. 5, Tab. 6 and Tab. 7 display "typical values" for each lever and process assuming the "most-likely" scenario. This means that a generalisation has been made. The term "typical value" refers to a value that should be expected as normal, characteristic or representative for this lever and process if the technical setting of the mill is typical. The key objective of the subsequent figures is to provide the right orders of magnitude and the specific weights of the levers. It is known and accepted that the "true values" of each pulp or paper mill currently operating in Europe may deviate from these "typical values" by 20% or even more. Statistical evidence neither can nor will be claimed. The values are the results of qualitative not of quantitative research. Furthermore, it needs to be noted that the "typical values" can even be outside the range of observed values for the respective process. This may happen if the investigated cases are for some reason not typical for their respective process. If, for example, only two magazine paper mills could be investigated, both covering their steam demand entirely by purchases (this may occur but is not typical), the observed opportunity costs of allowances employed are very low or even zero. However, opportunity costs of about 6 EUR/t are typical under the "most-likely" scenario.

Tab. 5 provides an overview of the typical values for the financial effects of emission trading on the four main pulping processes along the direct and indirect levers assuming the "most-likely" scenario (in EUR/t as well as in percent of manufacturing costs prior to the introduction of emission trading). More detailed quantifications, also including the other scenarios, can be found in Appendix 5.

Tab. 6 and Tab. 7 give the respective overview for the different paper manufacturing processes also assuming the "most-likely" scenario. Due to the significant weight of the fibre cost lever, supply with primary or virgin pulp is contrasted with supply with secondary pulp (recovered fibre). Again, more detailed quantifications – also including the other scenarios – can be found in Appendix 6.

Scenario: MOST LIKELY Administrative: DEFAULT	Chemical pulping EUR/t	%*	Mechanical pulping EUR/t	%	Thermo-mechanical pulping EUR/t	%	Fibre recovery EUR/t	%
1. DIRECT EFFECT								
Costs of scarce emission allowances	-2.00	-0.6%	0.00	0.0%	0.00	0.0%	-0.40	-0.3%
Opportunity costs of free allowances	9.00	2.6%	0.00	0.0%	0.20	0.1%	1.80	1.4%
Administrative costs	0.25	0.1%	0.25	0.1%	0.25	0.1%	0.25	0.2%
DIRECT EFFECT	**7.25**	**2.1%**	**0.25**	**0.1%**	**0.45**	**0.2%**	**1.65**	**1.3%**
2. INDIRECT EFFECT								
Cost increase fibrous raw materials	36.00	10.3%	17.00	8.5%	17.00	7.7%	0.00	0.0%
Cost increase chemical raw materials	0.50	0.1%	0.00	0.0%	0.20	0.1%	0.10	0.1%
Total cost increase raw materials	**36.50**	**10.4%**	**17.00**	**8.5%**	**17.20**	**7.8%**	**0.10**	**0.1%**
Cost increase fuels	0.50	0.1%	0.00	0.0%	0.05	0.0%	0.05	0.0%
Cost increase electricity	4.00	1.1%	28.00	14.0%	28.00	12.7%	1.50	1.2%
Total cost increase energy	**4.50**	**1.3%**	**28.00**	**14.0%**	**28.05**	**12.8%**	**1.55**	**1.2%**
INDIRECT EFFECT	**41.00**	**11.7%**	**45.00**	**22.5%**	**45.25**	**20.6%**	**1.65**	**1.3%**
3. GROSS EFFECT	**48.25**	**13.8%**	**45.25**	**22.6%**	**45.70**	**20.8%**	**3.30**	**2.5%**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE	**9.00**	**2.6%**	**0.00**	**0.0%**	**0.20**	**0.1%**	**1.80**	**1.4%**
5. OUT-OF-POCKET EFFECT	**39.25**	**11.2%**	**45.25**	**22.6%**	**45.50**	**20.7%**	**1.50**	**1.2%**
6. RECOVERY FROM PRICE INCREASE								
10% Recovery from price increase	3.93	1.1%	4.53	2.3%	4.55	2.1%	0.15	0.1%
50% Recovery from price increase	19.63	5.6%	22.63	11.3%	22.75	10.3%	0.75	0.6%
7. NET EFFECT								
Net effect at 10% recovery from price increase	35.33	10.1%	40.73	20.4%	40.95	18.6%	1.35	1.0%
Net effect at 50% recovery from price increase	19.63	5.6%	22.63	11.3%	22.75	10.3%	0.75	0.6%

* Percent of manufacturing costs

Tab. 5: Financial effects of emission trading on pulp manufacturing processes (Scenario: "Most-likely", typical values)

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: PRIMARY Pass on pulp cost increase: 0.5	Newsprint EUR/t	%*	Magazine EUR/t	%*	Writing EUR/t	%*	Printing EUR/t	%*	Tissue EUR/t	%*	Case materials EUR/t	%*	Board EUR/t	%*	ALL EUR/t	%*
1. DIRECT EFFECT																
Costs of scarce emission allowances	-0.40	-0.1%	-0.40	-0.1%	-0.60	-0.1%	-0.70	-0.1%	-0.80	-0.1%	-0.70	-0.2%	-0.30	-0.1%	-0.60	-0.1%
Opportunity costs of free allowances	6.00	1.4%	6.00	1.0%	7.00	1.0%	9.00	1.4%	12.00	1.7%	9.00	3.0%	4.00	0.7%	8.00	1.5%
Administrative costs	0.25	0.1%	0.25	0.0%	0.25	0.0%	0.25	0.0%	0.25	0.0%	0.25	0.1%	0.25	0.0%	0.25	0.0%
DIRECT EFFECT	**5.85**	**1.4%**	**5.85**	**1.0%**	**6.65**	**1.0%**	**8.55**	**1.3%**	**11.45**	**1.6%**	**8.55**	**2.9%**	**3.95**	**0.7%**	**7.65**	**1.4%**
2. INDIRECT EFFECT																
Cost increase fibrous raw materials	20.00	4.6%	15.00	2.6%	15.00	2.2%	15.00	2.3%	20.00	2.8%	18.00	6.0%	18.00	3.2%	18.00	3.3%
Cost increase chemical raw materials	0.20	0.0%	1.00	0.2%	1.40	0.2%	1.50	0.2%	0.50	0.1%	0.80	0.3%	1.40	0.3%	1.00	0.2%
Total cost increase raw materials	**20.20**	**4.7%**	**16.00**	**2.7%**	**16.40**	**2.4%**	**16.50**	**2.6%**	**20.50**	**2.8%**	**18.80**	**6.3%**	**19.40**	**3.5%**	**19.00**	**3.5%**
Cost increase fuels	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%
Cost increase electricity	5.00	1.2%	7.00	1.2%	5.00	0.7%	7.00	1.1%	9.00	1.2%	4.00	1.3%	8.00	1.4%	6.00	1.1%
Total cost increase energy	**5.10**	**1.2%**	**7.10**	**1.2%**	**5.10**	**0.8%**	**7.10**	**1.1%**	**9.10**	**1.3%**	**4.10**	**1.4%**	**8.10**	**1.5%**	**6.10**	**1.1%**
INDIRECT EFFECT	**25.30**	**5.9%**	**23.10**	**3.9%**	**21.50**	**3.2%**	**23.60**	**3.7%**	**29.60**	**4.1%**	**22.90**	**7.6%**	**27.50**	**4.9%**	**25.10**	**4.6%**
3. GROSS EFFECT	**31.15**	**7.2%**	**28.95**	**4.9%**	**28.15**	**4.1%**	**32.15**	**5.0%**	**41.05**	**5.6%**	**31.45**	**10.5%**	**31.45**	**5.6%**	**32.75**	**6.0%**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE	**6.00**	**1.4%**	**6.00**	**1.0%**	**7.00**	**1.0%**	**9.00**	**1.4%**	**12.00**	**1.7%**	**9.00**	**3.0%**	**4.00**	**0.7%**	**8.00**	**1.5%**
5. OUT-OF-POCKET EFFECT	**25.15**	**5.8%**	**22.95**	**3.9%**	**21.15**	**3.1%**	**23.15**	**3.6%**	**29.05**	**4.0%**	**22.45**	**7.5%**	**27.45**	**4.9%**	**24.75**	**4.6%**
6. RECOVERY FROM PRICE INCREASE																
10% Recovery from price increase	2.52	0.6%	2.30	0.4%	2.12	0.3%	2.32	0.4%	2.91	0.4%	2.25	0.7%	2.75	0.5%	2.48	0.5%
50% Recovery from price increase	12.58	2.9%	11.48	2.0%	10.58	1.6%	11.58	1.8%	14.53	2.0%	11.23	3.7%	13.73	2.5%	12.38	2.3%
7. NET EFFECT																
Net effect at 10% recovery from price increase	22.64	5.3%	20.66	3.5%	19.04	2.8%	20.84	3.3%	26.15	3.6%	20.21	6.7%	24.71	4.4%	22.28	4.1%
Net effect at 50% recovery from price increase	12.58	2.9%	11.48	2.0%	10.58	1.6%	11.58	1.8%	14.53	2.0%	11.23	3.7%	13.73	2.5%	12.38	2.3%

* Percent of manufacturing costs

Tab. 6: Financial effects of emission trading on paper manufacturing processes (Scenario: "Most-likely"; Pulp: Primary; typical values)

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: SECONDARY Pass on pulp cost increase: 0.5	Newsprint		Magazine		Writing		Printing		Tissue		Case materials		Board		ALL	
	EUR/t	%*	EUR/t	%*	EUR/t	%*	EUR/t	%*	EUR/t	%*	EUR/t	%*	EUR/t	%*	EUR/t	%*
1. DIRECT EFFECT																
Costs of scarce emission allowances	-0.40	-0.1%	-0.40	-0.1%	-0.60	-0.1%	-0.70	-0.1%	-0.80	-0.1%	-0.70	-0.2%	-0.30	-0.1%	-0.60	-0.1%
Opportunity costs of free allowances	6.00	1.4%	6.00	1.0%	7.00	1.0%	9.00	1.4%	12.00	1.7%	9.00	3.0%	4.00	0.7%	8.00	1.5%
Administrative costs	0.25	0.1%	0.25	0.0%	0.25	0.0%	0.25	0.0%	0.25	0.0%	0.25	0.1%	0.25	0.0%	0.25	0.0%
DIRECT EFFECT	**5.85**	**1.4%**	**5.85**	**1.0%**	**6.65**	**1.0%**	**8.55**	**1.3%**	**11.45**	**1.6%**	**8.55**	**2.9%**	**3.95**	**0.7%**	**7.65**	**1.4%**
2. INDIRECT EFFECT																
Cost increase fibrous raw materials	0.75	0.2%	0.70	0.1%	0.70	0.1%	0.70	0.1%	0.80	0.1%	0.75	0.3%	0.75	0.1%	0.75	0.1%
Cost increase chemical raw materials	0.20	0.0%	1.00	0.2%	1.40	0.2%	1.50	0.2%	0.50	0.1%	0.80	0.3%	1.40	0.3%	1.00	0.2%
Total cost increase raw materials	**0.95**	**0.2%**	**1.70**	**0.3%**	**2.10**	**0.3%**	**2.20**	**0.3%**	**1.30**	**0.2%**	**1.55**	**0.5%**	**2.15**	**0.4%**	**1.75**	**0.3%**
Cost increase fuels	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%	0.10	0.0%
Cost increase electricity	5.00	1.2%	7.00	1.2%	5.00	0.7%	7.00	1.1%	9.00	1.2%	4.00	1.3%	8.00	1.4%	6.00	1.1%
Total cost increase energy	**5.10**	**1.2%**	**7.10**	**1.2%**	**5.10**	**0.8%**	**7.10**	**1.1%**	**9.10**	**1.3%**	**4.10**	**1.4%**	**8.10**	**1.5%**	**6.10**	**1.1%**
INDIRECT EFFECT	**6.05**	**1.4%**	**8.80**	**1.5%**	**7.20**	**1.1%**	**9.30**	**1.5%**	**10.40**	**1.4%**	**5.65**	**1.9%**	**10.25**	**1.8%**	**7.85**	**1.4%**
3. GROSS EFFECT	**11.90**	**2.8%**	**14.65**	**2.5%**	**13.85**	**2.0%**	**17.85**	**2.8%**	**21.85**	**3.0%**	**14.20**	**4.7%**	**14.20**	**2.5%**	**15.50**	**2.9%**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE	**6.00**	**1.4%**	**6.00**	**1.0%**	**7.00**	**1.0%**	**9.00**	**1.4%**	**12.00**	**1.7%**	**9.00**	**3.0%**	**4.00**	**0.7%**	**8.00**	**1.5%**
5. OUT-OF-POCKET EFFECT	**5.90**	**1.4%**	**8.65**	**1.5%**	**6.85**	**1.0%**	**8.85**	**1.4%**	**9.85**	**1.4%**	**5.20**	**1.7%**	**10.20**	**1.8%**	**7.50**	**1.4%**
6. RECOVERY FROM PRICE INCREASE																
10% Recovery from price increase	0.59	0.1%	0.87	0.1%	0.69	0.1%	0.89	0.1%	0.99	0.1%	0.52	0.2%	1.02	0.2%	0.75	0.1%
50% Recovery from price increase	2.95	0.7%	4.33	0.7%	3.43	0.5%	4.43	0.7%	4.93	0.7%	2.60	0.9%	5.10	0.9%	3.75	0.7%
7. NET EFFECT																
Net effect at 10% recovery from price increase	5.31	1.2%	7.79	1.3%	6.17	0.9%	7.97	1.2%	8.87	1.2%	4.68	1.6%	9.18	1.6%	6.75	1.2%
Net effect at 50% recovery from price increase	2.95	0.7%	4.33	0.7%	3.43	0.5%	4.43	0.7%	4.93	0.7%	2.60	0.9%	5.10	0.9%	3.75	0.7%

* Percent of manufacturing costs

Tab. 7: Financial effects of emission trading on paper manufacturing processes (Scenario: "Most-likely"; Pulp: Secondary; typical values)

4.2.2.5 Effects under "best-case" scenario

Structured in accordance with Fig. 29 (page 68), all direct and indirect, gross and net effects of emission trading on manufacturing costs of different pulp and paper manufacturing processes have been described for the "most-likely" scenario in preceding chapter 4.2.2.4. Chapter 4.2.2.5 gives an overview of the effects under the "best-case" scenario. As the structure of the chapter again follows Fig. 29, some redundancies are inevitable. However, the introductory and summarizing remarks have been minimised compared to chapter 4.2.2.4. The focus is rather the magnitude of the effects than the mechanics behind. The latter can be found in more detail in preceding chapter 4.2.2.4. Any reader with time constraints may prefer a look at Appendix 5 and Appendix 6. The respective tables display ranges of all the effects modelled for the mills investigated and "typical values"[1].

4.2.2.5.1 Summary "best-case" scenario parameters

The scenario "best case" is that combination of parameter values of all seven groups of scenario variables which has the lowest arguable impact on the manufacturing costs of pulp and paper. However, as noted above, two conditions need to be met: (1) each single parameter value must be justifiable by itself. (2) All unilateral and mutual dependencies between the variables need to be considered. The first condition forbids choosing zero for all seven groups of parameter values. This combination would correspond to a fourth scenario called "as is". As some effects of emission trading have meanwhile become undeniable, e.g., increasing electricity prices, the "best-case" scenario differs from the theoretical "as-is" scenario.

(1) Price emission allowances
The parameter value of 5 EUR/t CO_2 is at the very low end of the range of justifiably allowance prices.

(2) Degree of free allocation
The degree of free allocation is a mill-specific scenario variable. In the "best-case" scenario, it is determined by the maximum value of actual annual allocation in the first emission trading phase (2005-2007) and 100%. Thus, all Eastern European mills benefit from an overallocation, while many mills in EU15 countries receive exactly as many allowances as required.

(3) Price increase fibrous raw materials
In the "best-case" scenario, softwood, hardwood, and recovered paper are regarded as not being competitive fuels compared to coal and peat even if the additional paying power from liberation of emission allowances is taken into account. Furthermore, the thermal use of recovered paper is prohibited. Thus, their prices do not increase as an effect of emission

[1] For a definition of the term "typical value", see the end of chapter 4.2.2.4.3.4.

trading. Pulp prices also remain constant, as prices are determined by non-European producers.

(4) Price increase chemicals
According to the "best-case" scenario, the prices of pulp and paper chemicals are determined by imports from outside the EU. Thus, chemical prices do not increase with the introduction of emission trading.

(5) Price increase fuels
The prices of fossil fuels presumably remain unaffected from emission trading. Sludges, as well as liquid and gaseous bio-fuels, accrue internally only and are neither purchased nor sold. Thus only solid bio-fuels remain critical. In this scenario, however, wood and recovered paper are regarded as not being competitive fuels (see above). Thus, their prices do not increase as an effect of emission trading.

(6) CO_2-intensity electricity generation
The upper end of the merit order of electricity generation is relatively fragmented. In the "best-case" scenario, gas turbines set the price – before as well as after introduction of emission trading. Thus, the CO_2-intensities are 0.371 t CO_2/MWh for the UCTE countries, respectively 0.332 t CO_2/MWh for the Nordel countries.

(7) Degree of pricing in marginal allowances in electricity prices
In the "best-case" scenario, the utility companies compete with each other. Accordingly, they do not manage to pass on more than 50% of the cost of the marginal allowance to the customers. This 50% is even calculated based on comparably clean gas turbines as price-determining power plants. Although the pass-on percentage is above the 25% ceiling the German Cartel Office proposed in the RWE case, it is assumed that the ceiling does not take effect.

4.2.2.5.2 Gross effect "best-case" scenario

4.2.2.5.2.1 Direct effect

As noted above, the direct effect of emission trading has three main levers: costs of scarce emission allowances, opportunity costs of allowances received for free, and administrative costs which are described in the following sections.

(1) Scarce emission allowances
In the "best-case" scenario, the price of allowances is low (5 EUR/t CO_2) and the allocation is sufficient or long (see Tab. 4 page 126). Accordingly, none of the mills has costs of scarce allowances and about half of the investigated mills benefit from selling excess emission

allowances. Here, manufacturing cost decreases reach up to 1.87 EUR/t pulp, respectively 2.55 EUR/t paper.

(2) Opportunity costs of free allowances

Due to the sufficient or even "long" allocation, all mills have opportunity costs arising from 100% of the actual emissions. At an allowance price of 5 EUR/t CO_2, this results in opportunity costs between 1.66 and 2.76 EUR/t for the seven investigated chemical pulp lines, between 0.00 and 0.13 EUR/t for the five investigated TMP and CTMP lines, and 0.00-0.77 EUR/t for the seven investigated fibre recovery lines (as noted above, many TMP lines and some lines of fibre recovery do not consume external heat and, thus, have no emissions). Looking at paper manufacturing, the values of 19 investigated lines, i.e., excluding those with external steam supply, range between 0.39 and 3.81 EUR/t based on 19 lines.

(3) Administrative costs

The administrative costs are not affected by the choice of the scenario. Thus, again the outside-in estimates introduced under the "most-likely" scenario have been applied. Assuming upfront administrative costs of 50,000 EUR for the entire mill, 25,000 EUR recurring costs, and an annual production of 300,000 t of all products, the specific upfront costs are 0.17 EUR/t, specific recurring costs 0.08 EUR/t. The real administrative costs for pulp and paper manufacturing ought to be within a range of minus 50% to plus 100% of these outside-in estimates.

(4) Total direct effect

The total direct effect of emission trading on the manufacturing costs of pulp and paper consists of the costs of scarce emission allowances, the opportunity costs of emission allowances received for free, and administrative costs (see Fig. 29 page 68). As all three levers have been described in the previous paragraphs, the presentation on the total direct effect is quite condensed.

In the "best-case" scenario, based on a sufficient or long allocation and an allowance price of 5 EUR/t CO_2, the direct effect on the investigated pulping lines ranges from 0.26 to 3.01 EUR/t if lines without combustion installations are excluded. The effect on chemical pulping is at the upper end of this range (0.74-3.01 EUR/t, respectively 0.3-0.8% of manufacturing costs based on seven lines), mainly originating from the opportunity costs of allowances allocated for free. At TMP and CTMP manufacturing and fibre recovery, the situation is different: heat and steam demand are very limited, in some lines actually zero. Furthermore, some of these mills do not operate their own boilers but cover their entire steam demand by purchases. Thus, the direct effect of emission trading is limited in these processes. In the "best-case" scenario, it ranges between 0.26 and 0.38 EUR/t (0.1-0.2%) for three investigated TMP and CTMP lines, respectively 0.27 to 0.85 EUR/t (0.3-0.6%) in the case of five lines of fibre recovery (mills with external steam supply excluded). In these processes, allocated administrative costs make up for a relevant, partially even prevailing share of the cost increase. Looking at paper manufacturing, the gross direct effect ranges between 0.39 and 3.81 EUR/t (0.1-0.6%), significantly effectuated by the arising opportunity costs but significantly varying owing to differences in energy intensity, fuel mix, and country (allocation).

4.2.2.5.2.2 Indirect effect

As noted in the context of the "most-likely" scenario, the indirect effect of emission trading has two main levers: the price increase in raw materials – comprising fibrous raw materials and chemicals – and the price increase in energy – comprising fuels and electricity which are described in the following chapter/sections/paragraphs.

(1) Price increase raw materials
(a) Fibrous raw materials
Again, wood and recovered paper as raw materials for pulp manufacturing and pulp as a raw material for paper manufacturing need to be considered separately.

Wood and recovered paper are regarded as not being competitive fuels compared to coal and peat in the "best-case" scenario, even if the additional paying power of freed allowances is considered. Furthermore, the thermal use of recovered paper is prohibited. Accordingly, their prices do not increase and the manufacturing costs of pulp remain unaffected.

The out-of-pocket cost increase is very moderate under the "best-case" scenario for all pulping lines investigated, typically below 1 EUR/t. Furthermore, it is assumed that non-European manufacturers determine the pulp price. Accordingly, no cost increase can be passed on and the manufacturing costs of paper remain unchanged in this respect.

(b) Chemicals
According to Fig. 29 (see page 68), the second indirect effect of emission trading originating from raw materials is the price increase in chemicals – primarily driven by increased electricity costs. Although, in the "best-case" scenario, electricity prices and, as a result, the manufacturing costs of chemicals increase moderately only. Furthermore, chemical prices are regarded as being determined by imports from outside the EU. Thus, the manufacturing costs of pulp and paper are not affected and remain unchanged.

(2) Price increase energy
(a) Fuels
The potential fuel price increase resulting from emission trading has been discussed extensively in chapter 2.1.3.2. In chapter 4.2.2.3 paragraph (5), it has been argued why

potential effects from fossil fuels, sludges, liquid, and gaseous bio-fuels will not be considered in the scenario-based quantifications. Only price increases in solid bio-fuels are regarded as variables in this respect. Though, as noted when looking at a potential fibre price increase before, solid bio-fuels are regarded as not being competitive compared to fossil fuels such as coal or peat in the "best-case" scenario, even if the additional paying power of freed allowances is taken into account. Thus, their prices remain unchanged and the manufacturing costs of pulp and paper unaffected.

(b) Electricity

All theoretical considerations discussed in chapter 2.1.3.2 and illustrated in Fig. 29 (page 68) make it obvious that increasing electricity prices may significantly affect the manufacturing costs of pulp and paper. For the calculations, the continental European (UCTE) and the Scandinavian electricity market (Nordel) have been differentiated.

As noted, the "best-case" scenario is based on an allowance price of 5 EUR/t CO_2, regards gas turbines as price setting and assumes that utility companies pass on 50% of the opportunity costs arising from allowances received for free. Accordingly, the electricity prices increased by 0.93 EUR/MWh in continental Europe (UCTE) and 0.83 EUR/MWh in Scandinavia (Nordel). Grid fees, taxes on energy and emissions, and all fees for promotion of RES and CHP are kept constant. Based on these assumptions, the electricity costs of the seven investigated chemical pulp mills increase by a moderate 0.11-0.48 EUR/t, whereas the four investigated TMP and CTMP lines have to bear additional costs of 1.06-2.71 EUR/t (0.5-1.0% of manufacturing costs). Similarly severe increases should be expected for mechanical pulping. The costs of six investigated fibre recovery lines, finally, increase by a moderate 0.04-0.23 EUR/t. Considering the drivers of these numbers – basically specific electricity consumption and share of external supply – the calculated electricity price effects appear fully generalisable. Looking at 18 investigated lines of paper manufacturing, the electricity price effect in the "best-case" scenario ranges from 0.12-0.74 EUR/t (0.0-0.1% of manufacturing costs), again depending on energy intensity and the share of external electricity supply.

(3) Total indirect effect

As displayed in Fig. 29 (page 68) and quantified in detail in the paragraphs above, the total indirect effect of emission trading on the manufacturing costs of pulp and paper has four levers: the price increase in raw materials – broken down into fibrous raw materials and chemicals – and the price increase in energy – broken down into fuels and electricity.

In the "best-case" scenario, the effect on the manufacturing costs of pulp and paper is very limited, as it originates from the electricity lever only which, moreover, has low amplitude. Accordingly, the cost increase of the six investigated chemical pulp mills ranges from 0.11 to 0.48 EUR/t (0.0-0.1% of manufacturing costs). The effect on fibre recovery is even lower. In five mills investigated, the total indirect effect accounts for a cost increase of 0.04-0.23 EUR/t (0.0-0.1%). Due to high specific electricity consumption and primary coverage of these demands by purchases, the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulping processes are affected more severely – but, compared to the "most-likely" and especially "worst-case" scenario, still on a moderate level. The four mills investigated bear a cost increase of 1.06-2.71 EUR/t (0.5-1.0%). The effect on paper manufacturing, finally, is likewise moderate: looking at 18 mills investigated, it ranges between 0.12 and 0.74 EUR/t (0.0-0.1%).

4.2.2.5.2.3 Total gross effect

The mechanics behind the total gross effect of emission trading is visualised in Fig. 5 on page 16. It comprises all direct and indirect effects which have been described, quantified and discussed before, while the value of allowances received for free and potential recovery from a price increase have not yet been deducted.

In the "best-case" scenario, the gross effect of emission trading on manufacturing costs is moderate for pulp as well as for paper. The cost increase is typically well below 1.0% and is, moreover, even dominated by the opportunity costs of allowances received for free. Thus, the out-of-pocket effect is very limited.

Looking at chemical pulping first, the gross effect observed in six mills investigated ranges between 0.87 and 3.33 EUR/t (0.4-0.9% of manufacturing costs). 84-93% of the gross effect originates from the direct levers, mainly the opportunity costs of allowances received for free.

At the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulping processes, the effect is in the same order of magnitude, whereas it primarily originates from increasing electricity costs (70-85%). In two investigated CTMP lines – the TMP lines do not allow a quantification here – the gross effect is 1.44, respectively 1.61 EUR/t (0.7% of manufacturing costs each).

Fibre recovery faces an even lower effect – due mainly to the opportunity costs of free allowances and administrative costs. In five lines investigated, the cost increase ranges from 0.31-0.96 EUR/t (or 0.4-0.7% of manufacturing costs).

Looking at paper manufacturing, finally, the effect is very moderate too. 14 investigated lines have to bear cost increases of between 0.51 and 4.21 EUR/t (0.1-1.4%). As the fibre, fuel, and chemical price effect are not relevant in this scenario, about 80% of the effect originates from the opportunity costs of free certificates with the remaining 20% composed of administrative costs and increasing electricity prices.

4.2.2.5.3 Net effect "best-case" scenario

As displayed in Fig. 5 (see page 16), the net financial effect of emission trading on pulp and paper manufacturing is calculated from the gross effect by deduction of the opportunity value of emission allowances received for free and the recovery from passing on a share of the remaining out-of pocket effect which is described in the following sections.

4.2.2.5.3.1 Opportunity value of emission allowances received for free

As noted under the "most-likely" scenario above, the opportunity value of emission allowances received for free mirrors the respective opportunity costs. For each mill, both effects are of the same magnitude, but act in opposite directions. Thus, a detailed description of the results of the model can be dispensed with. The reader will find the description and discussion of the respective levers and drivers in chapter 4.2.2.5.2.1 paragraph (2) (page 149).

4.2.2.5.3.2 Out-of-pocket effect

To highlight what was noted in the context of the "most-likely" scenario once again: the most important quantification of the effects of emission trading is that of the out-of-pocket increase. It is the basis for all considerations and decisions about passing on cost increases in the form of price increases. While subsequent pass-on ability and net effect are hard to quantify due to the need for – questionable – assumptions which will not be discussed in detail until chapter 5, the out-of-pocket effect is still logically stringent within the known three scenarios.

Under the "best-case" scenario, the effect after deduction of the opportunity values is moderate for pulp as well as for paper. The cost increase is typically well below 1.0%, in many cases below 0.5%, and in a few cases even negative due to an overallocation of emission allowances.

In the six chemical pulp mills investigated, the out-of-pocket effect ranges from -1.50 to +0.73 EUR/t (or -0.8 to +0.2% of manufacturing costs) as the opportunity value of free allowances accounts for 1.66-2.76 EUR/t cost reduction compared to the gross effect.

All mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulping processes, in turn, face a moderate out-of-pocket cost increase. As the consumption of steam is very low or even zero in these processes, the opportunity value of free allowances is rather negligible. It reduces the gross effect only marginally. Accordingly the out-of-pocket effect on the two investigated CTMP mills is 1.31, respectively 1.57 EUR/t (0.7% of manufacturing costs each). Although the data sets of other mechanical- and thermo-mechanical pulping lines are incomplete and, thus, do not allow a corresponding quantification, very similar out-of-pocket cost effects can be expected here.

In the five investigated fibre recovery lines, the effect ranges from 0.18 to 0.48 EUR/t (0.1-0.3% of manufacturing costs). The cost reductions due to the opportunity values are in the same order of magnitude (0.11-0.78 EUR/t where steam is required).

Looking at paper manufacturing, finally, the effect is very moderate too. As in chemical pulping, some of the 14 analysed lines face very low cost increases (up to 0.1% of manufacturing costs), while others benefit from an overallocation of allowances in this scenario (up to 0.6% manufacturing cost decrease). The out-of-pocket cost increase ranges from -1.93 to +0.91 EUR/t. Again, the opportunity value of allowances received for free often exceeds the gross effect, which is low anyway as twelve out of 14 lines receive more emission allowances than they need. The remaining effect primarily originates from increasing electricity costs and administrative efforts.

4.2.2.5.3.3 Recovery from price increase

The difficulties in quantifying pulp and paper manufacturer's ability to pass on cost increases to their customers have also been sketched under the "most-likely" scenario (chapter 4.2.2.4.3.3 page 140). Due to the afore-mentioned difficulties, the subsequent quantification of the net effect accepts a "temporary" simplification assuming a 50% pass-on capability across all product categories. The discussion of pricing aspects in chapter 5.2.7 will be much more differentiating. If the reader sees a contradiction between the 50% pass-on capability assumed for an individual (pulp) manufacturer here and the "best-case" scenario assumption of zero fibre cost increase for paper manufacturers (looking at the market rather than at an individual company), they may wish to omit reading the subsequent chapter 4.2.2.5.3.4 assume 0% pass-on capability, and take the out-of-pocket effect as the total net effect.

4.2.2.5.3.4 Total net effect

Under the "best-case" scenario, the net financial effect remaining after a pass-on of 50% of the out-of-pocket cost increase is absolutely minor in all investigated pulp and paper manufacturing processes or grades. Due to overallocations in many of the mills, a few lines even face a negative net effect which actually ranges between -0.75 and +0.78 EUR/t (-0.4 to + 0.3% of manufacturing costs) in 14 pulping lines, respectively -1.74 and +0.82 EUR/t (or -0.5 to +0.1%) in 14 lines of paper manufacturing. Due to the negligible low numbers, any differentiation of processes, grades, fibre mixes etc. can be omitted. An overview of all the quantifications can be found in Appendix 5 and Appendix 6. The respective tables display the ranges of all the effects modelled for the mills investigated and display "typical values"[1].

4.2.2.6 Effects under "worst-case" scenario

All direct and indirect, gross and net effects of emission trading on the manufacturing costs of pulp and paper have been described for the "most-likely" scenario and the "best-case" scenario in preceding chapters 4.2.2.4 and 4.2.2.5. Thus, this chapter closes with the "worst-case" scenario. Again, the description is structured in accordance with Fig. 29 (page 68). Any reader with time constraints may prefer to look at Appendix 5 and Appendix 6. The respective tables display ranges of all the effects modelled for the mills investigated and "typical values"[1].

4.2.2.6.1 Summary "worst-case" scenario parameters

The scenario "worst case" is that combination of parameter values of all seven groups of scenario variables which has the highest foreseeable impact on the manufacturing costs of pulp and paper. Again, the conditions of individual justifiability and consideration of dependencies are met.

(1) Price emission allowances
The parameter value of 40 EUR/t CO_2 is at the upper end of all recent projections of the allowance prices.

(2) Degree of free allocation
The degree of free allocation is a mill-specific scenario variable. In the "worst-case" scenario, it is determined by the minimum value of actual annual allocation in the first emission trading phase, the allocation required to meet the national target according to the Kyoto Protocol and 100%. Thus, all Eastern European mills receive exactly as many allowances as required, while mills in EU15 countries are up to 19% short of allowances.

(3) Price increase fibrous raw materials
In the "worst-case" scenario, softwood, hardwood, and recovered paper are regarded as fully competitive fuels compared to coal and peat already ahead of emission trading. Thus, the differences in specific emissions are entirely reflected in wood price increases. Considering an allowance price of 40 EUR/t CO_2, given emission factors and calorific values result in price increases of about 70 EUR/bdt of wood. Recovered paper may be used thermally, but certain obligations limit the price increase to 50% of the additional paying power of freed allowances.

[1] For a definition of the term "typical value", see the end of chapter 4.2.2.4.3.4.

Pulp prices are determined by European mills and direct as well as indirect cost increases are fully passed on to paper manufacturers.

(4) Price increase chemicals
Due to very significant increases in electricity prices in the "worst-case" scenario, the manufacturing costs of chemicals rise too. As European producers determine the prices and pass on their cost increases, chemical costs increase by 3.7%, respectively 5.6%.

(5) Price increase fuels
The prices of fossil fuels presumably remain unaffected by emission trading. Sludges, as well as liquid and gaseous bio-fuels accrue internally only and are neither purchased nor sold. Solid bio-fuels, however, are regarded as being fully competitive fuels compared to coal and peat already ahead of emission trading (see above). Thus, an allowance price of 40 EUR/t CO_2 results in almost a 4 EUR/GJ increase in the solid bio-fuel price. 50% of these solid bio-fuels are purchased specifically for energetic use, the remaining 50% occur as by-products in the woodyard (bark, sawdust etc.).

(6) CO_2-intensity electricity generation
Again, coal-fired power plants set the electricity price in the "worst-case" scenario. Thus, the CO_2-intensities remain 0.861 t CO_2/MWh for the UCTE countries, respectively 0.966 t CO_2/MWh for the Nordel countries.

(7) Degree of pricing in marginal allowances in electricity prices
In the "worst-case" scenario, the competition between the utility companies is very limited. They pass on 100% of the costs of the marginal allowance to the customers. Although the pass-on percentage is above the 25% ceiling the German Cartel Office proposed in the RWE case, it is assumed, that the ceiling does not take effect.

4.2.2.6.2 Gross effect "worst-case" scenario

4.2.2.6.2.1 Direct effect

As noted above, the direct effect of emission trading has three main levers: the costs of scarce emission allowances, the opportunity costs of allowances received for free, and administrative costs which are described in the following sections.

(1) Scarce emission allowances
In the "worst-case" scenario, which is based on an allowance price of 40 EUR/t CO_2, potential gains from overallocations have disappeared. Manufacturing costs increase up to 3.90 EUR/t pulp, respectively 3.15 EUR/t paper. In relative terms, this means 0.9%, respectively 0.4%, increases in manufacturing costs.

(2) Opportunity costs of free allowances

Assuming an allowance price of 40 EUR/t CO_2, the cost increase due to allowances received for free accounts for 10.98-21.50 EUR/t (3.9-10.8% of manufacturing costs) at chemical pulping, up to 0.98 EUR/t (0.5%) at TMP and CTMP, and 0.00-6.04 EUR/t (0.0-3.9%) at fibre recovery (some lines of fibre recovery require no steam). Looking at paper manufacturing, the cost increases range from 3.10 to 29.73 EUR/t (0.5-10.3%).

(3) Administrative costs

The administrative costs are not affected by the choice of the scenario. Thus, again the outside-in estimates introduced under the "most-likely" scenario have been applied. Assuming upfront administrative costs of 50,000 EUR for the entire mill, 25,000 EUR recurring costs, and an annual production of 300,000 t of all products, the specific upfront costs are 0.17 EUR/t and the specific recurring costs 0.08 EUR/t.

(4) Total direct effect

The total direct effect of emission trading on the manufacturing costs of pulp and paper consists of the costs of scarce emission allowances, the opportunity costs of emission allowances received for free, and administrative costs (see Fig. 29 page 68). As all three levers have been described in the previous paragraphs and, therefore, the presentation on the total direct effect will be very condensed.

Under the "worst-case" scenario, the direct cost effect of emission trading is significant, especially for chemical pulping and some paper mills. Looking at chemical pulping first, the direct effects account for 13.54-22.30 EUR/t (4.3-11.0%) increases in manufacturing costs. The opportunity costs of allowances received for free are still the predominant driver. In turn, the effect on TMP and CTMP manufacturing is still limited (0.58-1.30 EUR/t, 0.3-0.6%), due to the typically low steam requirement or even steam excess. The effects on the investigated lines of fibre recovery with steam demand range from 1.16 to 6.44 EUR/t (1.4-4.2%). The others are not affected. Focusing finally on paper manufacturing, the cost increase owing to the direct effect of emission trading ranges from 3.35 to 30.74 EUR/t (0.6-10.7%). Again, the opportunity costs are the most important driver.

4.2.2.6.2.2 Indirect effect

Looking at the indirect effect, again the raw materials price increase – fibre as well as chemicals – and the energy price increase – fuels as well as electricity – need to be differentiated.

(1) Price increase raw materials
(a) Fibrous raw materials
For both pulp and paper manufacturing, the "worst-case" scenario reveals the entire vulnerability towards fibre cost increases. Price increases in wood and recovered paper hit pulp manufacturers hard and paper manufacturers, in turn, suffer from pulp price increases.

The "worst-case" scenario, assumes an allowance price of 40 EUR/t CO_2 and full competitiveness of wood and recovered paper as fuels. Recovered paper may be used thermally, but certain obligations limit the price increase to 50% of the additional paying power of freed allowances. Accordingly, the effect on manufacturing costs is very high. The investigated chemical pulp mills would face fibre cost increases of 130.74-155.72 EUR/t (or 32.8-76.6% of manufacturing costs), TMP and CTMP would need to bear an additional 63.85-71.60 EUR/t (29.3-35.7%), and fibre recovery finally would have a fibre cost increase of 37.20-45.06 EUR/t (20.0-47.8%). These numbers instantaneously reveal the high vulnerability of pulp manufacturing in Europe towards the fibre price effect of emission trading.

Looking at paper manufacturing, especially stand-alone paper manufacturers relying on primary pulp are exposed to the effect. A 100% pass-on of the manufacturing cost increase of the consumed pulp grades in the "worst-case" scenario results in fibre cost increases of 42.89-49.39 EUR/t (or 7.7-18.0% of manufacturing costs) in the four paper lines using solely recovered fibre, respectively 105.23-156.59 EUR/t (or 16.1-53.1%) in the other ten investigated lines using predominantly primary pulp. These notably high numbers will be assessed in detail in chapter 5.

(b) Chemicals
The variables of the "worst-case" scenario – allowance price 40 EUR/t CO_2 and full pass-on of cost increases by chemical producers accounting for 3.7, respectively 5.6%, price increase in chemicals – result in moderate manufacturing cost increases also of pulp and paper. In the investigated chemical pulp lines, a cost increase of 0.73-1.90 EUR/t (0.2-0.5% of manufacturing costs, disregarding one outlier). In the CTMP lines, the effect accounts for 0.38, respectively 0.66 EUR/t (0.2/0.3%). Again, fibre recovery splits into lines without de-inking which remain unaffected and others where a manufacturing cost increase of 0.46-0.52 EUR/t (0.2-0.3%) can be observed. In the investigated paper manufacturing lines, the range of cost increases is again wide. The least affected mill has a cost increase of a moderate 0.45 EUR/t (0.1%), while the most severely affected mill bears an additional 5.39 EUR/t (0.7%).

(2) Price increase energy

(a) Fuels

The potential fuel price increase resulting from emission trading has been discussed extensively in chapter 2.1.3.2. In chapter 4.2.2.3 paragraph (5), it has been argued why potential effects from fossil fuels, sludges, and liquid and gaseous bio-fuels will not be considered in the scenario-based quantifications. Only price increases in solid bio-fuels are regarded as variables in this respect.

In the "worst-case" scenario, which is based on 40 EUR/t CO_2, an unrelieved effect of freed allowances on the price of solid bio-fuels and a 50% share of dedicated purchase, the manufacturing cost increases are significant. The chemical pulp mills investigated have to bear cost increases of 1.00-6.77 EUR/t or 0.3-2.4% of manufacturing costs, while the effect on the other pulping lines ranges between 0.00 and 1.02 EUR/t (or 0.0-0.8% of manufacturing costs; zero effect again explained by externally sourced steam). Looking finally at the seven affected paper lines that generate steam (also) from solid bio-fuels, a cost increase of between 0.39 and 9.11 EUR/t (or 0.1-1.6% of manufacturing costs) can be observed.

(b) Electricity

In the "worst-case" scenario, electricity prices increase by 34.44 EUR/MWh (UCTE), respectively 38.64 EUR/MWh (Nordel). The resulting manufacturing cost increases are considerable looking at chemical pulping, fibre recovery, and paper manufacturing and very severe at mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulping. In the chemical pulp mills investigated, costs increase by 4.33-22.59 EUR/t (or 1.5-5.3% of manufacturing costs), while fibre recovery becomes 1.53-8.61 EUR/t (1.8-4.5%) more expensive. Due to high specific electricity consumption and very limited internal electricity generation, the investigated TMP and CTMP lines face cost increases of 49.46-100.78 EUR/t (24.7-35.5%). The 18 investigated paper manufacturing lines, finally, have to bear additional 4.32-27.59 EUR/t (0.8-4.2%).

(3) Total indirect effect

Compared to the "most-likely" scenario, the total indirect effect of emission trading becomes absolutely severe. However, the drivers behind and basically even their relative weights remain the same in the "worst-case" scenario as in the "most-likely" scenario.

The six investigated chemical pulp lines face manufacturing costs increases of between 138.27 and 176.54 EUR/t (35.1-81.1% of manufacturing costs). In two investigated CTMP lines, the indirect effect accounts for 121.66, respectively 128.17 EUR/t (58.8, respectively 60.7%). Similar cost increases can also be expected for mechanical pulp and CTMP. Fibre recovery lines have to bear additional costs of 39.44-54.13 EUR/t (28.5-49.8%). Looking finally at paper manufacturing, a pass-on capability of 100% of the pulp producers is assumed in the "worst-case" scenario. Accordingly, the manufacturing cost increase is severe, especially where primary pulp dominates the fibre mix. While the four investigated mills relying on fibre recovery face cost increases by 50.66-68.17 EUR/t (10.7-20.2%) owing to indirect effects, the cost increases in the other mills range from 115.61 to 182.99 EUR/t (or 18.0-58.5% of manufacturing costs).

4.2.2.6.2.3 Total gross effect

The mechanics behind the total gross effect of emission trading is illustrated in Fig. 5 on page 16. It comprises all direct and indirect effects which have been described, quantified and discussed before, although the value of allowances received for free and potential recovery from a price increase have not yet been deducted.

Under the "worst-case" scenario, all the levers discussed under the "most-likely" scenario remain effective and with slight limitations even their relative weights remain the same. Absolute and specific cost increases, however, are far more severe.

Six investigated chemical pulp mills face a cost increase of 157.02-194.86 EUR/t (or 40.1-92.0% of manufacturing costs) from the gross effect. The wood price increase accounts for 77-88% of this, the opportunity costs of allowances received for free (9-12%) and increasing electricity costs (2-12%) are the second and third most effective levers.

Looking at the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp lines, the gross effect on the investigated CTMP lines is 122.96, respectively 128.76 EUR/t (59.1, respectively 61.4% of manufacturing costs). Increasing fibre costs (50/58 % of the gross effect) and electricity price increase (40/49%) are the two predominant levers of the gross effect. The direct effect as well as the chemical lever and the lever of solid bio-fuels can be neglected. Although TMP and mechanical pulping could not be modelled in this respect, a gross effect in the same order of magnitude should be expected as the exposure to the severe drivers is very similar.

At fibre recovery the gross effect on the five lines investigated ranges from 42.91 to 58.19 EUR/t (30.6-51.2% of manufacturing costs) in the "worst-case" scenario. 88-97% of the effect originates from the indirect levers, whereas solely increasing prices of recovered paper account for 77-93%. The second most severe lever is the electricity price increase, accounting for 4-15% of the gross effect. Whereas chemicals and solid bio-fuels can still be neglected as cost levers, the opportunity costs of the allowances received for free contribute another 2-11%.

Looking at paper manufacturing, the gross effect again mainly depends on the pulp mix. At the ten mills using significant shares of primary pulp and assuming 100% pass-on first, the gross effect ranges from 150.81 to 207.61 EUR/t (or 20.1-66.5% of manufacturing costs). 83-98% of the gross effect originates from the indirect levers; solely 73-85% can be traced to increasing pulp prices, another 3-16% to electricity. With about 2-3% contribution the chemical lever and the 0-3% cost increase in solid bio-fuels can be practically neglected. Finally, looking at the four investigated mills primarily relying on recovered fibre, the gross effect ranges between 66.85 and 96.87 EUR/t (or 15.1-30.9% of manufacturing costs) under the assumption of 100% pass-on of the pulp cost increase. 65-83% of the gross effect is caused by the indirect levers; increasing costs of recovered fibre account for 51-68%. Electricity prices account for another 9-21%.

4.2.2.6.3 Net effect "worst-case" scenario

As illustrated in Fig. 5 (see page 16), the net financial effect of emission trading on pulp and paper manufacturing is calculated from the gross effect by deduction of the opportunity value of emission allowances received for free and the recovery from passing on a share of the remaining out-of pocket effect which is described in the following sections.

4.2.2.6.3.1 Opportunity value of emission allowances received for free

As noted under the "most-likely" scenario above, the opportunity value of emission allowances received for free mirrors the respective opportunity costs. For each mill, both effects are of the same magnitude, but act in opposite directions. Thus, a detailed display of the results of the model can be dispensed with. The reader will find a description and discussion of the respective levers and drivers in chapter 4.2.2.6.2.1 paragraph (2) (page 157).

4.2.2.6.3.2 Out-of-pocket effect

As noted in the context of the "most-likely" scenario, the most important quantification of the effects of emission trading is that of the out-of-pocket increase. It is the basis for all considerations and decisions about passing on cost increases in the form of price increases. Under the "worst-case" scenario, this increase is severe, even for those processes which have been only affected moderately under the "most-likely" scenario.

The six investigated chemical pulp mills face an out-of-pocket cost increase of 138.52-178.07 EUR/t (or 36.1-81.2% of manufacturing costs). The opportunity values of the free allowances reduce the out-of-pocket effect by 9-14%.

The out-of-pocket effect on the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp lines is slightly lower than in the chemical pulp mills. In two investigated CTMP lines, it is 121.98, respectively 128.42 EUR/t (58.9, respectively 60.9% of manufacturing costs). As these numbers differ from the gross effects by less than 1 EUR/t each, it is obvious, that the opportunity value of free allowances does not play a role at CTMP. Although no fully analysable data sets exist from TMP and mechanical pulp lines, approximately the same out-of-pocket cost increase should be expected there.

While the out-of-pocket effect on the investigated fibre recovery lines was very moderate under the "most-likely" scenario, it significant under the "worst-case" scenario too, as the prices of recovered paper increased, due to the limited admission of its thermal use. Thus, the out-of-pocket cost increases of between 39.78 and 54.53 EUR/t (or 28.7-50.1% of manufacturing costs) primarily originate from the fibre cost lever (83-95%).

Finally, looking at paper manufacturing, mills using high shares of primary pulp again need to be differentiated from those using primarily recovered fibre. Starting with the ten mills using significant shares of primary pulp and assuming a 100%-pass-on of pulp cost increase first, the out-of-pocket effect ranges from 115.86 to 183.85 EUR/t (or 18.4-58.9% of manufacturing costs). It is unnecessary to stress that the majority of this out-of-pocket effect originates from rising pulp costs (75-91%). Switching finally to the four investigated paper lines primarily relying on recovered fibre, the out-of-pocket cost increase becomes severe under the "worst-case" scenario too. Effects between 51.57 and 69.50 EUR/t (or 10.9-20.6% of manufacturing costs) can be observed. Again, the difference is mainly caused by the fibre cost increase which accounts for 70-87% of the total out-of-pocket effect.

4.2.2.6.3.3 Recovery from price increase

The difficulties in quantifying pulp and paper manufacturers' ability to pass on cost increases to their customers has also been described under the "most-likely" scenario (chapter 4.2.2.4.3.3 page 140). Due to the afore-mentioned difficulties, the subsequent quantification of the net effect accepts a "temporary" simplification assuming a 50% pass-on capability across all product categories. The discussion of pricing aspects in chapter 5.2.7 will be much more differentiating. Those who see a contradiction between the 50% pass-on capability assumed for an individual (pulp) manufacturer here and the "worst-case" scenario assumption of 100% pass-on in the context of the fibre cost increase for paper manufacturers (looking at the market rather than at an individual company) may wish to omit reading the subsequent chapter 4.2.2.6.3.4, assume a 100% pass-on capability, and regard the total net effect as zero (neglecting the volume effect, of course).

4.2.2.6.3.4 Total net effect

Under the "worst-case" scenario, the net effect is severe on all pulping and paper manufacturing processes. The reduction of earnings, respectively the requirement for cost reductions (potentially the combination of both), in the six investigated chemical pulp mills amounts to 69.26-89.03 EUR/t (or 18.1-40.6% of manufacturing costs). A 10% higher or lower pass-on capability accounts for 13.85-17.81 EUR/t (3.6-8.1% of manufacturing costs). – The net effect on the two investigated CTMP lines is 60.99, respectively 64.21 EUR/t (29.5, respectively 30.4% of manufacturing costs. 10% higher or lower pass-on capability make up for 12.20 respectively 12.84 EUR/t (5.9/6.1%). Again, similar values should be expected for TMP and mechanical pulp mills. While fibre recovery was affected only very moderately under the "most-likely" scenario, the net effect under the "worst-case" scenario" has become significant, too. In the five lines where quantification is possible, it ranges between 19.89 and 27.26 EUR/t (or 14.4-25.1% of manufacturing costs). An additional 10% pass-on capability corresponds to 3.89-5.45 EUR/t (2.9-5.0%). Closing the description of the net effect with paper manufacturing, again two groups of mills need to be differentiated. The earnings of the ten investigated mills using mainly primary pulp are charged with a net effect of 57.93-91.92 (corresponding to 9.2-29.5% of manufacturing costs)[1]. A 10% higher or lower pass-on capability accounts for 11.59-18.38 EUR/t (1.8-5.9%). In the second group of mills, primarily relying on recovered fibre, the net effect is somewhat lower but still severe: 25.78-34.75 EUR/t (or 5.4-10.3% of manufacturing costs). An additional 10% pass-on accounts for 5.25-6.95 EUR/t (respectively 1.1-2.1%).An overview of all the quantifications can be found in Appendix 5 and Appendix 6. The respective tables illustrate the ranges of all the effects modelled for the mills investigated and display "typical values"[2].

4.2.3 Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

As outlined in chapter 4.1, the display and discussion of the results of the empirical part of the investigation in chapter 4 are structured according to the three hypotheses towards the first key question "What is the effect...?" The first and second hypotheses have been treated thoroughly in chapters 4.2.1 and 4.2.2. The third hypothesis, finally, asking about the relevance of emission trading on operational and strategic decision making is the focus of chapter 4.2.3. This assessment of the relevance or relative weight of emission trading on the decision making of pulp and paper companies will be theoretical and by observation, respectively a description of how decisions are made.

The theoretical consideration compares the influenceable energy-related effects of emission trading with the other quantifiable levers of energy costs. These levers are net costs of primary and secondary energy (fuels, respectively purchased electricity and steam), energy and emission taxes, and fees for as well as income from the promotion of RES and CHP. The other environmental political instruments, e.g., the EU IPPC Directive to apply best available

[1] The results are calculated assuming a 100% pass-on capability of pulp manufacturers (according to the scenario definition in chapter 4.2.2.3) but a 50% pass-on capability of paper manufacturers.
[2] For a definition of the term "typical value", see the end of chapter 4.2.2.4.3.4.

techniques, are hardly quantifiable and, thus, will be excluded here. A meaningful overview of the influenceable energy-related effects is provided in Fig. 42.

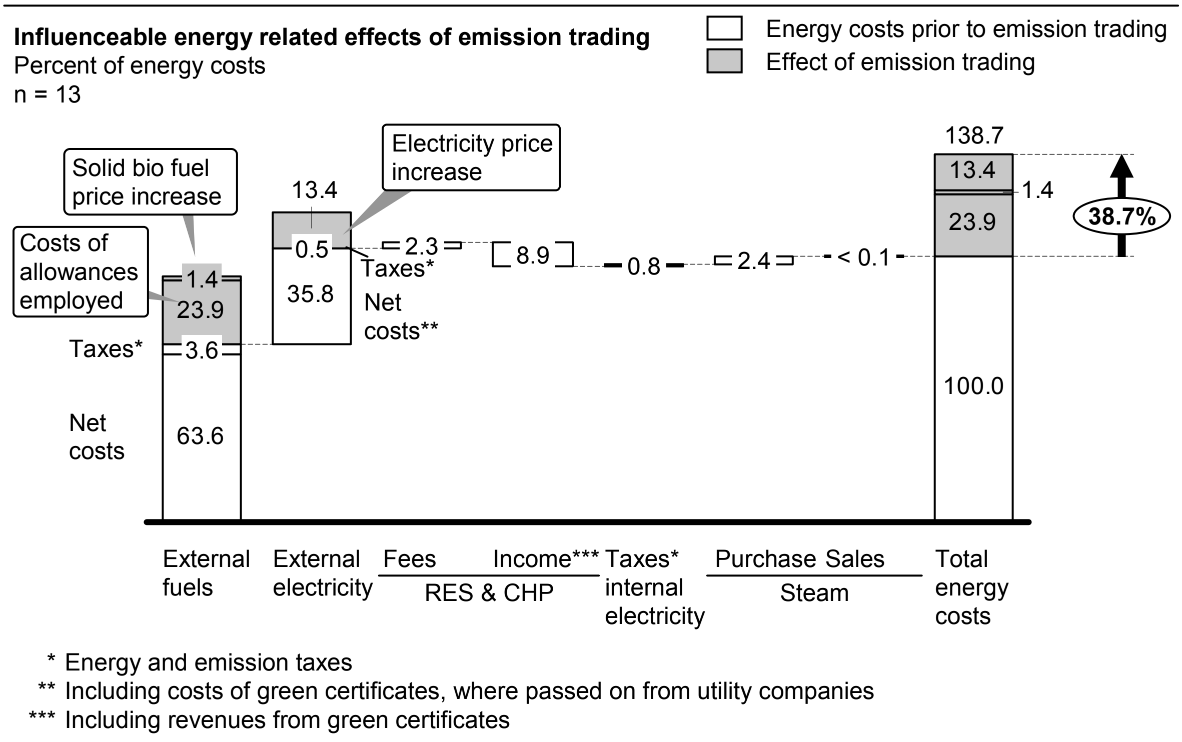


Fig. 42: Effects of emission trading on energy costs ("most-likely" scenario)[1]

Looking at the entirety of the 13 investigated mills, the introduction of emission trading increases total energy costs by 38.7%[2]. This increase originates from three influenceable energy-related effects. Compared to total manufacturing costs, the effect is significantly lower, of course.

The most important – quantitatively as well as with respect to the theoretical intention – are the costs of the allowances employed. They cause an energy cost increase of 23.9% and are the only effect acting as a direct incentive for the reduction of CO_2-emissions. All other effects are accepted side effects, not directly punishing emission of CO_2. However, 99.57% of the employed allowances have been allocated for free and cause opportunity costs only, while just 0.43% need to be purchased and, thus, are out-of-pocket costs. Although 100% of the employed allowances should incentivise the reduction of emissions – all saved allowances can be sold irrespective if they have been allocated for free – the companies may hesitate to reduce emissions significantly due to uncertainty regarding the future allocation mechanism. If the allocation is based on grandfathering – most countries have chosen this mechanism for

[1] Excluding costs for and revenues from powerhouse products (electricity, steam) sold to external customers. Illustrated steam sales originate from excess process steam.

[2] Calculated for the "most-likely" scenario under exclusion of costs for and revenues from powerhouse products (electricity, steam) sold to external customers. An inclusion would only marginally change the effects.

phase I – and the base years for phase II are the years of the first period, emission reductions achieved during the first period may result in lower allocations for the following period (see Bode (2003)). Although this problem can be solved in different ways (perpetuation of early base years, treatment as early actions or benchmarking), the inherent uncertainty hinders the consideration of the entirety of the employed allowances as opportunity costs.

The price increase in purchased electricity – the second biggest effect accounting for an energy cost increase of 13.4% under the "most-likely" scenario – is an accepted side effect only. It does not directly incentivise the reduction of CO_2-emissions. Nevertheless, it is influenceable and promotes electricity saving and efficient cogeneration, both presumably resulting in emission reductions.

The third effect on energy costs that is influenceable is the price increase in purchased bio-fuels. With a 1.4% energy cost increase, it is comparably minor. Only a limited share of the solid bio-fuels is purchased specifically for energetic use, while the larger share accrues as a by-product from fibrous raw material. Again, the effect does not directly incentivise emission reductions.

All other direct and indirect effects of emission trading, which have been illustrated in Fig. 29 (see page 68) and quantified in chapters 4.2.2.4, 4.2.2.5 and 4.2.2.6, are either not energy-related or not influenceable. Thus, they are not relevant for the verification of the third hypothesis.

Although emission trading severely affects the energy costs of the mills investigated – under the "most-likely" scenario they increase by 38.7% - it is only one lever amongst others. The net costs of fuels and purchased electricity have been described in chapter 4.2.2.2, energy and emission taxes as well as fees for and income from the promotion of RES and CHP will be described in the following paragraphs.

In theory emission taxes need to be differentiated from energy taxes (see chapter 2.1.1.4). In practice, however, this differentiation can easily be neglected and both taxes regarded as one. According to Council Directive 2003/96/EC[1], all EU member states have to levy taxes on energy products and electricity. Although the nominal tax levels are significant for the end user, the real burden on industry is moderate in most cases, as almost all countries have introduced exemptions or low ceiling levels for energy-intensive industries. As shown in Fig. 42, energy taxes on fuels account for 3.6% of total energy costs or 5.6% of gross fuel costs in the 13 mills investigated that were able to provide the respective data. Energy taxes on purchased electricity contributed 0.5% to total energy costs or 1.3% of electricity costs. Taxes

[1] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity (Council of the European Union, 2003)

on internally generated electricity, finally, account for another 0.8% of energy costs. Summing up the numbers, energy taxes cause nearly 4.8% of the total energy costs of the mills investigated. In specific costs, this means 0.63-8.67 EUR/t in six lines of chemical pulping (in one of the Eastern European countries, energy taxes had not been introduced in the base year of the investigation). The burden for the two investigated CTMP lines was 0.69, respectively 1.45 EUR/t in the base year 2004; other mechanical and thermo-mechanical pulps should face similar costs from energy taxes. In six lines of fibre recovery, the tax burden in the base year ranged between 0.10 and 1.71 EUR/t. The 16 investigated paper mills, finally, suffer from a more disadvantageous fuel mix. The energy taxes in the base year ranged between 0.67 and 7.16 EUR/t if two mills without internal steam supply and the aforementioned Eastern European mill are excluded.

The promotion of RES and CHP is a political target whose implementation was imposed by the EU on its member states in Directives 2001/77/EC respectively 2004/8/EC[1] (see chapter 2.1.2.2). The applicable political instruments to meet the targets can be seen in Fig. 43. Most relevant are four instruments directly promoting generation of RES, respectively CHP electricity. Feed-in tariffs or a quota for "green" (RES) and "red" (CHP) electricity in combination with respective certificates are used in most EU member states. Tax incentives and tendering are rather exceptions. The financing of the promotion, in turn, can be done using taxes, fees or an "invisible markup" (not explicitly shown) on the electricity price.

[1] Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market (European Parliament and Council of the European Union, 2001) and Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (European Parliament and Council of the European Union, 2004a)

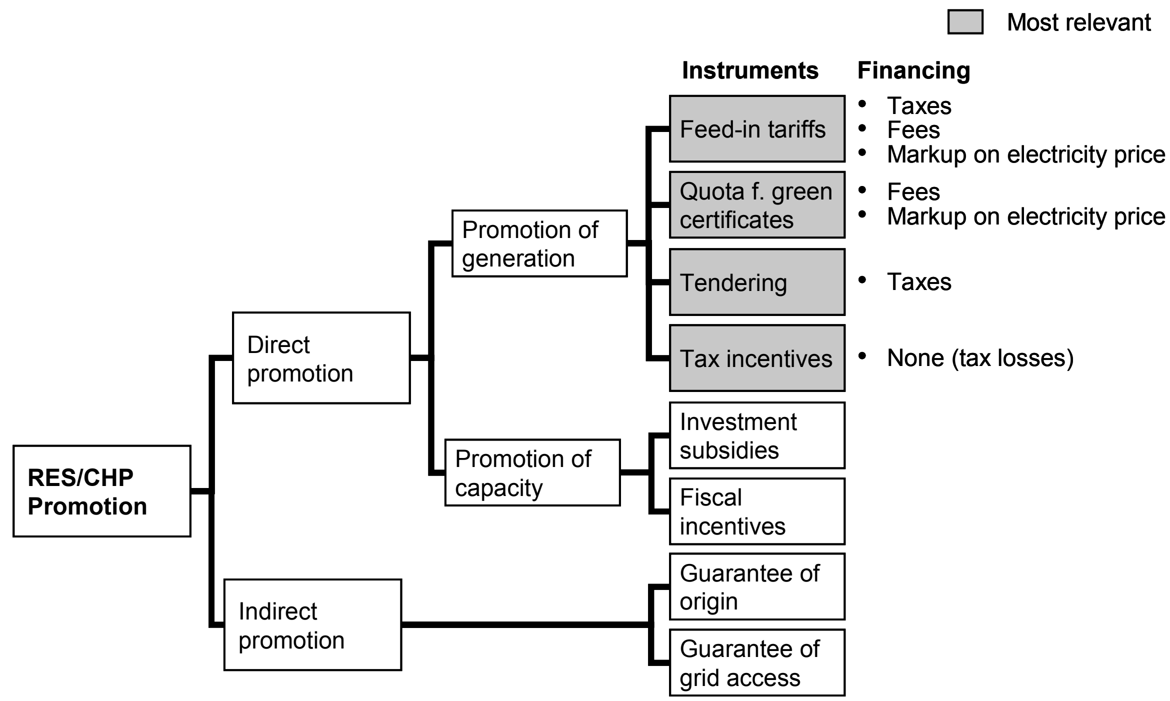


Fig. 43: Instruments for promotion of RES and CHP

While illustrating the available instruments and means of financing is relatively easy, it is rather complicated to provide an up-to-date overview of the implementation in the 25 EU member states. Assuming two laws (for RES and CHP) and two respective orders for each member state and an average duration of validity of two years, the overview would require a weekly update. Thus, all overviews can be snapshots only. Bearing this caveat in mind, several publications provide valuable overviews.

Looking at the promotion of RES first, Del Rio (2004) and the Commission of the European Communities (2005d) provide the most recent overviews of the available instruments applied in the EU. Faber et al. (2001), De Vries et al. (2003), the European Renewable Energies Federation (EREF, 2004), and again the Commission of the European Communities (2004c) display country by country the member states' performance in promoting RES and list the individually applied instruments and levels of promotion. Looking at CHP, the number and depth of publications is comparably limited. Löffler (2004) only provides examples of policies in different EU member states (Portugal, Belgium etc.), while Esdaile-Bouquet (2005) gives an overview on the electricity generation from CHP in all member states but only superficially describes the national legislation, respectively promotion schemes. In order to facilitate the reader in getting an overview of the legislation, Tab. 8 and Tab. 9 provide a current pulp-and-paper tailored overview of RES and CHP promotion for the nine investigated countries.

Country	Instrument (predominant)	Financing	Subsidies for generation		Costs for consumption		Comments
			Sales	Internal consumption	Purchase	Internal supply	
Austria	Feed-in tariff	Fees	Feed-in tariff ca. 27-165 EUR/MWh	None, sell-and buy-back not feasible	Regulated RES fee of ca. 1.43 EUR/ MWh on purchased electricity, add. negotiated surcharge for RES and CHP of ca. 1.88-4.95 EUR/MWh	None	Threat to wood supply/prices from promotion of co-firing
Belgium	Quota for tradable green certificates	Markup on price of purchased electricity	Revenue from sales of tradable green certificates worth ca. 65-125 EUR/MWh	Revenue from sales of tradable green certificates worth ca. 65-125 EUR/MWh	Price of purchased electricity increased by ca. 2-3 EUR/ MWh for required green certificates	None	Additional investment subsidies and fiscal incentives; Flanders diff. certificates for RES and CHP, Wallonia combines both; threat from promotion of co-firing
Czech Republic	Feed-in tariff	Fee on all consumed electricity	Green bonus on sales of RES-E ca. 45-158 EUR/MWh	Green bonus for internal consumption of RES-E ca. 45-158 EUR/MWh	Fee of ca. 1.25 EUR/MWh on all consumed electricity for RES and CHP	Fee of ca. 1.25 EUR/MWh on all consumed electricity for RES and CHP	Threat to wood supply/prices from promotion of co-firing (ca. 16-28 EUR/MWh)
Finland	Tax incentives	None (tax losses)	Tax incentive 2.50-6.90 EUR/MWh	Tax incentive 2.50-6.90 EUR/MWh	None	None	Additional investment subsidies
Germany	Feed-in tariff	Fees	Feed-in tariff ca. 84-175 EUR/MWh	Feed-in tariff ca. 84-175 EUR/MWh (sell-and-buy-back)	Fee of 5.50 EUR/ MWh on purchased electricity (ceiling at 0.50 EUR/ MWh in case of hardness)	None	Separate turbine required to benefit from feed-in tariffs; sludge from fibre recovery is not regarded as bio-fuel
Hungary	Feed-in tariff	Markup on price of purchased electricity	Feed-in tariff ca. 62-100 EUR/MWh	Feed-in tariff ca. 62-100 EUR/MWh (sell-and-buy-back)	Price of purchased electricity increased to finance feed-in tariffs	None	Introduction of green certificates intended; threat of wood supply/ prices from promot. of co-firing
Poland	Quota for tradable green certificates	Markup on price of purchased electricity	Revenue from sales of tradable green certificates worth ca. 55-62 EUR/MWh	Revenue from sales of tradable green certificates worth ca. 55-62 EUR/MWh	Price of purchased electricity increased by ca. 2-3 EUR/ MWh for required green certif.	None	Threat to wood supply/prices from promotion of co-firing
Slovakia	Feed-in tariff	Markup on price of purchased electricity	Feed-in tariff ca. 70-78 EUR/MWh	Feed-in tariff ca. 70-78 EUR/MWh (sell-and buy-back)	Price of purchased electricity increased but energy- intensive industries exempted	None	Threat to wood supply/prices from promotion of co-firing (ca. 51-57 EUR/MWh)
Sweden	Quota for tradable green certificates	Markup on price of purchased electricity	Revenue from sales of tradable green certificates worth ca. 25 EUR/MWh	Revenue from sales of tradable green certificates worth ca. 25 EUR/MWh	Price of purchased electricity increased	Also internally supplied electricity needs to meet quota obligation	None

Tab. 8: Overview of RES promotion policies in the investigated countries

Country	Instrument (predominant)	Financing	Subsidies for generation		Costs for consumption		Comments
			Sales	Internal consumption	Purchase	Internal supply	
Austria	Feed-in tariff	Fees	Feed-in tariff	None, sell-and buy-back not feasible	Regulated CHP fee of ca. 1.50 EUR/ MWh on purchased electricity, add. negotiated surcharge for RES and CHP of ca. 1.88-4.95 EUR/MWh	None	Additional investment subsidies; tax exemption for fuels used for electricity generation
Belgium	Quota for tradable CHP certificates	Markup on price of purchased electricity	Revenue from sales of tradable CHP certificates worth ca. 0-45 EUR/MWh in Flanders	Revenue from sales of tradable CHP certificates worth ca. 0-45 EUR/MWh in Flanders	Price of purchased electricity increased by ca. 0.50-1.00 EUR/ MWh for required green certificates	None	Additional investment subsidies and fiscal incentives; Flanders diff. certificates for RES and CHP, Wallonia combines both; tax exemption for fuels used for electricity generation
Czech Republic	Feed-in tariff	Fee on all consumed electricity	Green bonus on sales of CHP-E ca. 7.50 EUR/MWh	Green bonus for internal consumption of CHP-E ca. 7.50 EUR/MWh	Fee of ca. 1.25 EUR/MWh on all consumed electricity for RES and CHP	Fee of ca. 1.25 EUR/MWh on all consumed electricity for RES and CHP	Tax exemption for fuels used for electricity generation
Finland	None	None	None	None	None	None	Tax exemption for fuels used for electricity generation
Germany	Feed-in tariff	Fees	CHP bonus on sales of CHP-E ca. 14-51 EUR/MWh according to KWKG; additional bonus of 20 EUR/ MWh according to EEG	CHP bonus of 20 EUR/MWh for internal consumption of CHP-E according to EEG; no bonus according to KWKG	Fee of 0.50 EUR/ MWh on purchased electricity (ceiling at 0.25 EUR/ MWh in case of hardness); additional EEG-fee see RES	None	Promotion by two laws in parallel; (partial) tax exemption for fuels used for electricity generation
Hungary	Feed-in tariff	Markup on price of purchased electricity	Feed-in tariff ca. 54-87 EUR/MWh	N.a.	Price of purchased electricity increased to finance feed-in tariffs	None	Tax exemption for fuels used for electricity generation
Poland	Quota for tradable CHP certificates	Markup on price of purchased electricity	Revenue from sales of tradable "red" CHP certificates	Revenue from sales of tradable "red" CHP certificates	Price of purchased electricity for required CHP certificates	N.a.	Tax exemption for fuels used for electricity generation
Slovakia	Feed-in tariff	Markup on price of purchased electricity	Feed-in tariff ca. 42-49 EUR/MWh	N.a.	Price of purchased electricity increased	None	Tax exemption for fuels used for electricity generation
Sweden	None	None	None	None	None	None	Tax exemption for fuels used for electricity generation

Tab. 9: Overview of CHP promotion policies in the investigated countries

The initial illustration in Fig. 42 is underlined by Tab. 8 and Tab. 9: in most countries, pulp and paper producers have costs as well as benefits from the promotion of RES and CHP. In an average of 13 mills, 2.3% (of total energy costs) fees paid for the promotion of RES and CHP are by far more than balanced by 8.9% income. Even if the mill in the Czech Republic, which benefits from an unusually high green bonus for RES promotion, is excluded and an "invisible markup" on electricity prices financing RES and CHP promotion in some countries (see above) is taken into account, the mills earn money from RES and CHP promotion. The actual size of fees and income strongly depend on energy configuration (share of internal electricity generation, fuel mix etc.) and country. The specific fees and subsidies for pulp as well as for paper typically range between 0.00 and 4.00 EUR/t. Stand-alone chemical pulp mills should be at the upper end of this range or even slightly above, stand-alone paper mills at the lower end, and in all integrated mills, the specific fees and incomes are subject to the allocation mode.

Having looked at the net costs of primary and secondary energy, energy and emission taxes and the promotion of RES and CHP in chapter 4.2.3 the theoretical consideration on the relevance or relative weight of emission trading on decision making in the pulp and paper industry will be closed recapitulating the numbers found for the entirety of 13 mills: 63.6% of total energy costs are net costs of fuels, 35.8% net costs of purchased electricity, 4.8% energy and emission taxes, 11.2% RES and CHP promotion (for decision making, the sum of the absolute values is relevant), and 2.4% originate from the purchase and sales of steam. Emission trading accrues influenceable energy-related costs of 38.7%. Accordingly, it is a very relevant influencing factor in operational and strategic energy related decision making. Nevertheless, it is one factor among others and should not be regarded as a stand-alone influencing factor. Thus, from all theoretical considerations, hypothesis three appears to be validated.

However, two additional practical examples from the cases investigated will be sketched. In the first case, emission trading is one of various influencing factors in strategic decision making on mill level, in the second case, it is one factor within a model for the operation of the powerhouse.

A Swedish mill decided to rebuild a formerly medium-fuel oil-fired boiler to wood-powder firing. According to the mill management's calculations, the investment of about 5.5 million EUR pays off due to three components of savings in annual operations costs: about 1.6 million EUR annual savings are expected from lower fuels costs, 250,000 EUR from accruing green certificates, and about 200,000 EUR finally from saved emission allowances. Although the fuel cost saving is significantly higher than the revenue from green certificates and the value of freed allowances, only the combination of these three components finally moved the management to decide on the investment. Theoretically, each component by itself could finance the investment – resulting in different pay-back times, of course. However, the defined investment criteria each company has sometimes allow comparably limited financial effects to turn the balance. In this case, the saved emission allowances obviously reduced the pay-back time below three years and, thus, released the funds.

The second example originates from an integrated mill with several lines of pulp and paper manufacturing. The powerhouse comprises four back-pressure turbines for electricity generation with a total capacity of 98.0 MW. They are run according to a complex model considering current electricity consumption and electricity price, fuel costs, the value of green certificates, the price of emission allowances etc. As in the example on strategic decision making above, emission trading influences the decision on operation of the powerhouse as one factor among others.

Summarising the theoretical considerations at the beginning of this chapter and the findings from the two examples described, the third hypothesis on the first key question will also finally be adopted: emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments.

5. Implications and recommendations – take action immediately

In the preceding chapter 4, the first key question of the investigation asking for the effects of emission trading on the manufacturing costs of pulp and paper has been answered. Evidence has been found for the three hypotheses:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters as according to the manufacturing process, level of integration, energy mix etc. – all direct and indirect effects have been quantified in detail
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

Thus, it is the objective of chapter 5 to provide answers to the two remaining key questions of the investigation:

- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in political and economic environment?

Chapter 5 is structured accordingly. Chapter 5.1 covers the implications the manufacturing cost increase has on the profitability of the companies. Chapters 5.2 and 5.3 give recommendations in highlighting the actions that can be taken by the affected companies, respectively the politicians on a European as well as on a national level. Chapter 5.4 provides an outlook to the time beyond 2007, the last year of phase I of European emission trading, and beyond 2012, the last year covered by the Kyoto Protocol. Chapter 5.5, finally, critically assesses the applied methodology.

5.1 Implications – severe effect on profitability from indirect levers

Prior to the intended discussion of the implications of the manufacturing cost increase on the profitability and competitiveness of the affected companies, a definition of these terms is required.

Profitability is the ability of a company to make a profit. From an accounting perspective, profit (or "total earnings" or "net income") is the bottom line of the profit-and-loss account, calculated by deducting all costs of doing business, depreciation, interest, taxes, and other expenses (e.g., restructuring costs) from the revenues achieved from sales of products and services and potential proceeds from financial activities or sales of business units. In the context of this investigation, however, all non-operational and non-recurring activities (e.g., costs of restructuring, financial activities, sales of business units) are not focused on. Only operational effects on profitability are considered. While the aforementioned definition of profitability refers to a company as an entity, the term may be used in cost accounting for specific products too. In this case, it means the excess of a product's price over all its allocatable costs. The treatment of non-cash costs will be discussed below.

Competitiveness is a company's, an industry's or a nation's ability to maintain or extend its market share of selling certain products or services on certain markets in a sustainable way, i.e., without accepting losses or cross-subsidisation. The latter requirement links both definitions: there is no competitiveness without profitability and – at least in the long run – no profitability without competitiveness.

The implication of the emission-trading-induced manufacturing cost increase on the profitability of pulp and paper manufacturing can be calculated relatively easily, the implication on competitiveness, in turn, is more difficult to assess. Looking at profitability first, the relevant indicators to compare are the out-of-pocket effect of emission trading as defined in chapter 4.2.2.4.3.2 and the EBIT as defined in chapter 2.1.3.1. If no measures were taken by the company, i.e., emission trading takes full effect while prices and other costs remain unchanged, the out-of-pocket effect directly reduces the EBIT.

Tab. 5, Tab. 6 and Tab. 7 (page 144 ff.) illustrate the "typical values" for the out-of-pocket effects by pulp, respectively paper manufacturing, processes under the "most-likely" scenario. The effect is 11.2% of manufacturing costs in chemical pulping, 22.6% in mechanical pulping, 20.7% in thermo-mechanical pulping, and 1.2% in fibre recovery. Accordingly, the effect on paper manufacturing significantly differs depending on the source of fibre. If primary pulp is used, the typical out-of-pocket effect ranges between 3.1 and 7.5%, if solely secondary pulp is used it's 1.0-1.8%.[1] A comparison with the EBITs achieved in the pulp and paper industry reveals how dramatic these numbers are. As illustrated in Fig. 28 (see page 67), in 2004, in this respect more or less a normal year for the pulp and paper industry, the average EBIT of the top 5 European pulp and paper companies was 4.2% of turnover, respectively 4.6% of manufacturing costs[2]. Although the EBIT values of Fig. 28 and the above-mentioned averages refer to the integrated companies Stora Enso, UPM-Kymmene, M-real, SCA, and Norske Skog and cannot be broken down into different manufacturing processes, there is good reason to assume two things. (1) The profitability of the various

[1] The typical values for the "best-case" and the "worst-case" scenarios can be found in Appendix 5 and Appendix 6. While they are relatively moderate under the "best-case" scenario, they are severe under the "worst-case" scenario. The out-of-pocket effects range between 35.3 and 71.1% of manufacturing costs at pulp manufacturing, respectively between 20.8 and 50.8% at paper manufacturing from primary pulp.

[2] As in the entire investigation, the term "manufacturing costs" refers to mill level. Besides the EBIT, a markup of 5% of turnover is assumed for coverage of costs on corporate level.

processes may differ slightly but not by the order of magnitude and (2) the profitability of the smaller companies will be in the same order of magnitude as the top 5 companies – at least not significantly higher. Under these assumptions, all pulping processes, except fibre recovery and three of seven paper manufacturing processes, lose profitability and become EBIT-negative. If prices and other costs remain unchanged, chemical pulping will result in an EBIT of -6.6%, mechanical pulping in -18.0%, thermo-mechanical pulping in -16.1% of manufacturing costs, while only fibre recovery will still be EBIT-positive with 3.4%. The EBITs of paper manufacturing from primary fibre will be between -2.9 and 1.5%, only paper manufacturing based on secondary fibre will be consistently profitable with EBITs between 2.8 and 3.6%. Although all these numbers need to be flagged with the caveat of being typical respectively average values, which cannot represent each individual case of pulp and paper manufacturing across Europe, and refer to the "most-likely" scenario only, they are able to provide one general conclusion. The profitability of the European pulp and paper industry is seriously endangered through the introduction of emission trading. Significant counter measures need to be taken by the companies to safeguard profitability – and competitiveness.

Attempts to safeguard profitability through discontinuation of depreciation and amortisation are neither sustainable, nor – looking at pulp manufacturing – sufficient. Though some degrees of freedom exist here, in the top 5 companies depreciation and amortisation account for 10.2% of turnover, respectively 11.3% of manufacturing costs in 2004, priority should be given to more sustainable and cash-effective actions. These actions can apply to the cost as well as to the price lever. Any price change, however, will have an effect on the sales volume. The product may formally become profitable in the short run, but competitiveness can be lost and less sold units contribute to coverage of the fixed costs. This dependency will be one of the aspects discussed in chapter 5.2.

5.2 Recommendations I – what pulp and paper manufacturers should do

The first chapter on recommendations refers to the third key question: which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment? In this respect, the vague term "changes in political and economic environment" refers to both the downsides as well as the upsides from emission trading. While the downsides – primarily in the form of significantly increasing manufacturing costs and risks – are obvious, the upside potentials should not be lost sight of. Not only utility companies can benefit from emission trading, but also pulp and paper manufacturers can take advantage of certain developments. – While chapter 4.2.2.4 is the core chapter for the quantification of the effects of emission trading, chapter 5.2 is the core chapter in respect to the reactions to emission trading – sketching, structuring, and elaborating the recommendations to the affected companies.

So far, the entire investigation has focused on emission trading and its effects on energy and raw material costs. All other cash and non-cash costs (e.g., personnel, consumables and maintenance materials and services, packaging and logistics materials and services, overhead expenses and corporate fees, depreciation and leasing etc.), although accounting for significant shares of total costs, as Fig. 32 (page 71) and Fig. 33 (page 72) reveal, have been left untouched in an aggregated cost category "others". Thus, one consideration needs to be highlighted. For the maintenance or re-establishment of profitability, it is absolutely irrelevant if none, one or all cost categories affected by emission trading (see Fig. 29 page 68) are addressed by the actions. 5 EUR/t saved in consumables or personnel are as valuable as 5 EUR/t saved in fuel or electricity. Actions on the price side – paying attention to the elasticity of sales, of course – have a direct effect on the profitability as well. Furthermore, the manufacturing costs and prices of existing products from existing mills are not the only toeholds for maintaining or re-establishing the profitability of pulp and paper manufacturers. Actions Besides, current products and the current production network – in the following, called "actions beyond current business" – can safeguard the the companies' profitability too. Finally, it is not disadvantageous at all if measures are taken which could have been taken anyway, i.e., without the introduction of emission trading.[1] Fig. 44 illustrates the levers pulp and paper manufacturers have for reacting to emission trading.

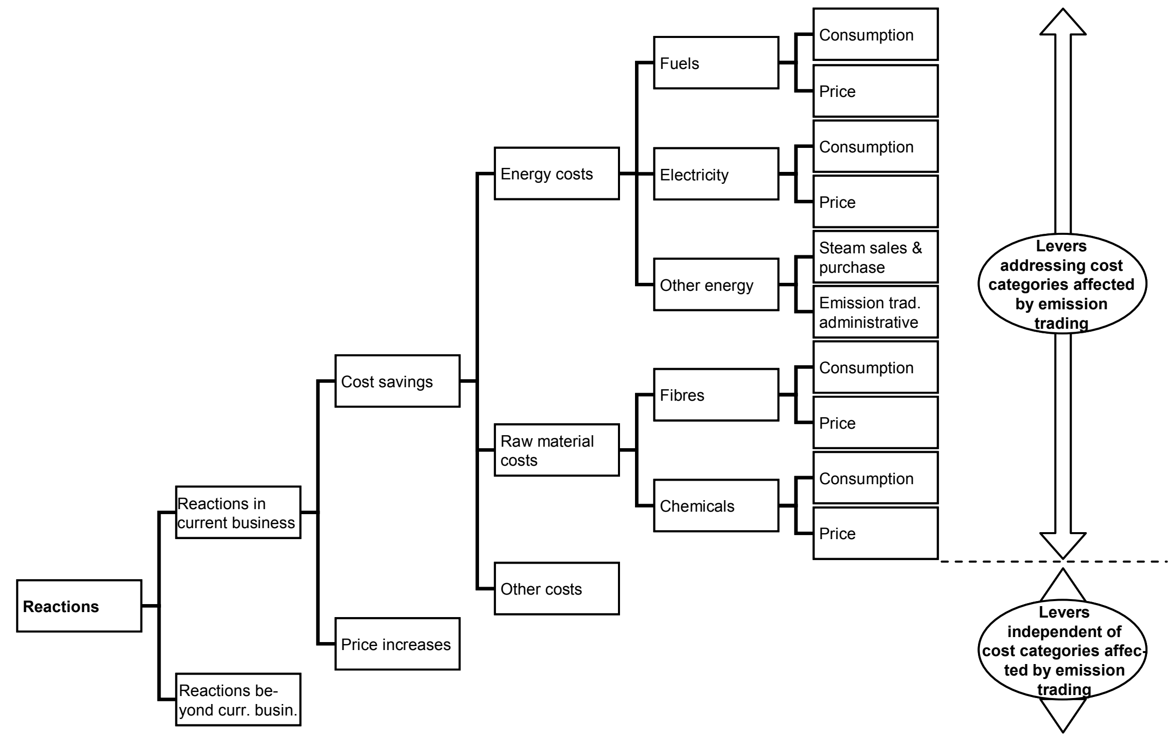


Fig. 44: Levers for reactions to emission trading

1 Martin et al. (2000) and De Beer at al. (2001) list various measures to reduce the energy consumption of pulp and paper manufacturing which have negative specific costs.

However, despite the afore-mentioned consideration referring to the wide solution space for actions to maintain or re-establish the profitability of pulp and paper manufacturers, the primary focus of the following recommendations will be on energy and raw material related measures. Accordingly, Fig. 44 grants more space to the levers addressing the cost categories that are affected by emission trading than to the levers independent of these cost categories. Other cost categories are intentionally factored out, as their discussion would entirely exceed the scope of the existing investigation. Some space, in turn, is granted to considerations on pricing and actions beyond current business. These actions, finally, are discussed only if they are at least somewhat related to energy or emission trading.

The depth of elaboration of the numerous actions may differ but can and will not reach a "ready-to-implement level" for a specific mill. Moreover, the elaboration is intended to initiate discussions within the affected companies if an action is applicable in the given situation, how it needs to be implemented, and at what costs and benefits. As the range of sophistication of the actions is wide – from simple function control of steam traps to advanced bio-refinery – some of the actions may be regarded as simply being good practice. However, more than one mill investigated had room for simple measures too.

The qualitative display of the "range of application" in the following sub-chapters can give a first indication only to which type of mill, to which energy configuration, fuel, and raw material mix etc. the specific action is applicable. Likewise, attempts to quantify "ease of implementation" (requirement for investment vs. pure management action, availability of required technology, short-term/operational vs. long-term/strategic) and "magnitude of impact" (specific effect on profitability) can be initial outside-in estimates only. If the investigation had an economic focus, attempts for precise quantifications of the actions would be expedient. As the existing investigation and especially the current chapter 5.2 have a business focus, however, detailed quantifications would pretend an accuracy which they cannot provide. Whereas some actions are implemented digitally in a mill (e.g., "replace outdated equipment A by state-of-the-art equipment B"), others allow gradual implementation (e.g., "save heat by insulating drying hoods"). Especially for the latter type of action, any outside-in quantification of the impact going beyond a qualitative assessment would be insufficient and ought to be avoided. It cannot be assumed that drying hoods were not insulated at all in the past, respectively will be 100% insulated in the future. Nevertheless, the qualitative assessment of ease and impact uses five fixed terms (very low, low, medium, high, and very high), which refer to an even more detailed 0-10 scale. Thereby, a "very low" is assigned to a point score of 0.0-1.5, "low" to 1.6-3.5, "medium" to 3.6-6.4, "high" to 6.5-8.4, and finally "very high" to 8.5-10.0. However, it needs to be stressed once again: the point score and term assigned for ease and impact are not intended as a generally applicable quantitative assessment. They have been estimated outside-in and provide orders of magnitude only. In a specific mill, both ease and impact can deviate significantly from this assessment. Qualitative appraisal of "range of application", "ease of implementation", and "magnitude of impact" are intended as starting points for discussions within the pulp and paper manufacturers affected by emission trading. Definite proposals and precise quantifications for specific but unknown pulp and paper mills cannot be made outside-in.

Another remark seems necessary before the individual actions aredescribed: actions are taken to cause a financial effect, not to cause a technical effect. Profitability and competitiveness are determined by financials, not by specific steam or electricity consumption or CO_2 emissions. The technical potential for energy and raw material savings is much higher than the economic potential. Accordingly, the Swedish research group "The Eco-Cyclic Pulp Mill" (KAM, Kretsloppsanpassad Massafabrik) demonstrated that their reference market kraft pulp mill model –consisting entirely of industrially tested components – has a significantly better energetic performance than the 1997 Swedish average mill (STFI, 2000). They reason the limited penetration of new, technically advantageous technology with a long and useful life of equipment in the pulp and paper industry as follows (Axegård et al., 2002, p. 29):

> *"Investments in new technology in existing mills are often not economically justifiable even if it would significantly improve the energy balance and lower chemical costs […] unless there is a major rebuild and the mill capacity is increased."*

Apart from the low replacement frequency of equipment in the pulp and paper industry, the classical first-mover problem hinders rapid penetration with new technology. Though certain developments promise energetic – and mid-term potentially also commercial – "quantum leaps" (e.g., black liquor gasification, water-less forming of paper etc.), but can be brought to commercialisation by well-founded consortia only. Single manufacturers hesitate to take the risks.

Chapter 5.2 is structured along the levers illustrated in Fig. 44. Most actions can be clearly allocated to these levers by their primary sources of favourability, although some measures affect two of more levers (e.g., a measure saves both fuel and electricity). In this case, the measure is mentioned twice or even more often but discussed and counted as an "action" only once – under the lever which corresponds to the action's primary source of favourability. At the second occurrence, the measure is only briefly mentioned and a reference to the respective action made. Thus, the more than 100 actions listed are almost entirely mutually exclusive. If an action has a positive effect on one but a negative effect on another lever (e.g., a switch from oil firing to coal firing may decrease net fuel costs but require more emission allowances), the bottom line in a total-cost-of-ownership perspective should guide the decision in the specific case. An overview of all actions with assessment of ease of implementation and impact is given at the end of chapter 5.2.9 and especially in Fig. 49 on page 269.

5.2.1 Cost savings – fuels

As illustrated in Fig. 44 fuel cost savings are broken down into consumption savings (5.2.1.1) and price savings (5.2.1.2). As the latter refers to the average price of the consumed fuel mix, it also comprises the variations in the fuel mix – at constant requirement of total primary energy.

5.2.1.1 Cost savings – fuel consumption

As described in 2.1.3.2 for the pulp and paper industry in general and in 4.2.2.1 for the investigated mills in particular, more than 85% of the fuels consumed are used for generation of steam in boilers, less than 15% provide direct heat (e.g., lime kiln, IR-drying). In order to maximise the yield from the fuels, the steam is typically generated at high energetic conditions (> 450°C, > 60 bar) and relaxed in back-pressure turbines to process requirements. As this procedure of combined heat and power generation is absolutely reasonable – it decreases the average costs (price) of electricity – the primary steam consumption of the turbines is left untouched in this chapter. Considerations of the electricity yield from this steam are made in chapter 5.2.2.2. Chapter 5.2.1.1 rather focuses on the consumption of process steam and direct heat, the recovery of heat from the process, and the yield of primary steam from fuels. It closes with a brief discussion of the advantages and disadvantages of direct heating vs. steam heating.

5.2.1.1.1 Cost savings – consumption of steam and direct heat in the process

(1) Save fuel costs reducing consumption of steam and direct heat automating monitoring, controlling, and steering

The implementation of a comprehensive system of monitoring steam and direct heat supply, transfer and consumption is the first step towards fuel saving. Leakages in pipes and steam traps (separating live steam from condensed steam and non-condensable gases) are reported immediately and can be repaired quickly (Martin et al., 2000). Variations in consumption will be observed and scrutinised. Thus, simple measuring evokes changes in the behaviour of the personnel. Manual process control should be replaced by automated process control (Commission of the European Communities, 2001). The steering of continuous or repeated processes should also be automated as far as possible. Martin el al. (2000) estimate about 7% savings of thermal energy at paper drying by using IR-profiling to measure the moisture content, fibre orientation etc. in the steering of the paper machines' press and drying sections. Steinbrecher and Hahn report similar fuel savings for gas-fired IR-dryers in coaters. Another application for automated steering is the airflow in the drying section of the paper machine. If automated steering reduces the air flow to an amount that the exhaust air is close to its dew point, not only is the electricity consumption minimised but also the heat recovery from the exhaust air becomes more effective (Commission of the European Communities, 2001). The initial investment in automated monitoring, control, and steering equipment typically pays off within a relatively short time. Recurring costs are comparably negligible.

Range of application: All pulp and paper mills with steam or direct heat consumption
Ease of implementation: High
Magnitude of impact: Low

(2) Save fuel costs reducing consumption of steam and direct heat through regularly maintaining equipment

The second action is a typical good practice measure again. Regular and properly accomplished maintenance allows energy savings in many process steps of pulp and paper manufacturing. Martin et al. (2000) estimate 3% savings in the overall fuel consumption by regularly inspecting and maintaining the steam distribution system. Minor leaks are observed more quickly and major leaks can be avoided. Other examples for saving steam or direct heat through proper maintenance are wires and felts in the wet section of the paper machine. If they are cleaned regularly and replaced when appropriate, the web dewaters better in the wet and press sections and a higher dry solids content at the beginning of the drying section can be reached. This action has basically no investment costs and current savings regularly exceed costs of maintenance.

Range of application: All pulp and paper mills with steam or direct heat consumption
Ease of implementation: Very high
Magnitude of impact: Low

(3) Save fuel costs reducing consumption of steam and direct heat through minimising production interruptions

The third action is also self-explanatory: as heat gets lost with any production interruption, all equipment-specific measures safeguarding good runability and minimising production interruptions save heat and thereby fuels. This is a typical problem of older and fast-running paper machines, where the web breaks frequently and subsequent run-ups take up to 30 minutes. Not only does the pre-dried paper get lost and is dissolved in the white water, significant heat losses also originate from the steam-heated drying cylinders in the dryer as convection or radiation (Commission of the European Communities, 2001). Measures to reduce production interruptions are favourable not only due to energetic reasons. Any production loss is also typically regarded as a loss in turnover and profit.

Range of application: Especially older and fast-running paper machines
Ease of implementation: Medium
Magnitude of impact: Low

(4) Save fuel costs reducing consumption of steam and direct heat through improving insulation

Digesters, bleaching equipment and, if applicable, also pulp dryers are the heaviest steam consumers in pulp manufacturing, the drying section of the paper machine and potentially also the succeeding coating equipment are the correspondents in paper manufacturing. Steam is typically provided to all these consumers in one or two process steam grids. An improvement in the insulation of grids as well as consumers allows significant savings of steam and, thereby, fuels. Steinbrecher and Hahn (2003) have discovered considerable potential in the steam grids. Martin et al. (2000) suggest heat savings through improvements in insulation of existing continuous digesters in chemical pulping. De Beer et al. (2001) put emphasis on the drying hoods of paper machines. They stress that a dew point increase by about 4°C allows significant reduction of ventilation air (see also action 1). The financial favourability of improving insulation of existing steam grids and consumers needs to be calculated case by case. Steam savings can usually only be achieved by significant investments.

Range of application:	All mills; especially chemical pulp mills and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(5) Save fuel costs reducing consumption of steam using advanced technology at cooking

Advanced cooking processes offer potential for significant steam and, thereby, fuel saving in chemical pulping. However, yield and pulp properties need to be observed and are at least as important as steam consumption. Martin et al. (2000), referring to Elaahi and Lowitt (1988), regard pulping in alcohol-based solvents (ethanol-water solution) as a potential future alternative to traditional kraft pulping. They report significant yield increases at reduced cooking times. The cooking process they describe removes 75% of the lignin in a first cooking stage and the remainder in a second stage (liquor extraction). The alcohol is largely recovered by steam stripping but is still a very costly cooking medium. Furthermore, a small amount of additional fuels is needed. This process tends to offer large potential in yield as well as in steam consumption. However, its feasibility on an industrial scale and commercial favourability still need to be proven. Nevertheless, it can be assumed that modified or newly developed cooking processes will replace some of the current processes due to a better combination of pulp properties, yield, and pulping costs.

Range of application:	Chemical pulp mills
Ease of implementation:	Low
Magnitude of impact:	Medium

(6) Save fuel costs reducing consumption of steam using state-of-the-art technology at washing

Various single measures allow steam and, thereby, fuel saving in the washing section of chemicals and partially also mechanicals and thermo-mechanical pulping. All of them can be summed up under "using state-of-the-art washing technology". The EU BAT-report (Commission of the European Communities, 2001) discloses savings potential in switching from a low- to medium- or high-consistency technique in the entire washing section. Basically, less water needs to be heated and pumped (an additional electricity saving). Another opportunity for steam saving is the replacement of the vacuum pressure units in brownstock washing by pressure diffusion or wash presses (Martin et al., 2000). The Swedish research group "The Eco-Cyclic Pulp Mill", furthermore, suggests fuel savings by heating the dilution and wash water stream (potentially with recovered heat) instead of using steam in the bleaching plant (STFI, 2000). While the replacement of the vacuum pressure units ought to be feasible, almost irrespective of the surrounding equipment in the washing section, and pay-off within a relatively short time, the general consistency increase and the change in heating require a significant retrofit of the entire washing section. Thus, it can only be implemented if a retrofit is required anyway.

Range of application: All pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(7) Save fuel costs reducing consumption of steam using state-of-the-art technology at bleaching

As steam consumption is only one of several drivers of a decision on the bleaching sequence in chemical pulping, the impact on steam will only be annotated. The more even the required temperature profile between the succeeding bleaching stages is, the lower the steam and, thereby, fuel requirement is. In this respect, ECF bleaching is usually favourable compared to TCF bleaching (STFI, 2000). Due to the comparably heavier weight of other drivers for decisions on bleaching sequences and the costs associated with a potential retrofit of the bleaching section of chemical pulp mills, this actions needs to be flagged as being "theoretical" in Europe.

Range of application: Chemical pulp mills
Ease of implementation: Low
Magnitude of impact: Medium

(8) Save fuel costs using state-of-the-art technology at causticising

About 5-10% of the fuels consumed by the European pulp and paper industry are burned for causticising in sulphate pulp mills. The sodium carbonate (Na_2CO_3) of the green liquor is liberated of its CO_2 in order to gain back the sodium hydroxide (NaOH) required for the white liquor. Classically, this is done using calcium hydroxide ($Ca(OH)_2$) at the interface between the sodium and the calcium loop of chemical recovery. The calcium hydroxide is generated in the slaker by a reaction of calcium oxide (CaO) and water. After the calcium hydroxide has taken over the CO_2 from the sodium carbonate in the causticiser, respectively the white liquor clarifier, it precipitates as calcium carbonate ($CaCO_3$) and needs to be re-burned to calcium oxide in the lime kiln. This latter step typically requires fossil fuel. Fuels can be saved in this classical causticising process in two ways: Martin et al. (2000) report a reduction in the fuel consumption in the lime kiln achieved by the use of high efficiency filters for the lime mud ($CaCO_3$). Any reduction in the water content of the lime kiln input reduces the fuel requirement. The Swedish research group "The Eco-Cyclic Pulp Mill" suggests causticising under pressure (STFI, 2000). The installations of high efficiency filters for the lime mud is comparably easy and pays off within a short time, the pressurisation of the causticising, in turn, requires a significant retrofit and tends to be only worthwhile if a retrofit is required anyway.

Range of application:	Sulphate pulp mills
Ease of implementation:	High
Magnitude of impact:	Low

(9) Save fuel costs using advanced technology at causticising

The entire calcium loop of classical causticising (see action (8)) and with it the lime kiln could be avoided, however, if causticising were done with sodium borate ($NaBO_2$) or sodium titanate ($NaTi_2O_4$ or $Na_2Ti_3O_7$) (STFI, 2000). Borate auto-causticising is much easier than conventional causticising and does not require any re-burning. Sodium borate, sodium carbonate and water react in two steps to (two molecules) sodium hydroxide, CO_2, and sodium borate when the smelt is dissolved (green liquor). Thus, sodium borate takes the role of a catalyst. Borate auto-causticising has already proven its applicability at industrial scale (yet for de-bottlenecking), although cooking conditions need to be sharpened a little due to decreased delignification owing to borate's ionic strength (STFI, 2000). Beyond the reduction of current costs, borate causticising is also persuasive because of its investment costs which are significantly lower than for current technology. It seems to be a good complement to black liquor gasification, as this process of chemical recovery increases the need for causticising. Titanate direct causticising is even more advanced. Lime kiln and causticiser can be omitted as in borate causticising, but significant research is still needed yet applicability on industrial scale is achieved (Sinquefield, 2005). As soon as commercial applicability will be reached, titanate direct causticising will presumably become an important component for high electricity yield from black liquor gasification (see action (56)). Investment costs, however, will be higher than with borate auto-causticising. However, its development has not yet exceeded lab scale. In 2000, the research group "The Eco-Cyclic Pulp Mill" expected a development time of more than ten years until commercial scale could be reached (STFI, 2000). Then titanate causticising could be the ideal complement to black liquor gasification. Besides from borate auto-causticising and titanate direct causticising, hopes are also directed at manganate conversion (Sinquefield, 2005).

Range of application: Sulphate pulp mills
Ease of implementation: Low
Magnitude of impact: Medium

(10) Save fuel costs reducing consumption of steam using advanced technology at pulp drying

Another opportunity for steam saving may arise for market pulp mills within the next few years. Allan et al. (1997) describe investigations into impregnating the wet fibre after bleaching with sodium carbonate (Na_2CO_3) in order to replace the water and reduce the energy consumption for drying the pulp. In lab-scale trials, a 16% reduction in energy for pulp drying was achieved. This procedure promises significant steam, fuel, and cost savings for market pulp mills but will still take some years until commercialisation.

Range of application: Market pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(11) Save fuel costs reducing consumption of steam and direct heat using advanced technology in the forming section

The largest share of steam and direct heat consumption in paper manufacturing is caused by paper drying, i.e., for most paper grades in the steam-heated drying cylinders, for some paper grades in directly (gas-) heated cylinders and gas-fired IR-dryers. The heat requirement originates from the need to evaporate the water to dry the paper from about 40-50% dry solids at the end of the press section to finally 95% dry solids. Thus, several investigations are being conducted with new media that can be used for the forming of the paper web. Martin et al. (2000) report the start-up of a first installation using air-laying techniques for forming. They describe a heat saving of about 5 GJ/t, corresponding to 70-80% of normal heat requirement, at the cost of a slight increase in electricity consumption. Another alternative to water could be ethanol or super-critical CO_2, as described by Koopmann (2006) as well as Gielen and Tam (2006). Whereas all three alternatives promise high heat savings, commercial favourability needs to be proven (costs of ethanol and super-critical CO_2). Furthermore, commercialisation does not appear feasible in the short term.

Range of application:	All paper mills
Ease of implementation:	Very low
Magnitude of impact:	High

(12) Save fuel costs reducing consumption of steam and direct heat using state-of-the-art technology in the wire section

As with the previous action, this one aims at increasing the dry solids content of the paper web before the beginning of the drying section in order to reduce the steam and, where applicable, the direct heat requirement. Other than the previous action, this one approaches the wire section. Wherever possible, long wire wet sections should be replaced by double wire wet sections. Their dewatering ability is significantly better and besides the reduction in the steam and direct heat requirement of the paper dryer, higher running speeds of the paper machine can be achieved. Special attention needs to be paid to the retention properties of the wires. However, it should be noted that not all paper grades can be produced on double wire wet sections (e.g., no tissue) (Commission of the European Communities, 2001). Additional dewatering can be improved using state-of-the-art vacuum boxes wires and felts (Talja, 2006).

Range of application:	Most paper mills (except tissue and few other grades)
Ease of implementation:	Medium
Magnitude of impact:	Medium

(13) Save fuel costs reducing consumption of steam and direct heat using state-of-the-art technology in the press section

The next section of dewatering the web in the paper machine is the press section, typically the last section before the web enters the dryer. Besides the increase in dry solids content, the paper properties are influenced by the conditions of pressing (pressure, retention time, temperature etc.). While roll pressing between two evacuated cylinders is or was the standard technology for many years, two modifications have been implemented in many mills which allow better dewatering and, thus, energy saving in the drying section.

The first modification is hot pressing. A more explanatory term would be pre-heating before pressing, as the pressing itself is not necessarily modified. Moreover, the water in the paper web is heated to 80°C or more before pressing, using a steam shower initiated from contact with a hot surface. The viscosity of the water is lowered and the structure of the sheet is softened, improving the water flow. Martin et al. (2000) report energy savings in the drying section of the paper machine of 0.61 GJ/t (about 10%), referring to Elaahi and Lowitt (1988). Due to clear financial favourability, this measure has already achieved relatively wide penetration.

The acceptance of the shoe press, long nip press, or extended nip press is similar. Due to a longer retention time compared to a standard roll press, it achieves an improvement in dewatering too. It increases the dry solids content of the fibre web by about 3-7% from about 40-42% to about 47-50%. Considering that each percentage point increase in dry solids content before the drying section reduces the requirement for thermal energy in the dryer by about 4% (De Beer et al., 2001), the requirement for thermal energy in the dryer can be reduced by 15-30%. Woodfree paper is at the lower end whereas wood-containing paper is at the upper end (Commission of the European Communities, 2001). For tissue paper, shoe presses are not applicable. Though the reduction of energy requirement in the dryer is somewhat diminished by an increase of electricity consumption – the electricity consumption in the press section doubles (Talja, 2006), while the air flow in the dryer can be reduced by 20-30% – the introduction of a shoe press is energetic- and financially-favourable, particularly as the tensile strength of the paper increases compared to conventional roll press (Martin et al., 2000).

Range of application:	Most paper mills (except tissue and few other grades)
Ease of implementation:	Medium
Magnitude of impact:	Medium

(14) Save fuel costs reducing consumption of steam and direct heat using advanced technology in the press section

Beyond the two introduced state-of-the-art measures to increase the dry solids content before the drying section of the paper machine compared to a standard roll press, there are two more advanced technologies which can be installed between the conventional press and the drying section as an alternative to a shoe press. Impulse drying and Condebelt (condensing belt) drying both improve paper properties, allow higher speeds, and save steam (De Beer et al., 2001).

At impulse drying, the wet paper web is pressed between a very hot rotating roll and a static concave press (nip, similar to a shoe press). Compared to a conventional static concave press or the subsequently described Condebelt technology, the pressure is 10 times higher. Thus, a steam impulse is induced in the fibre web and displaces the water (Gielen and Tam, 2006). While a roll press achieves about 40% dry solids, a shoe press 50%, impulse drying may achieve 55-65% at the end of the press section (Commission of the European Communities, 2001). Accordingly, the heat saving in the paper dryer may reach 50% or even more at 5-10% overall increased electricity consumption (De Beer, 1998). However, in current test installations, expensive gas or electricity heating is required for the hot rotating roll because as yet the appropriate conditions have not been achieved with steam heating. Thus, the energetic favourability of steam heating does not necessarily go along with financial favourability. However, even if the costs are not significantly lower than at conventional pressing, the improved paper properties (smoother, high mechanical integrity, high bending stiffness but slightly lower tensile strength (Commission of the European Communities, 2001)) may be worth the installation of impulse dryers as soon as commercial scale is reached. Although impulse drying has been under development since the 1970s, the technology is still waiting for a breakthrough.

The second advanced technology in the press section is Condebelt (condensing belt) drying. The Condebelt technology is positioned between the conventional press section and the drying section. Initially, it was intended to improve the drying, but meanwhile the significant strength increase observed of the paper can be regarded as the main reason for Condebelt, while the energy saving is a rather welcome side effect (Commission of the European Communities, 2001). The paper web is dried between two steel belts – one is steam- or gas-heated, the other water-cooled. The water in the web is evaporated from the direct contact with the hot steel belt and condensed on a coarse wire on the cooled steel belt. A fine wire between coarse wire and web reduces wire marking on the paper. According to Martin et al. (2000), the overall steam consumption is reduced by 15% and electricity consumption at least slightly. As the improvement in paper properties (20-60% strength increase) is significant, the description of the technology and its implications on paper manufacturing will be described in more depth in chapter 5.2.4.1 on cost savings by reduction of fibre consumption.

Range of application:	All paper mills
Ease of implementation:	Medium
Magnitude of impact:	High (Condebelt), medium (impulse drying)

(15) Save fuel costs reducing consumption of steam and direct heat using advanced technology in the drying section

In the foregoing actions (11)-(14), various measures have been described to reduce the energy requirement for paper drying by increasing the dry solids content of the web before it enters the dryer. As a next step, two advanced technologies will be introduced which aim at more energy-efficient drying.

The steam impingement technology saves fuel and electricity by evaporating water from the wet sheet using superheated steam as drying medium instead of air. The superheated steam is blown directly onto the wet sheet. De Beer (1998) estimates heat savings of 10-15% and electricity savings of 5-10%. Additional savings could be achieved using the latent heat from the purge steam. However, Martin et al. (2000) still regard steam impingement as a technology which has not reached commercialisation yet.

The second advanced drying principle, airless drying, also refers to the latent heat of the evaporated moisture. As in conventional dryers, the paper is dried on steam-heated cylinders.

This steam, however, is largely not generated in boilers but by compression of the evaporated water. About 60-80% of the heat needed originates from the condensed water vapour, only the reminder needs to be generated conventionally. De Beer (1998) estimates a 70-90% reduction in thermal energy requirement. A 15-20% increase in electricity consumption and the need for an airtight and well insulated drying hood is accepted. Although commercial favourability is undoubted, the technology has not yet achieved wide penetration as the development is still on the cusp of commercialisation.

Range of application: All paper mills
Ease of implementation: Medium
Magnitude of impact: High (airless drying), medium (steam impingement)

(16) Save fuel costs reducing consumption of steam and direct heat integrating pulp and paper manufacturing

The general energetic as well as commercial favourability of integrating pulp and paper manufacturing is undoubted. The advantages appear obvious: renouncement of pulp drying saves investment as well as recurring costs. Building additional buffer tanks for suspended pulp requires a lower investment than building a pulp dryer. More than 20% of the heat consumption of market pulp mills originates from the pulp dryer. This heat and accordingly these fuels are saved in integrated mills. Though a pulper is also usually needed in integrated mills to dilute the feed-in of additional market pulp, which is typically required for quality reasons, it can be smaller and the electricity consumption for stock preparation is reduced too. This reduction in mechanical wearing of the fibre may also increase the fibre yield and allow better properties of the paper produced. Finally, a larger number of endothermic and exothermic processes in a mill with different requirements for input heat conditions allows better heat integration (STFI, 2000). Contradictions to this general favourability of integration are limited to a few exceptions. The advantage of drying and re-diluting pulp, which one of the investigated mills observed (see chapter 4.2.2.1), tends to be an exception based on individual configuration of that mill. Overall the trend toward integration will continue in the pulp and paper industry, due to its energetic and commercial favourability, unless the shortage of primary fibre in the major paper-producing countries leads to an adverse trend again: paper production close to the consumer, primary pulp production close to the fibre.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: High

(17) Save fuel costs reducing consumption of steam and direct heat through reducing water consumption

The European pulp and paper industry has continuously reduced its water consumption during recent decades. This reduction in specific water consumption at the same time led to a reduction in heat demand. Every cubic meter of waste water leaving the mill at a higher temperature than the fresh water transports thermal energy out of the mill. The more the water flow gets a cycle, the less cold fresh water needs to be heated, and the more thermal energy can be recovered by various heat exchangers from the process water. The slight increase in electricity consumption is more than outbalanced by the savings in water and fuel (STFI, 2000). As the recovery of heat and the use for the low energetic steam and hot water gained will be discussed extensively in the subsequent chapter 5.2.1.1.2, the following paragraph will focus on remaining levers to close the discussion on the water cycle.

The EU BAT reference document (Commission of the European Communities, 2001) starts with a limited degree of concretion suggesting a counter-current white water system from paper mill to pulp mill depending on the degree of integration but becomes more specific in highlighting certain process steps, where they see the highest potential for increasing water recovery: At chemical pulping, they especially point out brownstock washing and screening as well as the bleaching plant. Martin et al. (2000) also disclose significant potential for water saving in the use of presses washing instead of washing with filters. Although initial equipment costs are slightly higher, washing presses are favourable as they reduce water and steam consumption and save chemicals compared to filters. At mechanical, thermo-mechanical, and chemi-thermo-mechanical pulping, the EU BAT reference document sees water saving potential. Two general levers for mechanical pulping, as well as for other processes in the pulp and paper industry, are the provision of sufficiently large buffer tanks and effective spill monitoring, containment, and recovery as well as the re-use of all condensates. Large buffer tanks help to save water storing, spilled cooking or recovery liquors, and dirty condensates at sudden peaks of loading and occasional upsets in the wastewater treatment plant. The reuse of condensates saves water and, thereby, fuels as well as chemicals. The EU BAT reference document discovers further potential for the recovery of condensates in the evaporation plant of chemical pulping as well as in the exhaust air of paper machines' drying hoods. Thereby, the recovery of steam always has two advantages: besides the water saving, thermal energy can be recovered from the latent heat of the moisture which can be used with heat exchangers for various purposes (see subsequent chapter 5.2.1.1.2). Overall, many possibilities for water and, thereby, steam and chemical savings exist. Although most mills have already picked the low hanging fruits, there is still potential for further improvement as comparisons across mills reveal.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Medium

5.2.1.1.2 Cost savings – recovery of heat from the process

Heat can be recovered from numerous process steps in pulp and paper manufacturing. This heat – typically gained as low energetic steam (≤ 3 bar) or hot water – can be used for many other process steps that use low energetic heat or sold to external consumers. The Swedish research group "The Eco-Cyclic Pulp Mill" suggests the illustrative display of heat requirements (inflow) and excesses (outflow) in two "grand composite curves" (temperature over flow). The better both curves can be matched, the less heat gets lost (STFI, 2000). The more heat consumers and heat suppliers – process steps releasing cooled inflow or generating heat in exothermic reactions (from mechanical work or chemical reactions) – can be included in this "matching components pumping system" (De Beer et al., 2001), the more fuel gets saved. This consideration underlines the favourability of integrated mills. Heat losses through convection (blow-offs of low energetic heat) and radiation should be minimised. Martin et al. (2000) estimate that 10% of the heat and, thereby, about 10% of the fuel input can be saved by measures with low investment costs. Further heat integration is feasible but requires higher investment (Axegård et al., 2002). Finally, the economic favourability of measures to achieve the ultimate heat recovery is doubtful. Where heat pumps are used to close gaps in the grand composite curves, the recovery rate increases, but electricity costs increase too (STFI, 2000). Thus, any of the subsequent actions to increase the heat recovery or use of recovered heat needs to be calculated according to the specific mill's conditions.

(18) Save fuel costs increasing heat recovery at mechanical pulping
The defibration of grinding, respectively refining, in mechanical, thermo-mechanical, and chemi-thermo-mechanical pulping is a sizable mechanical work which causes high specific electricity consumption (see chapter 4.2.2.1). However, significant shares of this electrical energy can be regained as low energetic steam (≤ 3 bar) and hot water. Whereas about 20-30% of the energy can be regained as hot water in all processes from SGW (stone groundwood) to CTMP, the feasible additional steam yield depends on the specific process. Roughly 20% can be achieved already at PGW (pressurised groundwood) and RMP (refiner mechanical pulp) and the yield can reach 40% at TMP and CTMP. Thus, total recovery rates of 70% (4-5 GJ/t) are feasible for TMP and CTMP, according to Martin et al. (2000) and De Beer at al. (2001). Due to impurities, the TMP/CTMP steam cannot be used directly. An intermediate heat exchanger is required. In cyclones, the TMP/CTMP steam is separated from the fibres before it is condensed in the re-boiler against vaporising clean steam (Commission of the European Communities, 2001).

Range of application: Mechanical pulping, TMP, CTMP
Ease of implementation: Medium
Magnitude of impact: High

(19) Save fuel costs increasing heat recovery at chemical pulping
Chemical pulping also offers various opportunities for heat recovery at cooking, lime re-burning, and potentially pulp drying.

Although continuous digesters are favourable compared to batch digesters when looking at the heat requirement (at the cost of slightly higher electricity consumption (Martin et al., 2000)), both technologies offer potential for improving heat recovery. The retrofit of old batch digesters to indirect heating with cycle pumping of heated liquor reduces the direct steam requirement. Similarly, heat exchangers between outgoing black liquor and internal circuits can save heat in continuous digester (STFI, 2000). Additionally, heat can be regained from outgoing steam.

The lime kiln is often forgotten in the search for sources of heat recovery. Wrongly so, as the exhaust gases of the lime kiln have relatively high temperatures and, thus, can be used for the generation of low energetic steam in heat exchangers.

In future, chemical as well as mechanical market pulp mills offer another opportunity for heat recovery. The steam impingement technology, which has been introduced in action (15), will be usable for pulp drying too. Superheated steam is used as a drying medium. While evaporated water at conventional air drying results in wet air, superheated steam still results in (low energetic) steam. Its heat can be recovered much better than the heat in wet air. The technology, however, cannot be used for all pulps and has not reached commercial penetration yet (STFI, 2000).

Range of application: Chemical (market) pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(20) Save fuel costs through increasing heat recovery at paper making
Heat recovery from paper machines focuses on the drying section (and coating section if available), as this is the section with highest heat requirements and highest excess heat (Steinbrecher and Hahn, 2003). While increasing the dry solids content of the paper from about 40-50% to 95%, large volumes of warm wet air are generated containing much latent heat. The air can either be cooled down in heat exchangers generating hot water and hot air or condensed to free the latent heat and released afterwards. According to Martin et al. (2000) the heat recovery can be increased from 15% to 60-70% (ca. 0.8 GJ/t) by installing closed

hoods instead of canopy hoods. An accompanying reduction in the air flow is advisable, as it eases the heat recovery and, furthermore, reduces the electricity consumption of the fans (Commission of the European Communities, 2001). For the recovery it is generally irrelevant if the initial heat has been applied as steam in heated cylinders or directly in gas-fired (Yankee) cylinders of IR-dryers. Only the drying hood for the collection of the hot wet air may look differently.

Besides this yield increase of heat recovery using conventional technology, the promising and steam impingement technology described above, which has not yet reached commercialisation, will be applicable to paper drying too.

Range of application: All paper mills
Ease of implementation: Medium
Magnitude of impact: Medium

The actions (18)-(20) have described and assessed the different opportunities for heat recovery in mechanical and chemical pulping as well as in paper manufacturing. But not only the sources of excess heat are manifold, the uses of this heat – low energetic steam, hot water and hot air – are also numerous. The two most common applications are the increase in dry solids content of the internally accruing fuels – especially the evaporation of black liquor but also the drying of bark and sludge – and the heating of the paper machine (De Beer et al., 2001). While the use of steam for the latter is self-explanatory, the increase in the dry solids content of the fuels will be taken up again in the subsequent chapter 5.2.1.1.3. However, there are some more uses for the heat beyond the two mentioned. Warm water, e.g., bleach plant effluents, can be used for defrosting round wood before debarking or chipping in the winter to pre-heat the chips before mechanical or chemical pulping (STFI, 2000). Market pulp mills can use the recovered process heat (if available as stem) for pulp drying (Commission of the European Communities, 2001). Another use for low energetic steam is the expansion of the process water evaporation in order to achieve a higher degree of water closure (STFI, 2000). Hot water and air, finally, can be used for feed water and combustion air pre-heating as well as for heating mill and office buildings. The remaining excess heat and – depending on the price – also additional dedicated heat (steam as well as hot water) can be sold to external consumers, neighbouring companies or as district heating.

5.2.1.1.3 Cost savings – heat yield from fuels

While both foregoing chapters have covered fuel and, thereby, cost savings through reduction of steam and direct heat consumption in the pulp and paper manufacturing processes respectively the recovery of excess heat from certain process steps, the existing chapter focuses on the increase in heat yield from fuels – especially steam yields in boilers. As described in more detail in chapter 4.2.2.1, there are few standard boiler configurations which are widespread in the pulp and paper industry. Yet chemical pulping inevitably requires a recovery boiler generating steam when burning black liquor and a second boiler for solid fuels, such as bark, sawdust or sludges. Here, BFB and CFB boilers are increasingly replacing old stoker-fired boilers. Pulverised-coal-fired boilers are exceptions due to their limited flexibility in fuels. All other mills would theoretically function with steam blocks. However, they are typically only supplements or back-ups, as they technically limit or commercially almost hinder the cogeneration of electricity. Thus, in the investigated stand-alone paper mills and fibre recovery/paper combinations stoker-fired or fluidised bed boilers operated with coal have been observed as well as steam generation subsequent to gas turbines. These "standard configurations" are considered in the subsequent actions aiming at reducing fuel costs respectively creating cost savings by increasing the steam yield in the boilers.

(21) Save fuel costs through increasing primary steam yield by automating monitoring, controlling, and steering

As outlined in action (1) for the consumption of process steam and direct heat, proper monitoring, controlling, and steering of combustion and steam generation in the boilers are the first steps towards fuel saving. On-line measuring and steering of flame temperature, oxygen, carbon monoxide, and smoke are required to safeguard full combustion of the fuels. Martin et al. (2000) assume a potential of 3% fuel saving in the pulp and paper industry from this action. An improvement in monitoring and steering, furthermore, allows the reduction of support firing. Steinbrecher and Hahn have highlighted this cost savings opportunity in their upfront investigation on the introduction of emission trading in the EU (Steinbrecher and Hahn, 2003). Another measure related to monitoring and controlling is the regular observation of the feed water to steam ratio of the boilers. Values significantly higher than 100% indicate leakages. Furthermore, the steam yield can be increased in soot blowing to clean the boiler of impurities. Steinbrecher and Hahn (2003) suggest impulse blowing instead of practiced continued blowing – ideally with high pressure steam instead of low energetic process steam, as a higher proportion of the energy in the steam can be recovered this way (Martin et al., 2000). The action is easy and cheap to implement as the monitoring, control, and steering equipment should be available. However, special implementation control is needed as in all behaviour-oriented measures.

Range of application:	All pulp and paper mills with steam generation
Ease of implementation:	High
Magnitude of impact:	Medium

(22) Save fuel costs through increasing primary steam yield by minimising energy of exhaust gases

The second action aiming at an increase of steam yield is also related to monitoring, controlling, and steering. The lower the flue gas temperatures from the chimney, the less heat gets lost into the environment. This heat recovery may occur in the flue gas even beyond superheater and economiser and generate low energetic steam, hot water or even hot air only. Nevertheless, it should be counted as a measure to increase the steam or heat yield from the fuels. Martin et al. (2000) estimate an additional 2% of fuel savings are assumed at very low investment costs, but they emphasise that the temperatures in the economizer or subsequent heat exchangers should not fall below the dew drop point of the acids in the flue gases in order to limit corrosion. As the ultimate heat recovery beyond these 2% savings may cause significant investments, the degree of implementation needs to be decided case by case.

Range of application: All pulp and paper mills with steam generation
Ease of implementation: High
Magnitude of impact: Low

(23) Save fuel costs through increasing primary steam yield by regularly maintaining equipment

Another good practice measure is the regular and properly accomplished maintenance of boilers. It helps increase the steam yield and reduces the risks of production downtimes. Thus, regular pressure probes of the boiler equipment are also well invested time. The OIT (1998) estimates that 20-30% of the initial boiler efficiency is lost within 2-3 years because of insufficient maintenance and 10% energy saving can be achieved with a simple but regularly accomplished maintenance programme. The costs of this maintenance programme are minor compared to the possible fuel saving. However, implementation control is needed for this behaviour-oriented measure.

Range of application: All pulp and paper mills with steam generation
Ease of implementation: Very high
Magnitude of impact: Low

(24) Save fuel costs through increasing primary steam yield by increasing dry solids content of burned black liquor

Black, respectively red, liquors of chemical pulping are burned to generate steam from the contained carbon and recover the various pulping chemicals. As the net calorific value of the liquor increases with the dry solids content, a portion of the water is evaporated using comparably cheap energy of low energetic steam. As conventional rising film evaporators achieve about 50% dry solids only, the generation of high energetic primary steam – needed for efficient cogeneration of electricity – in the recovery boilers is limited. Modern falling film technique, in turn, allows concentration of 70-80% (STFI, 2000). More primary steam can be generated. Additional pre-evaporation, using available hot water, can be a further contribution to an increase in the primary steam yield. Although evaporation may be formally a zero-sum game, it is absolutely favourable commercially. The value of the low energetic steam is considerably lower than the value of the additionally gained high energetic primary steam. On the one hand there is an excess of low energetic heat (many sources but only a limited number of valuable uses), while on the other hand, the efficiency rates of turbines significantly increase with higher pressures and temperatures of primary steam.

Range of application: Chemical pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(25) Save fuel costs through increasing primary steam yield by increasing dry solids content of burned bark

The reason for a measure to increase the dry solids content of bark is the same as for black liquor: the net calorific value increases and allows a higher yield of primary steam. The measure itself, however, is different. Press dewatering can be used achieving about 45% solids content (STFI, 2000). The efficiency is lower, of course, where outdated wet debarkers are still in use. The installation of bark presses is easy, and investment and current costs are relatively low. Thus, the action should pay off quickly.

Range of application: All pulp mills
Ease of implementation: High
Magnitude of impact: Medium

(26) Save fuel costs through increasing primary steam yield by increasing dry solids content of burned sludge

The increase in dry solids content of the occurring sludges follows the same rationale as outlined in actions (24) and (25). A dry solids content of 25-50% can be achieved with twin wire (belt) presses. An additional 10% increase is feasible with screw presses, decanter centrifuges and chamber filter presses (Commission of the European Communities, 2001). Thus, about 60% dry solids can be achieved which is enough to burn the sludges without support firing and gain some energy from the material, which would need to be landfilled otherwise. Again, saved fuel and landfill costs are worth the installation of twin wire and screw presses with a short payback time.

Range of application: All pulp and paper mills, especially fibre recovery
Ease of implementation: High
Magnitude of impact: Low

(27) Save fuel costs through increasing the heat yield of fuels using direct heating instead of indirect heating

This final action in the context of heat yield from fuels differs significantly from the aforementioned actions. While they aimed at increasing the yield of primary steam from fuels, this measure touches the efficiency gain from direct heating compared to indirect heating. Losses can occur only once, not twice. Thus, several equipment manufacturers and various authors suggest direct heating, especially in paper drying.

Here, gas-firing of the cylinders in the paper dryer has so far reached the widest penetration of direct heating. For Yankee cylinders in tissue manufacturing, gas-fired heating is a common technology, but Martin et al. (2000) assume, that the technology can also replace steam heating at other paper grades and allow average fuel savings of about 1.1 GJ/t. High retrofit costs, an increased need for maintenance and especially high gas prices relative to the prices of other fuels may question this action. Though, a combination of gas turbine with direct heating of Yankee or even conventional cylinders plus boiler – as recently suggested by equipment manufacturers Turbomarch and Metso (Durnicki and Vezil, 2006) – may tip the balance towards commercial favourability of direct heating.

A technology still waiting for commercialisation is air impingement drying. Hot air (about 300°C) is generated in gas burners and directly blown with high velocity against the wet paper web. According to De Beer (1998), the specific fuel consumption is 10-40% lower than in conventional drying, while the electricity demand increases by up to 5%. – As this technology has not been implemented on an industrial scale yet, the commercial favourability still needs to be proven.

Besides gas-fired drying, electricity-powered IR drying is feasible and can be applied for rapid drying especially in coating machines. Short-wave IR drying may also be applicable for regular paper drying. The energy is directed better into the web and specific energy use halves (Martin et al., 2000), but electricity is a comparably very expensive energy medium. Thus it is questionable if IR drying will find wide dissemination in the paper industry within the next years. It is still far from being a cost-efficient drying technology – apart from few limited exceptions.

Range of application:	All paper mills
Ease of implementation:	Low
Magnitude of impact:	Low

5.2.1.2 Cost savings – fuel price

More than two thirds of the energy costs in the mills investigated are fuel costs, as Fig. 42 (page 164) reveals. While 27 savings opportunities in the consumption lever have been described in chapter 5.2.1.1, this chapter focuses on the fuel prices. Besides commercial measures, fuel mix changes – considering purchased fuels as well as internally supplied fuels – changes in fuel logistics and the effects of political instruments on fuel prices are touched on.

(28) Save fuel costs using low-cost internal fuel by-products

Many pulp and paper mills use solid, liquid, and gaseous bio-fuels, which occur as by-products during the manufacturing process. Although it can be assumed that their occurrence is largely determined by the manufacturing process and potential variability in the main-product/by-product and a ratio favouring the main product will always be used, the yield of these by-products can usually still be increased. Actions (24)-(26) describe the increase in dry solids content and thus net calorific value of black liquor, bark and sludge. However, they are not exhaustive yet.

For certain of these by-products, collection can still be increased. Besides screening dust, this especially refers to bio-gas. Significant potential can still be mobilised at wastewater treatment (STFI, 2000). Anaerobic treatment produces methane which can co-burned in one of the existing boilers or dedicatedly used. A further advantage is that 50% less electricity is consumed than in aerobic treatment (Commission of the European Communities, 2001). Other high value by-products are turpentine, tall oil, and methanol. Their by-production at sulphate pulping could be increased in many mills. Besides profitable sales to other industries, value can be also created in internal applications, e.g., where these by-products replace expensive external fuels.

Beyond mobilisation and water content, the missing permission as fuel may hinder these by-products from being a cheap source of thermal energy. In Poland for example, the burning of sludges and rejects was not allowed in the pulp and paper mill investigated. Considerable volumes of sludges from fibre recovery needed to be landfilled. This legal constraint causes needless costs twice: costs of landfill and costs for alternative – presumably fossil – fuels. Here, only an appeal to the authorities may help.

If thermal use is allowed and the by-product mobilised and dried, only the application can be switched to gain higher value from the by-product. Expensive external fuels can be avoided in lime kilns not only by the use of by-products such as turpentine or tall oil but also by the use of bark. If the bark is gasified or pulverised in a grinder, it can fully replace other – more expensive – fuels such as fuel oil or natural gas. According to calculations of the Swedish research group "The Eco-Cyclic Pulp Mill", about 50% of the occurring bark would be required for this purpose (STFI, 2000).

Range of application: All pulp and paper mills, especially sulphate pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(29) Save fuel costs through regularly conducting requests for quotation
One of the simplest measures aiming at low fuel prices using commercial levers is the regular conduct of requests for quotation (RFQs). Depending on the type of fuel and the respective market situation each request should be sent out about once per year. Besides existing suppliers, potential new suppliers should be detected and approached. Standardised processes, potentially levering e-procurement, limit the efforts per request.

Range of application: All pulp and paper mills
Ease of implementation: Very high
Magnitude of impact: Low

(30) Save fuel costs through bundling volumes
Volume bundling increases negotiation power in the purchases. The levers are consolidation of the supplier base – easily feasible with all non-strategic goods – and the formation of buying consortia. While the volume bundling across different mills of one company should be good practice, buying consortiums with other companies can be considered. Partnering with other industrial fuel consumers or utility companies may offer significant savings potential. Also contractors of power plants may achieve better purchasing conditions, as the usually have a large total fuel purchasing volume.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Low

(31) Save fuel costs through using timing effects
Timing effects can offer additional savings potential in fuel costs. Besides typical seasonal fluctuations in fuel prices, the actual political situation should especially be considered. The continued observation of political developments helps avoid closing fuel contracts at price peaks.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Very low

(32) Reduce fuel cost through risk hedging purchases

Fuel price risks can be hedged by the use of financial instruments. Respective derivatives, typically referring to certain oil prices indices, can be bought at many commercial banks. The use of these instruments depends on the company's risk management policies. However, this fuel price hedging can only equalise fluctuations. However, a sustainable reduction in fuel prices is not achievable with these instruments in the long run.

Range of application:	All pulp and paper mills
Ease of implementation:	Very high
Magnitude of impact:	Very low

(33) Save fuel costs through changing fuel mix

The specific fuel prices, i.e. the total costs (net fuel price, taxes, and required emission allowances) per net calorific value, vary significantly between the fuels used in pulp and paper manufacturing. Substitution is usually feasible within the same condition of aggregation with the existing boilers, while a switch of fuels between different conditions of aggregation requires other boilers or at least fuel preparation. Thus, in the short run, there can be cost savings potential replacing coal by accruing or dedicatedly purchased solid bio-fuels such as bark, sawdust, forest residues or used wood, by replacing more expensive fuel oils (LFO, MFO) with cheaper fuel oils (HFO) or internally generated liquid bio-fuels as tall oil, turpentine or methanol and finally by replacing at least partially natural gas with generated bio-gas. In the longer run, i.e., when the equipment needs to be retrofitted anyway, switches between conditions of aggregation may also pay off. Accordingly, one of the investigated mills is planning to replace gas-fired steam boilers by coal-fired boilers. If the co-firing of used wood should be admitted, even revenues for disposal are achievable.

Range of application:	All pulp and paper mills
Ease of implementation:	High (within condition of aggregation), otherwise medium
Magnitude of impact:	Medium

(34) Save fuel costs through reducing fuel specifications

Some cost savings potential occurs in a reduction of fuel specifications. Typically, less clean fuels, i.e., fuels with higher sulphur and ash content, are cheaper than very pure fuels. If the operating license of boiler and filter equipment admits the use of these less clean fuels, it can be financially favourable to switch.

Range of application:	All pulp and paper mills
Ease of implementation:	Very high
Magnitude of impact:	Very low

(35) Save fuel costs through reducing inventories

A reduction in working capital and, thus, a cost saving can be achieved with a reduction in inventory levels. Consignment stocks may allow small own inventories. However, the actual cost saving may be limited, as joint costs with the supplier decrease only marginally.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Very low

(36) Save fuel costs optimising interdivisional flows

Besides the afore-mentioned advantage in volume bundling (internal buying consortia), interdivisional cooperation helps access low-cost bio-fuels. Own forests not only supply industrial round wood but give also access to forest residues. Saw mills within the same company can supply bark and sawdust etc. (For further considerations, see chapter 5.2.4.2).

Range of application: Pulp and paper mills within large companies
Ease of implementation: Medium
Magnitude of impact: Low

(37) Save costs of emission trading through highlighting direct effects

As described in great detail in chapter 4.2.2.4 (for the "most-likely" scenario), emission trading has a severe effect on manufacturing costs and, thus, on the competitiveness and profitability of the pulp and paper industry in Europe. The direct out-of-pocket component of the effect mainly originates from a scarce allocation of emission allowances for the combustion of fuels. As the calculation revealed, the magnitude of this component depends heavily on the allocation scenario. Thus, pulp and paper manufacturers should inform their relevant authorities about the effect and indicate the international competition in pulp and paper markets in order to receive the longest possible allocation in the next national allocation plan. Depending on the individual energy mix, the argumentation could focus either on historic emissions or benchmarks. Early actions should be referred to as well as the use of clean bio-fuels and potentially emission savings due to PCC manufacturing. Especially in the Eastern European countries, individual negotiations with the authorities have proven successful.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Very low

(38) Save costs of energy/emission taxation on fuels through indicating overlap with emission trading

The second action referring to the exercise of influence on political instruments affecting fuel costs focuses on energy or emission taxation. First of all, the respective tax legislation in the specific country must be understood. Various national legislation offers energy tax ceilings on fuels as well as on electricity for energy-intensive industries. In many cases, these hardness clauses and additional balancing options (e.g., energy tax vs. pension insurance in Germany) give pulp and paper manufacturers significant reductions in real tax burdens compared to nominal tax burdens. Furthermore, attention should be paid to where electricity is generated from renewable energy sources or in cogeneration. Usually, fuels used for these purposes should be exempted from energy taxation. A second consideration is the parallel exertion of energy or emission taxes and emission trading. Already in chapter 2.1.1.5 it has been argued that, due to the interference of both instruments, all industry sectors subject to emission trading should be exempted from energy taxation. Accordingly, pulp and paper manufacturers and their associations could take up lobbying activities at a national and an EU level for the waiver of the affected industry sectors from energy taxation. However, due to a potential reaction of the price of emission allowances, the actual cost saving might be the transaction costs of energy and emission taxes only. Furthermore, the incentive for these efforts may be limited, where real tax burdens are relatively low compared to nominal tax burdens.

Range of application:	All pulp and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Very low

5.2.2 Cost savings – electricity

Similar to savings opportunities in fuels cost outlined above, the description of electricity cost savings will be separated into electricity consumption and electricity price. The consumption lever, disaggregated in chapter 5.2.2.1, is straightforward. The electricity price lever, however, covered in chapter 5.2.2.2, requires an upfront remark as almost 40% of the electricity consumed in the European pulp and paper industry is generated internally (39.6% according to a report by CEPI (2005) for the entire European pulp and paper industry, 31.7% in the mills investigated). Thus, the coverage of electricity demand is a gradual make-or-buy decision. Accordingly, the average electricity price consists of costs of internally generated electricity and the price of purchased electricity. Thus, chapter 5.2.2.2 comprises actions aimed at the reduction of specific costs of internal generation as well as cost savings measures for electricity purchase. Looking at the share of electricity costs on total manufacturing costs (see Fig. 32 and Fig. 33), savings in electricity consumption and prices can be valuable contributions to maintaining or re-establishing the profitability of pulp and paper manufacturers.

5.2.2.1 Cost savings – electricity consumption

Whereas specific heat and especially water consumption have continuously declined in the pulp and paper industry during recent decades, the achievements in the specific electricity consumption, primarily at paper manufacturing, are less obvious, due to three main reasons. The first is the trend towards more advanced paper grades. Calendering, coating, and other process steps required in high-value paper manufacturing increase specific electricity consumption compared to basic papers such as newsprint etc. The second is the trend towards increasing the running speed of paper machines. According to a general mechanical law, dynamic friction increases in square with increasing velocity. This affects wires and felts of paper machines as well as pumps, fans etc. The third reason for increasing or at least stagnating specific electricity consumption is heat savings and recovery measures as well as efforts towards closure of the water cycle. More pumps are required and, therefore, more electricity is consumed (Talja, 2006).

Irrespective of these drivers for stagnation or even a slight increase, numerous actions can be taken to contain or decrease the specific electricity consumption. However, as pointed out when looking at fuels before, the technical potential is always higher than the economic potential. Not all electricity savings measures pay off in mill practice. Thus, the assessment of the magnitude of impact again refers to cost savings not to consumption savings.

(39) Save electricity costs through automating monitoring, controlling, and steering
As mentioned in action (1) in chapter 5.2.1.1 under fuel savings, the implementation of a comprehensive system of monitoring electricity supply and consumption is the first step towards electricity cost saving. Variations in consumption will be observed and scrutinised. Thus, simple measuring evokes changes in the behaviour of the personnel. Manual process control should be replaced by automated process control (Commission of the European Communities, 2001). The steering of repeated or continuous processes should also be automated as far as possible. As reported above, an application where automated steering opens up cost savings potential is the airflow in the drying section of the paper machine. If the air flow is reduced to an amount so that the exhaust air is close to its dew point, electricity consumption can be reduced significantly – furthermore heat recovery from the exhaust air becomes more effective (De Beer et al., 2001). A means to regulate electrical engines in line with automated steering is the use of variable (adjustable) speed drives. Frequency converters at larger engines (debarker, chipper, refiner etc.) but also at pumps and fans can provide significant savings in electricity consumption (see De Beer et al. (2001) and Jokinen (2006)). Another example for the benefits of automated steering again refers to paper drying. Due to the relatively high consumption of electricity powered IR-dryers, Steinbrecher and Hahn (2003) report considerable savings potential from improved steering at IR-dryers in paper and coating machines. Due to the significant savings in electricity consumption, the initial

investment in automated monitoring, control, and steering equipment typically pays off within a relatively short time. Recurring costs are comparably negligible.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Low

(40) Save electricity costs through regularly maintaining equipment
While action (39) corresponds to action (1), action (40) corresponds to action (2). Improving the maintenance of steam generators, grid, and consumers saves fuel as improving the maintenance of electricity generators and engines saves electricity. Regular and properly accomplished maintenance allows electricity savings in various process steps of pulp and paper manufacturing. The EU BAT reference document especially refers to the big electricity consumers such as refiners (Commission of the European Communities, 2001). This action has no investment costs and current savings regularly exceed costs of maintenance at least for big consumers.

Range of application: All pulp and paper mills with steam or direct heat consumption
Ease of implementation: Very high
Magnitude of impact: Low

(41) Save electricity costs through properly sizing the equipment
Proper sizing of the equipment is another good practice action aimed at energy saving. It refers to the design and dimensioning of electrical engines as well as to all pipes and pumping equipment (Commission of the European Communities, 2001). An example for the latter is the use of fine-slotted wedge wire baskets in fibre screening systems instead of traditional screening systems. Pipe diameters and pumps can be dimensioned smaller (Martin et al., 2000). Due to the comparably long useful life of equipment in the pulp and paper industry, the electricity and, thus, cost savings potential in existing mills is however limited. Thus, this action primarily refers to required retrofits and new installations.

Range of application: Especially older and fast-running paper machines
Ease of implementation: High
Magnitude of impact: Medium

(42) Save electricity costs through optimising consistencies in each process step
A similar action targeted at electricity saving is the optimisation of pulp, respectively stock consistencies, in each process step. The potential for heat saving by switching from a low- to a medium- or high-consistency technique in the entire washing section has been described in chapter 5.2.1.1. However, the electricity savings potential is also considerable. The research

group "The Eco-Cyclic Pulp Mill" estimates a 6-10% reduction in electricity consumption in the fibre line by increasing the consistency from 1-3% to 8-12% throughout washing, screening, and bleaching (medium consistency). The slight friction increase is more than outbalanced by the reduction in the volume which needs to be pumped (STFI, 2000). In stock preparation as much as 33% of the electricity can be saved through operating at higher consistencies and with an optimised rotor design (Commission of the European Communities, 2001). A consistency increase in forming of the fibre web in paper manufacturing can allow further electricity savings. Martin et al. (2000) report 8% saving in the vacuum boxes by increasing the consistency of furnish from 1.5% to 3.0% referring to Elaahi and Lowitt (1988). Other authors estimate even 20% electricity savings potential in forming the web at higher consistencies (Commission of the European Communities, 2001). This high consistency forming, however, is feasible only at low weight paper grades (newsprint, tissue). Finally, consistency changes in the refiners at mechanical, thermo-mechanical, and chemi-thermo-mechanical pulping allow significant electricity savings. However, as these consistency changes go along with other modifications in the refining process, they will be touched on in one of the subsequent actions covering state-of-the-art refining technology.

Range of application:	Most pulp and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(43) Save electricity costs through adapting efforts to requirements

Another action in the context of steering and consistency (actions (39) and (42)) is the adaptation of efforts in fibre processing and refining to the actual requirements of the respective paper manufacturing process. Significant electricity savings can be achieved in the stock preparation in fibre recovery if the refining is reduced to the needs of the paper produced. Basic paper grades can make do with less refined fibre and, thus, allow lower electricity consumption and higher fibre yield than advanced paper grades. According to the EU BAT reference document, the specific electricity consumption varies by factor three between different plant concepts (Commission of the European Communities, 2001). Although the full potential can only be tapped from specifically configured equipment, a good share of the electricity, fibre and, thus, cost savings potential should also be achievable with the existing equipment.

Range of application:	Paper recovery and paper mills
Ease of implementation:	Very high
Magnitude of impact:	Low

Actions (39)-(43) describe measures whose favourability primarily originates from their effect on specific electricity consumption. All four are rather behaviour- or management-oriented and not limited to specific process steps of pulp or paper manufacturing. The latter is true also for two more measures, but their primary source of favourability is fuel, respectively fibre saving. Accordingly, they deserve a brief mention at this point but are listed as actions in chapters 5.2.1.1 respectively 5.2.4.1.

The first of these two measures is the minimisation of production interruptions which has been highlighted when looking at fuels in action (3). Beyond losses in heat and turnover, their effect on the specific electricity consumption is one more reason to take equipment-specific measures to safeguard good runability. Especially older and fast-running paper machines frequently have downtimes due to web breaks. Although some of the engines can be stopped entirely, electricity is wasted. The remaining required engines of paper machine and ventilation run at full electricity consumption (if the speed is not adjustable) and white water pumps are at peak performance. Overall, measures to reduce production interruptions pay off quickly considering energy consumption and production downtime (Commission of the European Communities, 2001).

The second is the minimisation of fibre losses. As the respective actions are in the focus of chapter 5.2.4.1, solely the impact of these actions on the specific electricity consumption will be highlighted at this point. Any defibration – mechanical as well as chemical pulping – and subsequent process steps such as washing and bleaching consume significant amounts of electricity. Thus, all measures to minimise losses of dispersed fibres in systems of washing and bleaching sections as well as in white water recycling of paper manufacturing save electrical energy. Accordingly, measures reducing these losses pay off not only due to yield increase but also due to their positive effect on specific energy consumption.

Whereas the afore-mentioned actions (39)-(43) were rather behaviour- or management-oriented and not specific for certain process steps of pulp or paper manufacturing, the subsequent actions (44)-(51) are rather technical and mostly process step specific.

(44) Save electricity costs using state-of-the-art technology at debarking

In action (25) it has already been mentioned that wet debarkers – either high pressure water blast or wet drum debarkers – are an outdated technology today. In North America, they were installed until the late 1970s, while in Europe their penetration was low even at that time. Nevertheless, in a few mills their replacement by newer technologies may allow energy and, thus, cost savings. Martin et al. (2000) estimate about 40% electricity savings through replacement of wet ring debarkers with dry ring debarkers. However, even the latter have been widely replaced by dry drum debarkers. They are currently the most common debarking technology in Europe. Further savings can be achieved using one of two even more state-of-the-art technologies. The Cradle Debarker developed by Dieter Bryce Inc. in the mid 1990s allows about 33% energy savings and an increase in the wood yield compared to the dry drum technology (United States Department of Energy, 1999). According to Martin et al. the accruing sawdust is reduced by 75%. Another more advanced but already commercially available technology is the enzyme aided debarking described by Martin et al. (2000). They report approximately 60% energy savings. However, the effect on the wood yield and fuel value of bark remains unclear. While the Cradle Debarker seems commercially favourable due to both effects, energy savings and yield increase, the favourability of enzyme aided debarking still needs to be proven in practice.

Range of application:	All pulp mills with drum debarkers
Ease of implementation:	Medium
Magnitude of impact:	Low

(45) Save electricity costs through using state-of-the-art technology at chip transport

Electricity and cost savings can also be obtained in some mills at the chip transport. Where the chips are still conveyed pneumatically, high savings in the electricity consumption are achievable. The replacement of pneumatic conveyers for chip handling by belt conveyers reduces electricity consumption by about 85%. Furthermore, the wood yield increases by approximately 1.6% as Martin et al. (2000) report. A respective retrofit in the mills still applying the old technology should pay off within a very short time due to electricity as well as fibre savings.

Range of application:	All pulp mills with pneumatic chip transport
Ease of implementation:	Medium
Magnitude of impact:	Low

As Fig. 30 and chapter 4.2.2.1 reveal, the electricity consumption of mechanical, thermo-mechanical and chemi-thermo-mechanical pulping are high compared to other pulping processes. Looking at the development of specific consumption during the last decade, no significant decrease could be observed, although significant savings potential exists (Gielen and Tam, 2006). Measures to unlock this potential – electricity consumption and manufacturing costs – will be outlined in the three subsequent actions (46)-(48). While (46) refers to state-of-the-art grinder and refiner designs and materials, (47) covers the state-of-the-art refining conditions, and (48) introduces advanced technology for mechanical pulping.

(46) Save electricity costs through using state-of-the-art technology at mechanical pulping (grinder and refiner design and materials)

Even under the perpetuation of today's processes in mechanical pulping and under basically unchanged thermo-mechanical conditions, the specific electricity consumption can be reduced considerably with improved surface materials and refiner designs. Many mills have not yet fully utilised this savings potential lying in state-of-the-art technology. Whereas the replacement of disc refiners by conical refiners together with a decrease in the consistency from 50% to 30% – allowing 11% electricity savings according to Martin et al. (2000) and De Beer et al. (2001) – has largely taken place in the European pulp and paper industry, improved materials could still increase their penetration. Ahtila (2006) and Burkhart (2006) suggest improved grinder surface materials (e.g., replacement of stone by metal matrix) and refiner blades. Overall, the EU BAT reference document estimates 33% reduction potential in specific electricity consumption by the use of best-practice refiners and regular maintenance (Commission of the European Communities, 2001).

Range of application:	Mechanical pulp mills, TMP mills, CTMP mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(47) Save electricity costs through using state-of-the-art technology at mechanical pulping (grinding and refining conditions)

Looking at the efforts of implementation, changes in grinding and refining conditions exceed the introduction of improved designs and materials as described in action (46) as they are typically not limited to certain process steps or specific machines but require a retrofit of the entire process chain. Nevertheless, several more recent but available process innovations tend to be promising due to lower electricity consumption and improved product properties.

Starting with mechanical pulping, the replacement of the standard PGW process by the Super-PGW process appears very beneficial. An increase in the pressure towards 4.5 bar softens the lignin with higher temperatures and results in fibre properties close to TMP. Electricity consumption is reduced by 50% and significantly below that of TMP-pulp (De Beer et al., 2001). Accordingly, manufacturing costs are reduced compared to PGW and higher prices can be achieved due to the increase in product properties. The Super-PGW process could be a step ahead to safeguard the position of primary pulping against fibre recovery.

In thermo-mechanical pulping, three more state-of-the-art processes may gain share compared to the standard TMP process. The smallest innovation is the LCR (low consistency refining) process. According to Cannell (1999), it reduces the specific electricity consumption by 7% compared to the standard TMP process. Another modification of TMP pulping is the RTS process. It differentiates by shorter residence or retention time, elevated temperature, and higher speed in the first refiner stage. The specific electricity consumption is 10-15% lower than in the standard TMP process (Commission of the European Communities, 2001). A third modification is Thermopulp, again a two-stage process. In the first stage, the temperature is low, while the second stage is characterised by high temperature and high pressure defibration. As in the RTS process, energy savings are 10-15% compared to the TMP process (Commission of the European Communities, 2001).

Range of application: Mechanical pulp mills, TMP mills
Ease of implementation: Medium
Magnitude of impact: Medium

(48) Save electricity costs through using advanced technology at mechanical pulping
Whereas the modifications described in actions (46) and (47) have meanwhile been developed to industrial scale, the subsequently outlined measure still requires continuation of the development to become applicable on a large scale. The use of fungi or isolated enzymes to reduce the mechanical work required for grinding or refining promises significant electricity savings but still faces obstacles (Akhtar et al., 1995). The chips are pre-treated in large silos after fungi inoculation, where the enzymes in fact break down the lignin and, thus, reduce the mechanical work required. Scott et al. (1998) report 25-40% electricity saving compared to mechanical refining. However, problems still arise from the limited selectivity – celluloses and hemi-celluloses are also decomposed to a certain degree – and the investment costs for large silos as the chips need to be pre-treated for about 14 days before pulping (Kallioinen et al., 2003). Another cost factor is the steam required for pre-treatment of the chips before fungi inoculation. Overall the use of fungi or isolated enzymes is promising, but has not yet proven commercial favourability. Developments during the next few years may unlock the significant electricity savings potential.

Range of application: Mechanical pulp mills, TMP mills
Ease of implementation: Medium
Magnitude of impact: Low

(49) Save electricity costs through using state-of-the-art technology in the forming section
In action (11), two advanced technologies of steam and direct heat savings in paper making have been introduced which apply to forming. Both the air laying technique for web forming as well as the use of ethanol or super-critical CO_2 as forming media may be future technologies which have not yet reached commercialisation. State-of-the-art gap formers (blade former, roll former or roll-blade former), by contrast, have already achieved relatively wide penetration in the paper industry. Nevertheless, there are still mills which could replace outdated Fourdrinier formers by state-of-the-art gap formers to benefit from capacity increases, quality improvements, and electricity savings (Martin et al., 2000). As the required retrofit of the forming section is a limited investment, it should pay off within a relatively short time if it corresponds to the surrounding equipment.

Range of application: All paper mills
Ease of implementation: High
Magnitude of impact: Low

(50) Save electricity costs through using state-of-the-art technology in the wire section
As in action (12) in chapter 5.2.1, this action (50) refers to the wire section of the paper machine. However, the focus of action (50) is not on improving dewatering and, thus, saving fuel but on saving electricity. The two levers are application (and regular maintenance/ cleaning) of state-of-the-art wires, felts, and sliding surfaces, on the one hand, and the use of modern vacuum systems, on the other hand. The latter should not only improve dewatering capabilities (Talja, 2006) but also electricity consumption. The EU BAT reference document estimates 25% electricity savings potential between old and state-of-the-art vacuum systems (Commission of the European Communities, 2001).

Range of application:	All paper mills
Ease of implementation:	High
Magnitude of impact:	Low

(51) Save electricity costs through using state-of-the-art technology at lighting
Although action (51) is clearly a technical measure, it cannot be allocated to certain process steps of pulp or paper manufacturing. It is an action applicable in any mill. Although lighting is not one of the major electricity consumers in most pulp and paper mills, some electricity and costs can be saved using up-to-date technology. High-pressure mercury lamps can be replaced by electronic ballasts and fluorescent tubes in warehouses and offices respectively high-pressure sodium lamps in the manufacturing area. Martin et al. (2000) estimate 40% electricity savings potential in lighting.

Range of application:	All pulp and paper mills
Ease of implementation:	High
Magnitude of impact:	Low

One final technical-oriented measure which can be clearly attached to a specific department of pulp and paper mills will be mentioned at the end of the chapter on electricity savings. However, as its primary source of favourability does not originate from a reduction in the specific electricity consumption it has already been sketched in chapter 5.2.1.2 referring to fuel prices under action (28). The switch from aerobic water treatment to anaerobic water treatment not only generates bio-gas, which can be used as a cost-free by-product fuel, but also saves 50% of the electricity needed at water treatment (Commission of the European Communities, 2001). Whereas a retrofit of the existing water treatment plant of a mill tends to be improbable, this favourable process should be considered for all new water treatment plants and retrofits which are inevitable for other reasons.

5.2.2.2 Cost savings – electricity price

For many mills in the pulp and paper industry, the electricity "price" is a weighted average between the actual purchase price of electricity and the costs of internal electricity generation.

As described in chapter 2.1.3.2 for the European pulp and paper industry in general and in chapter 4.2.2.1 for the investigated mills in particular, a share of 30-40% of the electricity consumption is covered with internally generated electricity. Basically, all chemical pulp mills, whether stand-alone or integrated, generate electricity internally, mostly in back-pressure and to a smaller degree also in condensing turbines. About half of the integrated mills producing mechanical pulp or recovered fibre and paper also operate boilers fired with bark, sludge, coal, oil or gas and run back-pressure or condensing turbines. Combined cycle gas and steam turbines are still exceptions, but will presumably gain share within the next decade. The contribution of small scale hydro power turbines is even smaller.

For all these mills, internal electricity generation vs. electricity purchase is a gradual make-or-buy decision that needs to be taken day-to-day or, as we will see below, even every 15 minutes. In the short run, a mill should maximise its internal electricity generation until the marginal costs of generation equal the marginal costs of electricity purchase or the power limit of the turbines is reached. The algorithm required for steering the turbines needs to consider numerous variables on the generation as well as on the purchase side. Besides fuel costs, emission allowances employed or subsidies for cogeneration as well as the use of accruing process steam should be included. On the purchase side, the relation between current electricity consumption and ordered power is an important driver in the algorithm as the purchase of balancing power (or operating reserve) usually is very costly. Thus, even less efficient internal generation capacity such as condensing turbines can be valuable as a buffer for consumption peaks. In the long run, the number of factors to consider in the make-or-buy decision even increases, as numerous different energy configurations (boilers, turbines etc.) can be chosen. In this horizon joint power plants or transforming stations with other large electricity consumers in the neighbourhood may also be worth consideration. Likewise, sales of internally generated electricity and heat to neighbouring companies or public grids should be assessed.

Despite the afore-mentioned cost and flexibility considerations when looking at internal electricity generation, cogeneration of steam and electricity in pulp and paper mills helps increase generation efficiency and reduce CO_2-emissions on a national level. The yield of comparably cheap internally generated electricity from the fuels burned in the pulp and paper industry can be enhanced – moderately if today's technology (recovery and bark boiler plus back-pressure turbine) is used, drastically if advanced technology (black liquor and bark gasification) reaches industrial scale.

(52) Save electricity costs through increasing electricity yield at internal generation by properly monitoring, controlling and steering turbines

The electricity yield from a given steam enthalpy can also be influenced by behaviour-oriented measures. Besides monitoring, controlling, and steering of the turbines, the merit order of the turbines is an easily influenceable but important success factor. Combined gas and steam turbines use the energy from fuels very efficiently if they are operated at nominal capacity. As they lose efficiency significantly if they are operated below nominal capacity, they are not very flexible. This is a typical problem in the ramp-up phase (up to five years) of a new mill (STFI, 2000). Stand-alone back-pressure turbines use the energy of primary fuels comparably efficient too if there is full use of the secondary steam. If it needs to be blown off, efficiency is immediately lost. Condensing turbines, in turn, are comparably inefficient, but may be a reasonable use for excess steam (Commission of the European Communities, 2001). While in the long run, a proper combination of turbines maximises the cost-efficient internal generation of electricity from existing fuels, in the short run a merit order of turbines is required. Gas and subsequent back-pressure turbines should run all the time on nominal capacity, stand-alone back-pressure turbines should be ranked according to their efficiency, and condensing turbines ought to be buffers for consumption peaks (to avoid the need for balancing power) and temporary excess steam only. Additionally, the installation of buffer tanks for the secondary steam of back-pressure turbines should be considered. If such a tank is available, the turbine can be run also during a short production stop and reduced process steam requirement without blowing-off the secondary steam. A capacity of 30-60 minutes is sufficient to maintain efficiency in this respect.

Range of application:	All pulp and paper mills with internal electricity generation
Ease of implementation:	High (merit order), Medium (buffer tank)
Magnitude of impact:	Medium-low

(53) Save electricity costs through increasing electricity yield at internal generation by maximising enthalpy of generated steam

The efficiency of steam turbines (MWh generated electricity per GJ consumed steam enthalpy) increases with the difference of specific enthalpies between primary steam and secondary steam. The conditions of the secondary steam are largely determined by the requirements in the various pulp and paper manufacturing process steps. Where tolerances exist, the EU BAT reference document suggests utilising the enthalpy of the steam in back-pressure turbines down to the lowest possible pressure level (Commission of the European Communities, 2001). The enthalpy of the primary steam, in turn, remains rather an (gradually) adjustable variable. Thus, the boilers should be operated at the highest possible temperatures and pressures of primary steam within the limit set by material properties (see The Commission of the European Communities (2001), STFI (2000), Jokinen (2006), Gielen and Tam (2006)). To date, recovery and bark boilers can usually achieve 450-510°C and 60-90 bar. Above these temperatures and pressures, the material does not withstand corrosion caused by the pulping chemicals. However, within the given material limits, the electricity yield can be maximised by increasing temperature and pressure. Accordingly less – expensive – electricity needs to be purchased and the average costs per MWh of electricity consumed decrease. As the implementation refers to steering of existing equipment only, it is easy and pays off immediately.

Range of application: All pulp and paper mills with steam turbines
Ease of implementation: Medium
Magnitude of impact: Low

(54) Save electricity costs through increasing electricity yield at internal generation by using external superheating

As sketched under previous action (53), the maximisation of electricity yield from consumed steam requires the maximisation of the enthalpy of the primary steam within the material limits. Due to increasing corrosion caused by pulping chemicals, current boiler materials do not allow temperatures above 510°C, respectively pressures above 90 bar. Any higher pressure would cause wet steam in the turbine. The only option to achieve higher enthalpies with current materials is external superheating: steam is heated to 510°C or less in the conventional superheater of the recovery boiler and post-heated in an external superheater to 530°C or more using clean fuels which do not cause the corrosion problems known from black liquor. Even cheaper materials for the recovery boiler would be feasible (STFI, 2000). Whereas the technical implementation of this action is not too complicated and could be done in the course of a required retrofit of the boiler, financial favourability depends on the costs of the fuel used for superheating and the gain in electricity yield.

Range of application: Chemical pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(55) Save electricity costs through increasing electricity yield at internal generation by using advanced boiler materials

The third lever for the increase in the electricity yield by enhancing the enthalpy of the primary steam is the boiler, respectively superheater, materials. The Swedish research group "The Eco-Cyclic Pulp Mill" estimates 15% yield increase if the steam conditions can be raised from the current standard (450-510°C, 60-90 bar) to 530°C/110 bar (STFI, 2000). However, materials able to withstand these conditions in recovery boilers are still under development, respectively need to become cheaper, to be usable for this application. However, the costs of these advanced alloys do not pay off by the increase in electricity yield.

Range of application:	Chemical pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(56) Save electricity costs through increasing electricity yield at internal generation by using black liquor gasification

A tremendous leap ahead for chemical recovery, steam, and electricity generation of chemical pulp mills seems to be black liquor gasification. As soon as it is fully available on an industrial scale, it will provide either a significant increase in electricity yield from black liquor or be the cornerstone for an advanced bio-refinery. However, one caveat needs to be made at the beginning: black liquor gasification is not a perpetual motion violating the laws of thermodynamics. It cannot maximise the yields of electricity, steam, chemicals, and wood at the same time. It's either optimised towards electricity yield, which is discussed in chapter 5.2.2.2, or towards bio-refinery, which is covered in chapter 5.2.8.

Black liquor gasification has not yet reached full commercialisation, although more than 20 different attempts at development and commercialisation have been made in Europe and North America since the 1950s (Whitty, 2002). Whereas the gasification approach and temperature differ across these attempts, all of them have the generation of synthesis gas, steam generation at gas cooling, and the use of syngas in common. Irrespective of the gasification approach the syngas is either burned aiming at high electricity yield from the black liquor or used for the production of hydrogen, Fischer-Tropsch-liquids or methanol and successive chemicals. Most of the attempts – about half of them followed the low temperature route (inorganic compounds, i.e., the pulping chemicals, accrue as ash) and half the high temperature route (inorganic compounds accrue as smelt) – have meanwhile been abandoned. Typical hurdles were low efficiency, the limited durability of reactor materials, and problems in chemical recovery resulting in high, non-competitive prices of electricity or chemicals gained.

Today, only two development routes are still visibly pursued: MTCI (Manufacturing & Technology Conversion International, Inc.) has installed two full-scale systems in North America, both following the low temperature approach, and is involved in a further three (Whitty, 2005). The installation at Norampac Trenton (Ontario) started up in 2003 and processes 100 tons dry solids black liquor per day, while the installation at Georgia Pacific Big Island (Virginia), started up in 2004, gasifies 200 tons per day. The Swedish Chemrec AB, in turn, follows the high temperature approach. Its Booster system was first applied at commercial scale at Weyerhaeusers New Bern (North Carolina) mill with 300 tons dry substance per day in 1996 to relieve the existing recovery boiler. The more recent concepts are BLGCC (black liquor gasification combined cycle) and BLGMF (black liquor gasification motor fuels) which have reached the status of a development plant in Piteå (Sweden), and started in 2005 (Gebart, 2006).

Based on the Chemrec DP-1 reactor in Piteå as the most recent concept, the generation of syngas and its use for electricity generation in a BLGCC will be briefly introduced. Black liquor of about 65% dry solids content is heated with steam to 135°C and sprayed by use of high pressure oxygen into the upper part of the gasifier (STFI, 2000). About 0.5 tons of oxygen are used per ton dry solids black liquor and blown in at about 32 bar. Alternatively, the use of air instead of oxygen and atmospheric pressure instead of high pressure would be feasible (Booster technology), but result in lower energetic syngas and reduce the overall efficiency significantly. The small black liquor spray droplets are combusted only partially, generating heat of 950-1050°C. The inorganic compounds sodium sulphide (Na_2S) and sodium carbonate (Na_2CO_3) trickle down as small droplets into a quench cooler, while the organic compounds are converted to a combustible syngas of medium calorific value consisting of hydrogen (H_2), hydrogen sulphide (H_2S), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) and trace elements (Gebart, 2006). The hydrogen sulphide contains about 50% of the entire sulphur (less at low-temperature gasification), while the remainder is in the sodium sulphide of the smelt (STFI, 2000). The syngas is cooled, generating medium and low pressure steam (12 and 3 bar), while the yield of medium pressure steam increases with temperature and pressure in the gasifier (STFI, 2000). After cooling, the syngas is discharged into the white liquor to recycle the sulphur of the hydrogen sulphide. Finally, the cool and clean syngas is used either for highly efficient electricity generation (BLGCC) or fuel production in a bio-refinery (BLGMF). The chemical recovery, in turn, is somewhat similar to the standard recovery process used in kraft pulping. The smelt – looking at the high temperature gasification – is dissolved to obtain the green liquor which contains about half of the sulphur (originating from the sodium sulphide). Due to the release and pressurised re-absorption of hydrogen sulphide in the quench cooler, more alkali is present as sodium bicarbonate ($NaHCO_3$) in the green liquor than in the conventional process. Accordingly, the lime demand in causticising is higher and more lime needs to be re-burned (STFI, 2000). The remaining sulphur is added to the white liquor generated, when the syngas with its hydrogen sulphide is discharged into it (Gebart, 2006). While the two separate streams of sodium and sulphur are an advantage of black liquor gasification compared to the standard process (Gebart, 2006), as they allow better process control, the increased demand for causticising is a significant disadvantage. Thus, hopes are directed at borate auto-causticising, titanate direct causticising and, under certain conditions, also manganate conversion (see action (9)). However, significant future research is needed, especially looking at titanate and manganate (Sinquefield, 2005), as they have not reached commercial applicability yet (Axegård et al., 2002).

Though remaining hurdles need to be overcome for a wide commercial application of black liquor gasification in sulphate pulp mills, the efforts appear to be worthwhile. Besides the options opened up for bio-refineries (see chapter 5.2.8 below), the electricity yield is significantly better than in the standard configuration with recovery boiler and back-pressure turbine.

If the black liquor gasification is optimised for electricity generation, i.e., if the syngas is burned in a state-of-the-art gas-turbine/steam-turbine combination, the surplus power of a sulphate pulp mill can be doubled to 1,450 kWh/bdt compared to about 700 kWh/bdt with the standard configuration of recovery boiler and back-pressure turbine (STFI, 2000)). While the standard combination realises an electricity yield of about 15-20% (electricity generated per lower heating value of fuels burned), BLGCC reaches 35-41%. If advanced gas turbines were used and operated at optimum efficiency even 50% power yield could be achieved, 90% thereof contributed by the gas turbine and 10% contributed by the back-pressure turbine. If all Swedish sulphate pulp mills were equipped with this technology, the entire electricity demand of the Swedish pulp and paper industry could be covered internally (STFI, 2000). However, this optimisation towards power (instead of heat or bio-refinery) would cause a moderate shortage of steam for the process. Accordingly, slightly more biomass, bark or other solid bio-fuels such as forest residues, need to be added – pre-dried with flue gases and gasified as the black liquor – in order to be both electricity and heat self-sufficient.

Whereas the technical potential of black liquor gasification for electricity generation as well as for bio-refinery is tremendous and undoubted, its economic potential still needs to be unlocked. Gebart et al. (2005) report higher investment costs for the Chemrec process compared to the standard configuration and assume a two-year longer payback time, but regard black liquor gasification as economically favourable afterwards assuming 2006 fuel and electricity prices. Further price increases would reduce payback time and increase the net present value of the investment.

Nevertheless, significant efforts need to be spent to overcome the remaining problems of the current development stages of the Chemrec process as well as of the MTCI process. Only if these problems (material durability, causticising etc.) are solved, will black liquor gasification attain the potential to fully replace today's standard configuration of chemical pulp mills, (Gebart et al., 2005) either owing to higher power yields and, thus, moderate electricity costs or owing to revenues and profit from the bio-refinery.

Range of application:	Sulphate pulp mills
Ease of implementation:	Very low
Magnitude of impact:	Very high

Cost reductions in purchased electricity can be achieved using commercial levers, switching voltage level of grid connection, minimising consumption of balancing energy, and using certain political instruments.

(57) Save electricity costs through regularly conducting requests for quotation or purchasing electricity at exchange

Pulp and paper mills' abilities to save electricity costs using commercial levers strongly depend on the degree of liberalisation of the electricity market in the respective country. In some countries, they are still obliged to source from one national supplier, while in other countries power and grid can be contracted separately. In the latter case, the power prices can usually be negotiated, while the grid fees are largely regulated. Due to these differences in legislation, it is difficult to propose actions for general applicability. Thus, the more liberalised case is chosen in the following and mills in countries with a lower degree of liberalisation still need to wait for the full range of options. The developments in the liberalised countries have revealed, however, that liberalisation does not necessarily result in decreasing power prices and grid fees.

Where liberalisation is already in place, large industrial consumers can choose between buying electricity with a full service contract from the local grid operator – power, grid, and the required share of RES electricity – or contracting power, grid, and partially also RES electricity separately. In the latter case, the grid still needs to be contracted with the local operator (natural monopoly), while at least the power can be bought one day ahead at an energy exchange or with a fixed contract from a utility company or any other power plant operator. The treatment of RES electricity depends on national legislation. Either its supply is guaranteed by the grid operator or it can also be contracted on the market (see Tab. 8 page 168 and Tab. 9 page 169 for the countries investigated). All three cases, full service contract, separate contract for power and grid as well as fixed grid contract plus day-ahead purchase at an energy exchange have certain advantages and disadvantages which need to be considered. None of them is generally favourable. Full service is most convenient but typically neither very flexible nor cheap. Fixed contracting of power allows regular requests for quotations. They ought to be sent out about once per year depending on the actual market situation. Standardised processes are favourable, but e-procurement does not provide material benefits in this case as the number of items to be negotiated is limited. The design of the contracts allows many windows of opportunity to assign the risks rather on the supplier side than on the consumer side. The price can be fixed for the entire period or oriented at the daily or hourly quotation at the energy exchange with a certain discount or markup. Furthermore, differentiation can be made between seasons, days of the week, and hours of the day. The day-ahead purchase at the energy exchange is the second polar case. The entire price risk is assigned to the consumer but they save trade margins and can actively pursue lowering average electricity prices by adapting the consumption to the current 15-minute electricity price (see Voigt (2004) and action (59)). This latter case, however, requires the highest amount of management capacity as it succeeds only with good knowledge of the dynamics of electricity markets and accurate consumption forecasting. None of the three options of electricity purchasing is generally favourable. Key is the understanding of and proper reaction to market structure and dynamics. The higher the risk the consumer is willing to take in their purchase strategy (day-ahead purchase compared to full service contract), the higher the savings achievable if consumption and purchase are managed properly. Differentiated contracts are also essential for the success of subsequent actions (58) and (59).

Range of application: All pulp and paper mills
Ease of implementation: High (country specific)
Magnitude of impact: Very low

(58) Save electricity costs through bundling volumes
Volume bundling increases negotiation power in electricity purchases. The lever behind is the forming of buying consortia. While volume bundling across different mills of one company located in the same country or at least control area should be good practice, buying consortia with other companies should also be considered. Partnering with other industrial electricity consumers located in the same control area may offer significant savings potential if the power is purchased in a fixed contract from a utility company or other power plant operator. The additional effects on grid level and balancing power are touched on in actions (61) and (62).

Range of application: All pulp and paper mills
Ease of implementation: Medium (country-specific)
Magnitude of impact: Very low

(59) Save electricity costs through using timing effects
Even more than at fuel purchases, timing effects allow significant cost savings in electricity purchases. Other than with fuels, this is not a question of seasonal timing as electricity needs to be purchased when it is consumed, but a question of day and hour. Electricity prices are quoted on a 15-minute or one-hour basis at the energy exchanges and the weekly and daily variations are significant, as Fig. 45 and Fig. 46 reveal for the intraday energy trading (spot market) of the European Energy Exchange of fourth quarter 2006.

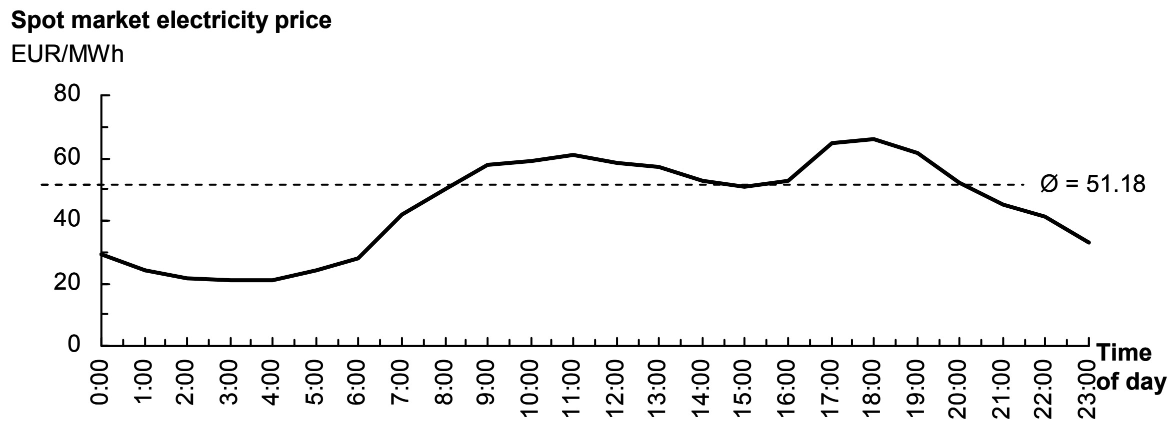


Fig. 45: Intraday electricity price development[1]

The weighted average spot market price at the EEX in the fourth quarter of 2006 was 51.18 EUR/MWh. In daytime, all quotations were above average with peaks in the later morning (11:00-12:00h: 60.80 EUR/MWh) and in the rush hour (18:00-19:00h: 66.14 EUR/MWh). During nighttime, in turn, the quotations were significantly below average, below 24.00 EUR/MWh at any time between 1:00 and 6:00h. The lowest quotation (4:00-5:00h) was 60% below average, the highest 29% above. The differences between the days of the week were a little less dramatic (see Fig. 46). The average spot market quotations for the business days Monday to Friday were 5-14% above the average of 51.18 EUR/MWh, while Saturday and Sunday were 22, respectively 38%, below average (39.66 and 31.80 EUR/MWh).

These tremendous variations in the power prices need to be made accessible in electricity purchase contracts (see action (57)) or by direct power purchase at the energy exchanges and utilised through adaptation of the consumption profile to the actual price level. This adaptation is possible to a certain extent only – many engines also need to run during daytime – but in most mills there is still unused potential. The operation of all significant electricity consumers which are not bottlenecks within the mill and whose products can be stored at low cost for some hours or days can be optimised in this respect. Debarkers and chippers can be run at full capacity during the night and at weekends and stopped during peak hours during business days. The same is possible for the large engines of mechanical pulping (grinders, refiners), however their integration into the steam grid of the mills needs to be considered.

[1] Fourth quarter 2006 intraday energy trading (spot market) according to EEX (2007b)

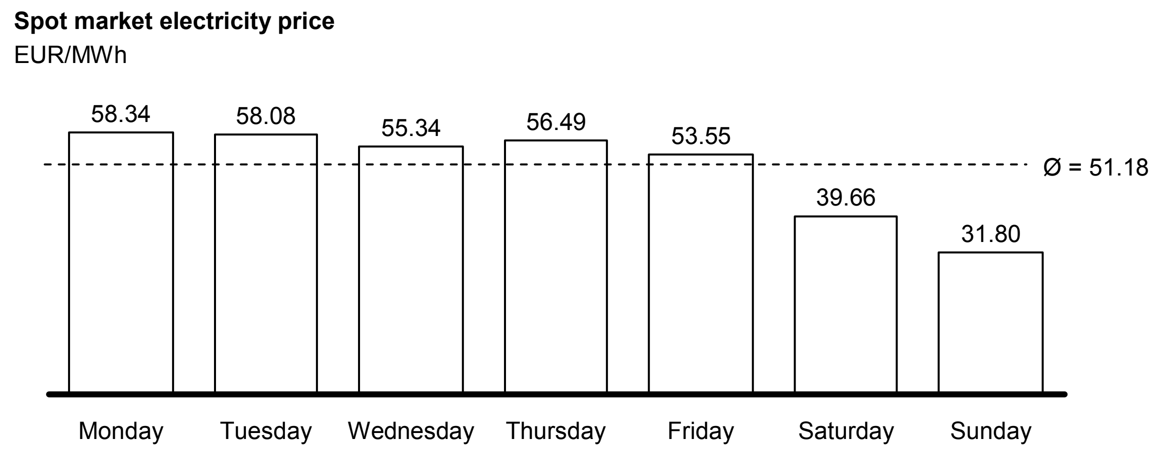


Fig. 46: Intraweek electricity price development[1]

The mill management will easily identify the large electricity consumers whose operation schedule can be adapted, as soon as the electricity purchase allows advantage to be taken of the price variations. The additional labour costs of nighttime and weekend work are comparably low in a TMP mill, where electricity costs are almost twice as high as labour costs (see Fig. 32).

Range of application: All pulp and paper mills
Ease of implementation: Medium (country specific)
Magnitude of impact: Medium

(60) Reduce electricity price risk through hedging purchases

Electricity price risks can be hedged by the use of financial instruments – as similarly outlined for fuel price risks in action (32). Respective derivatives, typically referring to certain electricity prices indices, can be bought at many commercial banks. The use of these instruments depends on the company's risk management policies. One of the companies investigated hedges the price up to 60 months ahead, according to a certain schedule of up to 80% for the forthcoming year. However, this electricity price hedging can only equalise fluctuations. A sustainable reduction in fuel prices is not achievable with these instruments in the long run.

Range of application: All pulp and paper mills
Ease of implementation: Very high
Magnitude of impact: Very low

[1] Fourth quarter 2006 intraday energy trading (spot market) according to EEX (2007b)

(61) Save electricity costs through switching grid level

The grid fees consumers need to pay for electricity purchases are largely regulated and typically decrease with increasing voltage levels. Direct connection to the 110 kV distribution grid (in some countries, the voltage levels deviate slightly) saves fees for the medium voltage grid of 30 kV or further down to 10 kV. Higher or lower voltage levels are not common for pulp and paper producers. Though the different grid fees are country- and region-specific or may be negotiated with the grid operator within a certain range in some countries, the difference between the voltage levels is significant in most cases. However, the connection to a higher voltage level creates the need for a larger transforming station to achieve the operating voltage of the engines. The transformer can either be owned and operated by the consumer or rented from the grid operator. In the latter case, the financial advantage of a higher grid level will be very limited. Thus, volume bundling with other large electricity consumers in the neighbourhood and operation of a joint transforming station might be the most favourable option.

Range of application:	All pulp and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Medium

National electricity transport and distribution grids are divided into control areas. The company responsible for a control area needs to safeguard that the input to and output from the grid are balanced at any time. In the case of an imbalance – the grid is "long" (more input than output) or "short" (more output than input) – the frequency of the grid deviates from the standard of 50 hertz causing interferences in generators or consumers. Thus, each generator as well as each consumer is obliged to forecast supply and consumption with high accuracy. Deviations from the forecasts are financially penalised.

(62) Save electricity costs through avoiding consumption of balancing power

In the case of full service contract electricity purchase, consumers order a certain amount of power (MW) at their local grid operator. Usually pulp and paper manufacturers are incentivised to achieve good forecast accuracy by two clauses: a take-or-pay clause determines that the power ordered needs to be paid for even if the actual consumption is lower. If it is higher than the power ordered, in turn, the energy rate is far higher than the spot market electricity quotation. As the grid operator might be urged to access expensive balancing power (operating reserve, see action (63)), he charges the consumer a significant markup on the energy rate and – depending on contract conditions – may also raise the ordered power fee to the peak level for the entire contract period. In the case of separate contracting of power and grid, the financial incentives for good forecast accuracy are basically the same. The local grid operator still safeguards the balance and charges a markup and raises the fee for the power ordered if the ordered or announced power is exceeded.

As the penalties are typically high in either case, consumers should make efforts to properly forecast and avoid consumption peaks. Besides negotiating more favourable conditions with the grid operator and avoiding consumption peaks with proper production planning, basically two options exist to evade a penalty which both require perpetual monitoring of consumption and internal generation. Either large engines are stopped (e.g., debarker, chipper, grinder, refiner or other engines whose stopping does not cause considerable production losses or interferences in running processes) or internal electricity generation is increased at short notice. This is relatively easy where sufficient boiler capacity and back-up turbines exist. If back-pressure turbines are used for the generation increase, process steam buffer tanks can help maintain an efficient yield from fuels, as noted in action (52).

Although it should be assumed, that many mills already pay some attention to the issue described, savings potential still exists in many cases. Production planning and consumption forecasting can often be improved, more attention paid to monitoring and merit orders for turbine ramp-ups, and engine stops defined and executed. Consortia buying of electricity at higher grid levels with an own transforming station helps balance consumptions and, thus, reduces peaks.

Range of application:	All pulp and paper mills
Ease of implementation:	Very high
Magnitude of impact:	Low

(63) Increase profitability through supplying balancing power

While imbalances between ordered power and actual electricity consumption at the consumer level and respective penalties were in focus of action (62), action (63) focuses on the imbalances between input to and output from the transfer and distribution grid, i.e., on balancing power or operating reserve. Although the actual mechanisms keeping the grid balanced and frequency stable deviate slightly between countries or grid areas, the general principle of balancing power or operating reserve is the same everywhere. The responsible for a grid control area contracts with suppliers of positive or negative operating reserve. If a positive reserve is contracted, the contractor guarantees the supply of certain power within a defined activation time to support the "short" grid. This can be done physically, i.e., by use of a turbine, or "nominally", i.e., by reducing the actual consumption below the previously ordered power. In the case of negative balancing power, the contractor discharges the "long" grid by consuming a defined power. In countries whose electricity markets are largely liberalised, the lots of positive and negative operating reserve are typically auctioned by the grid operator.

The responsibles for the four German control areas have defined three types of operating reserve: primary and secondary balancing power as well as minute reserve. The following examples are largely representative for the German market. The primary balancing power is activated automatically by the grid operator within 30 seconds if the grid gets short or long. The average demand rate for the RWE control area within the period July to November 2006 was about 50,520 EUR/MW. An energy rate was not paid (Regelleistung.net, 2007b). The secondary balancing power, which can be activated within 5 minutes, yielded on average 41,300 EUR/MW demand rate and 71.50 EUR/MWh energy rate for the positive case, respectively 14,950 EUR/MW demand rate (no energy rate) for the negative case (Regelleistung.net, 2007c). The minute reservewhich is auctioned in four-hour tenders, is activated by the contractor on telephonic demand of the grid operator for 15-60 minutes. He is compensated with a comparably low demand rate but high energy rates. On January 22nd 2007, demand rates in the RWE control area were 33.30 EUR/MW for the positive and 38.43 EUR/MW for the negative balancing power. The average positive energy rate was 284.16 EUR/MWh, the highest rate contracted was even 1500.00 EUR/MWh. Negative energy rate, in turn, was as low as 4.66 EUR/MWh (Regelleistung.net, 2007a).

Though these figures are German examples from limited time periods only, they reveal an opportunity for potential future profits of pulp and paper manufacturers. If the manufactures successfully participate in the auctioning of operating power (in the German example probably only minute reserve is applicable), they can "sell" stops of large engines (e.g., debarker, chipper, grinder, refiner; see action (62)) at favourable prices. If the process steps, which are driven by the respective engines, have a high share of electricity costs and are not production bottle necks, buffers exist for the intermediates (e.g., chip piles, pulp tanks) and interferences with other process steps and run-up costs are low, short-term production stops can be worthwhile. However, thorough calculations need to be made before participating in auctions for balancing power. Furthermore, activities in this direction can only be proposed if the electricity markets are fully unbundled and fair access to non-utility companies is guaranteed. In Germany for example, these prerequisites have obviously not been fulfilled yet and further monitoring by the respective authorities is still required.[1]

Range of application:	All pulp and paper mills
Ease of implementation:	Low (country-specific)
Magnitude of impact:	Medium

Political instruments related to electricity generation and consumption, taxes as well as RES and CHP promotion, have been described in detail in chapter 4.2.3 (page 163 ff.). The implementation of these instruments in national legislation provides levers for pulp and paper manufacturers to reduce associated costs and earn additional revenues.

[1] For further considerations on markets of balancing power, see Müller-Kirchenbauer and Zenke (2001).

(64) Save costs and generate profits from RES legislation

As the overview in Tab. 8 (page 168) reveals, the RES legislation provides both downsides (costs) as well as upsides (revenue potentials) for the pulp and paper industry in Europe. To minimise costs and gain revenues, pulp and paper manufacturers must understand the legislation – on a European level and on a national level. Some countries require separate turbines for RES and non-RES electricity, others even subsidise co-firing. Some countries require physical transfer of the green electricity generated as they pay feed-in tariffs, others subsidise the generation irrespective if the electricity is used internally or sold to the grid. The understanding of these differences is the relevant success factor. As noted in chapter 4.2.3, Del Rio (2004) and the Commission of the European Communities (2005d) provide the most recent overviews of the available instruments applied in the EU. Faber et al. (2001), De Vries et al. (2003), the European Renewable Energies Federation (EREF, 2004) and again the Commission of the European Communities (2004c) display the member states' performance in promoting RES country by country and list the individually applied instruments and levels of promotion.

However, making use of the existing instruments is only the first step. The second, even more powerful, step is the challenge of the existing legislation. Politicians have different instruments to hand (see Fig. 43 on page 167) and may implement one and the same instrument in different ways or to different degrees. Two countries may have fee-financed feed-in tariffs for the promotion of RES electricity, but one of them limits promotion to dedicated small-scale biomass power plants, while the other also supports co-firing. The effect on fibre prices and fees the electricity consumers need to pay for RES electricity may differ hugely (see action (83) on page 238). Whereas the beneficial use of the existing legislation is an exercise for the individual management of the pulp and paper manufacturers, their associations are in charge here too.

Range of application:	All pulp and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Low (effects apart from co-firing; see also action (83))

(65) Save costs and generate profits from CHP legislation

Though the CHP legislation does not bear a similar threat for the pulp and paper industry as the RES legislation touched on in action (64), the general dynamics are similar and again there are downsides as well as upside potentials. Tab. 9 on page 169 provides an overview. Again a thorough understanding of the specifics of national legislation is the key success factor to minimise CHP related costs and benefit from revenue potentials. Besides the treatment of avoided grid costs, the question of physical transfer vs. internal consumption is the most relevant issue. As noted in chapter 4.2.3, the number and depth of publications is comparably limited. Löffler (2004) only provides examples of policies in different EU member states (Portugal, Belgium etc.), while Esdaile-Bouquet (2005) gives an overview of the electricity generation from CHP in all member states but describes the national legislation, respectively promotion schemes, only superficially.

Again, making use of existing instruments is only the first step. Shaping the future legislation on an EU and on a national level is a longer lever, especially as some European countries have not yet implemented EU Directive 2004/8/EC[1] (Italy and some Eastern European countries). The instruments are the same as differentiated before (see Fig. 43 on page 167). In this context, equal treatment of CHP electricity sold to the grid and CHP electricity consumed internally is important for pulp and paper manufacturers. Internal consumption should rather be preferred (saved grid costs) than penalised compared to feed-in. As with RES promotion, pulp and paper manufacturers are in charge as well as their associations.

Range of application:	All pulp and paper mills, esp. those generating electricity
Ease of implementation:	Medium
Magnitude of impact:	Low

(66) Save costs of energy/emission taxation on electricity through indicating overlap with emission trading

Energy or emission taxation is another area where the exercise of influence on existing or pending legislation can improve the cost situation of pulp and paper manufacturers. Looking at fuels, this has been outlined in action (38). The situation looking at energy taxes on electricity is analogous. Again, first of all, the respective tax legislation in the specific country must be understood as various national legislation offers energy tax ceilings on fuels as well as on electricity for energy-intensive industries. In many cases, these hardness clauses and additional balancing options allow pulp and paper manufacturers considerable reductions in real tax burdens compared to nominal tax burdens. Furthermore, attention should be paid to where electricity is generated from renewable energy sources or in cogeneration, as this electricity may be exempted from energy taxation. The parallel exertion of energy or emission taxes and emission trading has been discussed in chapter 2.1.1.5 and action (38) looking at fuels. The argumentation asserted also applies to electricity taxes. Due to the interference of both instruments all industry sectors subject to emission trading should be exempted from energy taxation. Pulp and paper manufacturers and their associations could take up respective information activities for politicians. The incentive for these efforts may be limited though where real tax burdens are considerably below nominal tax burdens.

[1] Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (European Parliament and Council of the European Union, 2004a)

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Very low

(67) Save costs of emission trading through indicating indirect effects
Chapters 4.2.2.4, 4.2.2.5, and 4.2.2.6 provide detailed insights into the effects of emission trading on manufacturing costs and, thus, the competitiveness and profitability of the pulp and paper industry in Europe. The indirect effect arising from increasing electricity prices is a significant component of the overall out-of-pocket effect – especially at electricity-intensive processes such as mechanical and thermo-mechanical pulping, where it accounts for 14.0, respectively 12.8%, manufacturing cost increase (base case scenario, see Tab. 5-Tab. 7 on pages 144-146). Thus, pulp and paper manufacturers and their associations should make all the efforts required to inform their relevant politicians about the threat their decisions on the general allocation principles and the national allocation plans have on the international competitiveness and profitability of pulp and paper manufacturing in Europe. Although politicians and authorities have obviously failed to set up a proper allocation scheme considering the competitive environment n electricity markets for phase I of the EU ETS (2005-2007) and limited the degrees of freedom for phase II (2008-2012), all efforts are well invested against the background of the tremendous skimming-off of utility companies ("windfall profits"). Auctioning allowances for electricity generation and recycling of the funds received appears much more promising than the current allocation mechanisms (see recommendations to politicians in chapter 5.3).

Range of application: All pulp and paper mills
Ease of implementation: Low
Magnitude of impact: High (mechanical pulp mills), medium (others)

5.2.3 Cost savings – other energy-related costs and income

5.2.3.1 Cost savings and revenue potentials – steam purchase and sales

Although steam has played already a prominent role in the preceding chapters 5.2.1 and 5.2.2 on fuel, respectively electricity, consumption, cost savings opportunities and revenue potentials referring to steam have not been developed exhaustively. The comparably short lever of steam purchase and saleshas yet to be described.

(68) Save steam costs leveraging negotiation power in purchases
As described in chapter 4.2.2.1, a few pulp and paper mills in Europe do not generate the steam required internally but purchase it from neighbouring power plants. Two out of the 21 investigated mills covered their steam demand by purchases. However, these purchases

account for only 4.0% of the entire steam supply of all the mills investigated (see Fig. 39 on page 109). The price lever for this steam has yet to be described.

Due to the close interlinkage between the producer and consumer of this steam, the variety of purchasing levers (commercial levers, specifications, logistics, political instruments etc.) is very limited. Both parties usually know the cost structures, respectively price willingness, of each other quite well. Thus, the price for the supplied steam is basically a question of negotiation power. At what costs can the consumer generate the required steam internally? What revenue does the producer lose if the consumer stops purchasing steam? Supposing that the favourability of supply-consumption relation was evenly allocated across both parties at the beginning of the cooperation, the pulp and paper manufacturer should pay close attention that the situation does not change to his cost. If, for example, a bonus for cogeneration is introduced and the power plant operator can claim it due to the steam supply to the pulp and paper manufacturer, this should be reflected in a steam price decrease.

Range of application:	All pulp and paper mills purchasing steam
Ease of implementation:	High
Magnitude of impact:	Low

The opposite case to the afore-mentioned steam purchase is the sales of steam and hot water to neighbouring consumers. As mentioned in chapter 5.2.1.1.2, heat can be recovered from numerous process steps in pulp and paper manufacturing at moderate costs. Actions (18)-(20) outline its recovery from chemical and mechanical pulping and paper machines. This heat – typically gained as low energetic steam (≤ 3 bar) or hot water – can be used for many other process steps that can make do with low energetic heat or sold to external consumers, i.e., to neighbouring companies or to municipalities for district heating.

5.2.3.2 Cost savings – administrative costs of emission trading

(69) Save costs properly through managing the administrative requirements of emission trading

Efforts to limit the direct component of emission trading's out-of-pocket effect by lobbying for less strict allocation of allowances has been touched on in action (37), while regulatory measures against the electricity price effect were in the focus of action (67). Thus, looking at energy costs, the administrative requirements caused by the introduction of emission trading has not yet been described. However, these requirements need to be regarded as necessities rather than as cost savings or revenue opportunities.

In the interviews, the following measures were revealed as good practice:

- Pool Europe-wide knowledge on emission trading and related aspects as regular emission market observation and definition of company-wide trade strategy in the headquarters
- Pool allowances across mills and countries and execute all trade and potential hedging at company level
- Select one specialised multinational legal consulting firm for all legal matters referring to energy and emission trading
- Select one experienced multinational accounting firm (certifier) to set up emission reports and verification across all countries
- Assign one champion for all aspects of emission trading (regular updates of national legal situation, application, verification etc.) for each country
- Educate and regularly update one accountant per mill to monitor fuels and emission data and prepare reports for the external accounting firm (certifier)

Range of application: All pulp and paper mills purchasing steam
Ease of implementation: Medium
Magnitude of impact: Very low (rather a necessity than an opportunity)

5.2.4 Cost savings – fibres

Fibre cost savings measures have become increasingly important for pulp and paper manufacturers. Whereas fibre costs always account for a significant share of manufacturing costs – examples for cost structures of major pulp and paper grades (TMP and NBSK respectively newsprint and coated woodfree) can be found in Fig. 32 (page 71) and Fig. 33 (page 72) – the importance of savings or "cost containment" measures increases with the enormous wood cost increases observed during the last two years. Identical to fuel and electricity cost savings, the approach to fibre costs is broken down into a consumption lever (chapter 5.2.4.1) and a price lever (chapter 5.2.4.2). The consumption lever comprises all actions which can be taken under retention of the specific pulp or paper manufacturing process. At this point, the considerable yield differences between different processes (see chapter 4.2.2.1) are intentionally left untouched. Although fibre costs account for a significant share of manufacturing costs, there are more drivers in the decision for a new pulping line. Thus, a potential action "save fibre replacing chemical pulping by mechanical pulping" would be too short sighted. Nevertheless, the implication of emission trading on the relative competitiveness of pulping processes will be discussed in chapter 5.2.9. Looking at the price lever, commercial actions are described as well as changes in fibre mix and specifications, actions referring to logistics and, finally, exercise of influence on political instruments affecting fibre prices.

5.2.4.1 Cost savings – fibre consumption

Reductions in the specific fibre consumption pay off in form of two aspects, as especially Ahtila (2006) stresses: beyond the primarily intended reductions in wood, recovered paper, and pulp purchases, internal processing costs are reduced if the fibre yield can be increased. Any reduction in fibre losses in the process means a reduction in specific steam and electricity consumption per unit of end product. Energy is misinvested in fewer fibres which get lost during subsequent process steps. Thus, some measures to reduce fibre losses have already been described as actions looking at fuel and electricity consumption. To avoid counting them twice, these measures which have been listed as actions in chapters 5.2.1.1 and 5.2.2.1 are only briefly mentioned in the following section.

Following the fibre processing chain in the pulp and paper industry, the first measure resulting in significant fibre savings is the use of state-of-the-art debarkers. As noted in action (44), the Cradle Debarker developed by Dieter Bryce Inc. in the mid 1990s considerably increases the wood yield compared to today's dry drum technology and allows about 33% electricity savings (United States Department of Energy, 1999). Martin et al. (2000) estimate an achievable reduction in "sawdust" of 75%.

The second step in the fibre processing chain, for which measures to increase the wood yield have been reported when looking at actions saving fuels or electricity consumption, is the cooking at chemical pulping. The improvement of steering the cooking process is theoretic-cally easy – even with state-of-the-art technology – but challenging in practice. The more reliably the targeted cooking result (kappa number etc.) is met, the lower the fibre losses are due to overly long cooking times. As mentioned when looking at the specific steam con-sumption in action (1), automating monitoring, controlling, and steering need to go hand in hand with the experience of the operators. Whereas improved steering will increase the fibre yield at chemical pulping by a few percentage points, the advanced cooking technology described in action (5) may allow even significantly higher yield increases at comparable pulp properties. Elaahi and Lowitt (1988, cited in Martin et al. 2000) regard pulping in alcohol-based solvents (ethanol-water solution) as a potential future alternative to traditional kraft pulping. They report significant yield increases at reduced cooking times. At that point it should, however, be realed that similar hopes, i.e., higher yields or lower energy consumption at given pulp properties, respectively improved properties at given consumption, are directed at other pulping processes too which are still on the cusp of commercialisation.

The third step in the fibre processing chain allowing fibre yield increases, which have been described when looking at fuels or electricity, is the stock preparation. As noted in action (43), the EU BAT reference document (Commission of the European Communities, 2001) suggests the adaptation of efforts in fibre processing and refining to the actual requirements of the respective paper manufacturing process. Basic paper grades make do with less refined fibre and, thus allow, higher fibre yield and lower electricity consumption than advanced paper grades. Furthermore, the EU BAT reference document discovers fibre savings potential from a reduction in losses using better screening systems in the stock preparation.

The fourth step in the fibre processing chain, for which measures to reduce the fibre consumption have already been noted when looking at fuel savings, is the press section at paper manufacturing. In action (14), the advanced Condebelt technology has been introduced. As mentioned, the technology was initially intended to improve the drying, but meanwhile the observed significant paper strength increase can be regarded as the main reason for Condebelt, while the energy saving is a rather welcome side effect (Commission of the European Communities, 2001). Due to the special treatment of the web between the two steel belts, the surface of the paper, which gets in contact with the hot belt, is smoothed and welded so that the strength increases considerably (20-60% increase in tensile strength) and sizing can be omitted. This effect allows the use of cheaper fibres – even if TMP or recovered fibres are used, strength properties known from virgin kraft fibres, and conventional drying can be achieved. Alternatively the grammage of the paper can be reduced at constant strength. Results from the paper machines, which already apply the Condebelt technology, validate the prospects which have arisen from research at the laboratory scale.

The last primarily energy-related action, which has a positive side effect on fibre consumption, is black liquor gasification whose electricity component has been introduced in action (56). Besides the positive effect on electricity yield or as a cornerstone for a bio-refinery, the fibre yield from raw wood will also be positively influenced. Gebart et al. (2005) estimate a potential yield increase of up to 5% (absolute) referring to tests conducted at the STFI (Swedish Pulp and Paper Research Institute) without, however, giving an explanation of how this can be achieved.

Beyond the afore-mentioned actions whose contributions to fibre cost savings are rather side effects compared to their primary source of favourability which lies in fuel or electricity savings, there are several dedicated fibre savings measures. These specific measures are described in the following actions (70)- (73).

(70) Save fibre costs using state-of-the-art screening technology prior to cooking

State-of-the-art chip screening and treatment can provide a valuable increase in the fibre yield. The improvement originates from milder cooking conditions which can be applied if the distribution of chip sizes can be narrowed. The more homogenous the chips are, the higher the kappa numbers (along with yield and strength) that can be obtained without significant amounts of undesired particles (e.g., fibre bundles, flakes) in the pulp. Classically, the over-thick chips are chopped in slicers or re-chippers. This post-treatment, however, causes considerable fibre losses too. According to Strakes (1997), slicers produce up to 15% pins and

2-8% fines depending on knife conditions, moisture content, and loading. Re-chippers cause even higher losses. If the pins are added to the normal-sized chips in the cooking process, their fibres are degraded to very low kappa numbers associated with low yield and strength. Fines do not even to a minor degree contribute to paper strength but act similarly to fillers, only increasing grammage and opacity and improving formation. Thus, Strakes suggests using chip conditioners for the over-thick chips instead. Chips are compressed between two parallel rolls, whose surfaces are covered with pyramids and valleys. Thereby, the cracks accrue in the chips along their grains. This opening up of the chip surface eases the penetration of the chips with liquor and accordingly improves the delignification, so that the over-thick chips can be cooked with normal-sized chips. Martin et al. (2000) estimate the fibre saving to be about 1.2% of entire wood consumption at chemical pulping accompanied by reduced steam and electricity consumption. Furthermore, they announce about 2% wood savings potential from the use of bar screens (flat steel bars alternately attached to eccentric shafts) instead of disc screens (axis orthogonal to material flow) or v-type screens (axis parallel to material flow) for the first screening stage. How this saving is achieved, however, remains unclear.

Range of application:	Chemical pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Medium (chip conditioner)

(71) Save fibre costs through using state-of-the-art technology at fibre screening of mechanical pulping

The second dedicated fibre savings measure refers to screening again but applies to a later process step – to fibre screening subsequent to chemical or especially mechanical pulping. The minimisation of reject losses can contribute to significant fibre savings. The EU BAT reference document (Commission of the European Communities, 2001) suggests the use of pressure screens with holes or slots followed by centricleaners as the most efficient reject handling equipment. Rejects – making up for about 25% after primary refining at mechanical pulping – should be refined in a second refining stage and fed back into the main line. As described above in chapter 5.2.2.1, this action not only contributes to fibre savings but also results in a considerable reduction in the specific electricity consumption. Less fibre, which has been gained under substantial power consumption, gets lost. Thus, all measures minimising losses of dispersed fibres in reject handling systems of washing and bleaching sections as well as in white water recycling of paper manufacturing save electrical energy. Accordingly, measures reducing these losses pay off not only due to yield increase but also due to their positive effect on energy consumption.

Range of application:	Mechanical pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Medium

(72) Save fibre costs through improving white water filtration
A similar action aimed at fibre savings is the improvement of white water filtration. Although a high degree of closure has been achieved in most mills during recent decades, the EU BAT reference document (Commission of the European Communities, 2001) still assumes savings potential for fibres and fillers. In mills, which have already achieved full closure, this may refer to a reduction in fibre degradation only. The more wear a fibre has to withstand during the recovery process, the more its strength properties are reduced and the more fines accrue. In other mills, in turn, which still have potential for further closure – in a secondary or tertiary circuit – the fibre yields can usually also be improved. Here, even the recovery of comparably low qualitative fines and fillers is an improvement.

Range of application:	All paper mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(73) Save fibre costs through increasing share of fillers
Besides the afore-mentioned "true" fibre savings actions, the further replacement of expensive fibres by comparably cheap fillers should not be ignored. Of course, this replacement is not a new or even surprising cost savings opportunity and has meanwhile been implemented to a high degree by many mills. Nevertheless, for some mills a further increase may yield a yet unexhausted cost savings potential, although negative side effects, especially strength decrease, need to be considered. The requirements for retention aids – beneficial for both fillers and fibres (fines) – are touched on separately by action (88) in chapter 5.2.5.1 on chemical consumption.

Range of application:	Many paper mills (not all grades, e.g., no tissue)
Ease of implementation:	Medium
Magnitude of impact:	Medium

5.2.4.2 Cost savings – fibre price

Looking at cost savings potential from the fibre price lever, the three main sources need to be differentiated: wood and recovered paper used for pulp production, respectively pulp used for paper manufacturing. A further breakdown into the various assortments of wood, recovered paper and pulp grades is made where required. Although the chapter formally focuses on the price of fibre, the question of mobilisation deserves almost the same level of attention. In imperfect markets, a limited increase in demand may cause a significant increase in price even if the theoretical supply curve is relatively flat beyond the original supply volume. If these additional available volumes have not been accessed for a long time, the potential additional suppliers may not consider supplying although they could even if the price is only slightly above original level. In this case, all actions mobilising additional supply potentially help contain a price increase. Whereas the pulp markets are extensively developed – the trade flows to and from CEPI countries can be found in the CEPI annual statistics (CEPI, 2006b) – a significant supply potential of wood and recovered paper is still untapped in Europe.

In most countries, the annual wood harvest does not exceed two thirds of the annual increment and even this increment could be increased by a considerable amount. Besides manuring of forests, which is currently being discussed again in the course of "Sweden's oil-free future" programme, rotation cycles may be a lever to increase the average annual increment. Looking at German forests, Polley and Kroiher (2006) modelled the development of stocking wood volume based on different rotation cycles and harvest patterns. In their base scenario, they found that the stocking volume will increase by 24% from 1987 to 2022 if forests are operated in a business-as-usual mode. A major share of the increase has taken place already. However, as the annual increment of mature forests is lower than that of mid-aged forests (the S-shape of increment curve), biomass increment declines. A shorter rotation cycle helps keep forests in a more productive stage. Dieter (2007) calculated an additional harvest potential of about 20 million m^3/a for Germany within the next 15-20 years (on the basis of a current harvest level of 74 million m^3). Subsequently, harvest potential would drop back to base level. The mobilised potential originates from two levers: on the one hand, it can be traced to a reduction in wood stock to a level of the late 1980s. This is naturally a temporary and non- sustainable effect. On the other hand, the S-shape of forest increment curves is used. Wood is harvested before the stocking volume reaches a saturation phase.

At recovered paper, there is also still untapped potential. A current collection rate of 62.6% for recovered paper (CEPI, 2006b) compares to a technical potential of about 81% (CEPI, 2006a). Accordingly, pulp and paper manufacturers should take action to mobilise these additional potentials, as they can provide additional fibre at affordable costs. Beyond this issue of mobilisation, the total-cost-of-ownership character of actions looking at fibre prices ought to be highlighted. The actual fibre price accounts for a share of effective fibre costs only: 65-75% of the costs of log wood lying in the woodyard of a pulp mill originate from wood on stumpage, an additional 10-18% is caused by harvesting and forwarding within the forest, 8-15% by transport from forest to woodyard and, finally, 3-8%, are other costs. Accordingly, the actions aimed at fibre cost savings ought to include these cost categories too.

(74) Save fibre costs through extending the potential supplier base

For the purchase of many goods, the extension of the potential supplier base is the primary commercial action aimed at cost savings. The higher the number of potential suppliers, the lower the risk of collusion and the higher the potential for price savings. In this context, extension may refer to the geographical scope of sourcing as well as to the characteristics of potential suppliers. Looking at fibre prices, geographical extension primarily applies to pulp, as relative transport costs tend to prohibit long-haul transport of wood and recovered paper –

at least per truck. Accordingly, different approaches are indicated for wood and recovered paper, respectively pulp.

As wood has a comparably high specific transportation cost if forwarded by truck, the potential for geographical extension of the supplier base is limited. Pulp mills located away from harbours (sea ports or domestic ports) are usually limited to extending their wood catchment area around their mill to a certain degree. Even train transport is only viable for a limited number of mills. Any discontinuation in transport (transhipping from truck to train or vessel to truck) cause significant additional costs which in many cases overcompensate the cost savings achieved by sourcing in cheaper areas. Mills located at harbours – especially at sea ports – have more options for extending the geographical scope of purchasing. In Europe, this refers to numerous mills located on the Baltic Sea and a few that have direct access to the North Sea, Atlantic Ocean or Mediterranean Sea. The first can access Russian wood supply, while the latter benefit from shipments from Latin America. Although this cross-Atlantic shipment is costly too, some wood is even imported from Brazil by Dutch power plants for co-firing. For both types of pulp mills, located at ports or in the interior, in turn, increasing the penetration of the potential local supplier base is viable and reasonable. Here, the potential primarily originates from the above-mentioned mobilisation aspect. Only a small number of forest owners utilises the full annual increment for harvesting. The gap often makes up for a third or more of the increment. While state-owned forests and large private forests are usually relatively good in mobilising their supply potential, especially small private forests, even if they are formally members of forest organisations, often have a high untapped potential. Its mobilisation is one of the key actions consumers of log wood ought to consider. Looking at wood chips, saw mills are the main suppliers. Here, the supply potential should be largely already tapped. Another group of potential suppliers are traders. Due to volume bundling effects and efficiency in managing the fibre chain, they may offer wood (logs and chips) at favourable conditions, but savings potential may arise from direct purchase saving the trade margin.

The situation in the market of recovered paper is somewhat similar. As costs of transportation by truck are relatively high compared to the fibre value, markets are rather regional. Exports out of the CEPI area, accounting for 13.6%, leave Europe by ship, with 95% of exports directed to Asia. Imports, in turn, are negligible amounting to 0.6% of recovered paper available in CEPI countries (CEPI, 2006b). Thus again, penetration is the lever to apply rather than geographical extension. As mentioned before, on a European level a collection rate of 62.6% for recovered paper (CEPI, 2006b) compares to a technical potential of about 81% (CEPI, 2006a). The remaining 19% are either not recoverable (stored in libraries or archives, used for construction applications or tissue paper) or not recyclable. The average annual growth rate of collection amounted to 5.5% between 1991 and 2005. Considerable differences in the collection rates between the CEPI member states underline the remaining potential for further supply of recovered paper. While the top three countries in 2003 collected two thirds or more of the consumed paper (Germany and Switzerland each 70.4%, Sweden 66.6%), many countries are still below 50% collection (Greece 33.3%, Poland 37.3% and Ireland 37.6%) (CEPI, 2004b). Especially in the countries with below-average collection rates, penetration, i.e., expansion and efficiency increase of the existing collection system, is a promising measure to access the yet unused fibre potential even if the economic potential is smaller than the technical potential. Whether this should be done by an own collection organisation or via dedicated collection companies is another question which will be outlined in action (81).

Looking at pulp, the high degree of integration needs to be highlighted. According to CEPI annual statistics (CEPI, 2006b), the consumption of pulp by European paper mills has been covered 56% by internal supplies (on site or from other mills of the same company), 27% by market pulp produced in Europe and, finally, 17% by imports. The market is fairly transparent, the number of producers by pulp grade is limited, the producers are well known, and market pulp is also supplied across competitors. Thus, the penetration lever, i.e., the inclusion of further national or European pulp producers in requests for quotation, is largely exhausted. Savings potential should rather arise from a further extension of the geographical scope. More non-European suppliers ought to be included in the requests. While NBSK (northern bleached softwood kraft pulp) and other important softwood kraft pulps can be sourced in the northern hemisphere only (North America and potentially Russia), Latin America is gaining share as a supplier of BHKP (bleached hardwood kraft pulp) and other hardwood pulps. Accordingly, Latin America has caught up with North America as a supplier of pulp to the CEPI area. While North American supplies have declined recently to 4.0 mt in 2005 with an average annual growth rate of -4% between 2001 and 2005, supplies from Latin America are continuously growing (3.1 mt in 2005, growth rate +14%). However, all other regions are still negligible as suppliers for Europe.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Medium

(75) Save fibre costs through regularly conducting requests for quotation

The foregoing described extension of the potential supplier base is only the first step towards lower fibre prices. The consecutive step is the regular conduct of requests for quotation (RFQs), which ought to be done for wood, recovered paper and especially pulp. Depending on the respective market situation, each request should be sent out about once a year. Besides existing suppliers, potential new suppliers should be detected (see action (74) above) and approached. Standardised processes, potentially levering e-procurement, limit the efforts per request. The impact of this action depends heavily on the tightness of the respective market.

As the wood market currently tends to be a seller's market in Europe, the savings potential levering the competition in an RFQ is probably limited. Looking at pulp, the action ought to be more promising. The use of imports exerting pressure on domestic markets may be successful here.

Range of application:	All pulp and paper mills
Ease of implementation:	High
Magnitude of impact:	Low

(76) Save fibre costs through bundling volumes
As noted in action (30) when looking at fuels, volume bundling increases negotiation power in purchases. Whereas the typical levers of volume bundling are consolidation of the supplier base and the formation of buying consortia, consolidation takes a step back here back here, especially for wood and recovered paper, while the buying consortia lever is further extended. Due to the tight supply situations in wood and also in recovered paper markets, capturing available supply and allocating it internally according to paying power emerges. It becomes more and more favourable to build buying consortia internally, i.e., with other pulp or saw mills within the company, and with other fibre consumers. Either both (or more) partners have equal rights or one steps forward and becomes the trader. Although this backward integration is formally a step beyond current business (chapter 5.2.8.3), it is listed as an action at this point as it is very closely linked to current fibre purchase. Assuming a lead purchase role covering own fibre demand and supplying to other industrial consumers allows the safeguarding of good access to all forest owners within the catchment area and preferred supply at usually favourable prices. Specific transaction costs are lower for the consortium leader (or trader) and for forest owners. However, only one or very few companies among the large wood consumers can benefit from having a lead purchase role. Furthermore, it is not entirely foreseeable how large forest owners will react to this volume bundling, respectively if authorities indict them for misusing a cartel. Whereas the afore-mentioned backward integration can be regarded as a fibre cost savings measure, any forward integration, for example into paper, fuel or other chemical production, is regarded as an action beyond current business and accordingly outlined in chapter 5.2.8.

Looking at recovered paper, volume bundling in the sense of consortium building is favourable only if it is intended to establish an own collection system. Otherwise, i.e., for pure improvement of negotiation power, volume bundling is not a reasonable action for recovered paper as volumes are limited and the structure of collection of recovered paper is somewhat fragmented compared to pulp and paper producers. Looking at pulp, in turn, volume bundling across different mills of one company should be good practice and forming buying consortia with other companies could be considered.

Irrespective of the actual fibre price – wood, recovered paper, and pulp, volume bundling is very reasonable considering handling and freight. As noted above, harvesting and transportation of log wood can account for almost 30% of total wood costs. Thus, bundling allows the negotiation of more favourable conditions, especially, if the contractor or forwarder can increase their utilisation and minimise changeover times or light running.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Medium

(77) Save fibre costs through using timing effects
As in fuel purchases, timing effects can offer additional savings potential at fibre costs. This refers primarily to log wood. Besides demand dynamics, log wood prices are affected by supply fluctuations. They may occur seasonally or irregularly in the form of calamities. The seasonal price variance arises from problems in harvesting and forwarding in winter times. If wood cannot be retrieved for some weeks or even months – this has occurred several times during the last few years – current supply does not meet current demand and prices may increase considerably. Contracts closed and prices agreed sufficiently before the start of winter time help avoid paying these peak prices. Furthermore, woodyards should be prepared in autumn to safeguard operation even if wood supply is interrupted for four to eight weeks. In contrast, the emergence of wood from calamities cannot be estimated in advance. Nevertheless, pulp mills can benefit from the price decline which is typical for the months after the calamity. This is not a sustainable saving, of course, but can provide cost advantages over competitors.

Range of application: All pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(78) Reduce fibre cost through risk hedging purchases
Other than fuel and electricity prices, fibre prices cannot be hedged by the use of plain financial instruments. Respective derivatives are not issued by commercial banks. Thus, only long-term contracts with suppliers can equalise fluctuations in wood and pulp prices. However, it is doubtful whether a paper producer should hedge its pulp purchases across the typical five-year cycles displayed in Fig. 26 (page 65). The use of this instrument depends on the company's risk management policies.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Very low

(79) Save fibre costs through changing fibre mix

Within the three fibre categories wood, recovered paper, and pulp, prices of different grades vary significantly. Chips are cheaper than log wood, ONP (old newsprint) cheaper than OCC (old corrugated carton), and PGW (pressurised groundwood) cheaper than TMP and BHKP and NBSK. Substitution is usually feasible within a certain range without endangering the properties (especially strength) of the final product. Of course, this substitution of expensive grades by cheaper grades has largely taken place during recent years. Nevertheless, there is further savings potential from gradual replacement, as mill visits revealed. This refers to wood, recovered paper, and to pulp. The mechanical pulp grades are especially affected. TMP may lose share to Super-PGW (see action (47)), SGW and PGW will be more and more replaced by recovered paper, especially in those countries where collection and utilisation of recovered paper are not yet developed (see action (74)). Overall, the shift towards lower grades is gradual, but the development has still not reached an end. The decision on further substitution needs to be made case by case.

Range of application:	All pulp and paper mills
Ease of implementation:	High
Magnitude of impact:	Medium

(80) Save fibre costs through reducing fibre specifications

In addition to cost savings from changing the fibre mix, some further savings may be achieved by reducing specifications within the same grade. Again, this applies to log wood and chips, to recovered paper, and to pulp. A slight reduction in the brightness of a pulp – allowing reduced bleaching (costs) – may be acceptable if the paper is coated anyway; recovered paper does not need to be de-inked if it is used for greyback board. Overall, savings potential may be limited but can be realised without high efforts.

Range of application:	All pulp and paper mills
Ease of implementation:	High
Magnitude of impact:	Low

(81) Save fibre costs through controlling the fibre chain

Getting control over the entire upstream fibre chain has become increasingly important for pulp mills. As wood becomes scarce and prices rise, large consumers such as pulp manufacturers should make efforts to gain access to all forest owners and paper collectors within their catchment area and establish a position as a "preferred customer". Whereas this has been noted when looking at volume bundling in action (76), action (81) primarily refers to savings potential in harvesting and logistics. Full access and full control allow mobilisation of all savings potentials along the chain. Margins of traders and contractors become visible and can be eliminated if own execution is favourable. Efficiency of harvesting, forwarding, and road transportation can be increased due to the volume effect. Contractors or own equipment can be deployed where they are required and are at hand even in the case of scarcity in the market (e.g., when a windblow in another region ties up independent harvesting companies). Within certain limits, the favourability of getting control over the chain applies to the collection and transport of recovered paper too. Advantages in accessing the entire fibre potential and efficient logistics go hand in hand. Again, the action exceeds current business and formally belongs to chapter 5.2.8. Nevertheless, it's outlined at this point due to the effect on upstream fibre logistics and, thus, fibre costs.

Range of application: All pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(82) Save fibre costs through optimising interdivisional flows
Beyond the volume bundling effect described in action (76) and the advantages in joint logistics described in previous action (81), interdivisional flows can help achieve a good fibre cost position. Pulp manufacturers integrated into forests and saw milling have access to a reliable fibre base safeguarding a wood supply at relatively constant costs. Even if own forests do not cover the entire wood demand, they help buffer price volatility in purchases. The use of chips generated in owned saw mills also provides a constant supply at moderate prices, i.e., at least without any trade margin. The integration of pulp and paper manufacturing acts in the same way to the advantage of the paper branch. Although trade margins are saved, transfer prices close to the market may be charged. For integrated manufacturers, it may be favourable sometimes to sell the pulp to the market while stopping paper manufacturing for a while. Again, the decision on interdivisional flows and transfer prices needs to be made case by case.

Range of application: Integrated pulp and/or paper manufacturers
Ease of implementation: Medium
Magnitude of impact: Medium

(83) Save fibre costs through indicating indirect effects of political instruments
As derived in chapters 2.1.3.2 (pages 68 ff.) and 4.2.2.3 (pages 120 ff.) instruments of environmental politics, especially emission trading and RES promotion, can have severe effects on fibre prices. The subsequent manufacturing costs increase of pulp has been demonstrated in chapter 4.2.2.4.2.2 (pages 133 ff.). The effect on the competitiveness of the national industry needs to be made clear to the legislators. Thus, pulp and paper manufacturers should take action to influence the respective legislation. Looking at fibre prices, RES promotion is the primary lever. Physical use must be preferred to thermal use. The promotion for combustion of fibrous biomass should be limited to dedicated small-scale biomass power plants. Co-firing should not be supported. The combustion of used paper

should be limited to the non-recoverable and non-recyclable fractions. The fulfilment of the current self-commitment of the pulp and paper industry to recycle at least 56% of consumed paper ought to be properly monitored. In case utility companies absorb significant volumes of recovered paper as fuels, thermal use exceeding an inevitably limited share in municipal waste ought to be prohibited. As mentioned in the "sister-action" (64) looking at direct costs and benefits from the RES legislation, pulp and paper manufacturers are in charge of this action but should be supported by their associations on a national and European level. Environmental favourability and higher economic value creation per ton of fibre are the key arguments.

Range of application:	All pulp and paper manufacturers
Ease of implementation:	High
Magnitude of impact:	Medium

5.2.5 Cost savings – chemicals

Though chemical costs are subordinate to fibre costs in pulp and paper manufacturing, this raw material cost position can not be omitted when looking at cost savings opportunities in pulp and paper manufacturing. As noted in chapter 4.2.2.3 (page 120 ff.), chemicals costs account for 6-13% of total manufacturing costs in 19 of 25 investigated production lines. Fig. 33, referring to Paperloop's Cornerstone benchmarking (Paperloop, 2005), even shows an 18%-share in coated woodfree paper. In line with the breakdown in chapter 4.2.2.2, three main applications can be identified: dissolving chemicals at chemical pulping, bleaching chemicals at chemical and conditionally also mechanical pulping and, finally, paper chemicals as pigments, fillers, retention, and sizing agents. Identical to the display of potential profit improvement options in the previous chapters, the subsequent chemical cost savings actions are be separated into a consumption lever and a price lever.

5.2.5.1 Cost savings – chemical consumption

Pulp and paper manufacturers can take several actions to reduce chemicals consumption along their processes. Most of them are dedicated chemicals savings measures; others are favourable due to multiple reasons, whereas chemicals saving are only a positive side effect.

One of them is the reduction in fibre losses. In chapter 5.2.4.1 it has been emphasised that any reduction in fibre losses not only saves fibrous raw material but also the energy invested in defibration. However, not only energy has been invested in deliberating fibres and preparing pulp but also significant amounts of dissolving and bleaching chemicals. Accordingly, all fibre savings measures taking effect beyond the woodyard are chemicals savings measures too. Examples are improvements in screening and white water filtration technology described in actions (71) and (72). The latter also saves paper pigments and fillers which have not been retained in the fibre web at the wire section or accrue at the recycling of wet or dry brokes.

Although the advanced causticising introduced in action (9) and resumed looking at black liquor gasification in action (56) appears to be a very promising approach, it is still doubtful whether it will reduce chemicals costs. The benefits from borate auto-causticising, titanate direct causticising or manganate conversion primarily originate from considerably lower investment costs and the omission of lime reburning. Chemicals cost savings still need to be proven and, if at all, will only be a side effect. Likewise the intended favourability of advanced cooking technologies (see action (5)) originates from heat savings and yield increases, while chemicals costs will presumably not diminish. Furthermore, savings potentials from reducing chemicals use at cooking and the increasing subsequent recovery of cooking chemicals tend to be largely exhausted, adhering to today's pulp properties.

(84) Save chemicals costs through adapting efforts to requirements at bleaching
In the context of reducing specific electricity consumption, the adaptation of efforts in fibre processing and refining to the actual requirements of subsequent paper manufacturing process has been suggested in action (43). A similar reduction in efforts can help save chemicals at pulp bleaching. A slight reduction in the brightness of a pulp may be acceptable not only at purchased pulp (see action (80)) if the paper is coated anyway; recovered paper does not need to be de-inked if it is used for greyback board. A reduction of paper brightness (less pigments) does not also necessarily mean lower prices if it is marketed as more ecologically friendly. Again, overall savings potential may be limited but can be realised without high efforts.

Range of application:	All pulp and paper mills
Ease of implementation:	Very high
Magnitude of impact:	Low

(85) Save chemicals costs through extending delignification prior to bleaching
Efforts of delignifying bleaching significantly depend on the kappa number achieved before bleaching. Although a simple extension of the cooking time is usually too shortsighted as lower kappa numbers are often accompanied by lower yield and lower strength. Thus, two other concepts can be pursued between cooking and actual bleaching: extended delignification and oxygen delignification. Both help save bleaching chemicals while maintaining good pulp properties and yield. Similar results can be achieved by the addition of anthraquinone to the pulping liquor.

The extended delignification reduces the lignin content of the pulp before it enters the bleach plant. Different processes have been developed and are known under the same term. They comprise increasing the cooking time, adding the cooking chemicals at several points throughout the cooking process, regulating the cooking temperatures, and carefully controlling the concentration of hydrogen sulphide ions and dissolved lignin. The lignin content of the brownstock can be reduced by 20-50% compared to normal kraft pulp without losses in pulp yield or strength. The process changes do not degrade the cellulose which would normally accompany increased cooking time (EPA, 2002). The EU BAT reference document (Commission of the European Communities, 2001) and the research group "The Eco-Cyclic Pulp Mill" (STFI, 2000) also suggest cooking down kraft pulp to a kappa number of 22 followed by a powerful two or more stage oxygen delignification to a kappa number of nine.

Oxygen delignification is another means to reduce the lignin content prior to bleaching. Brownstock pulp leaving the digester is washed and mixed with sodium hydroxide or oxidized cooking liquor. Subsequently it is fluffed, deposited in an oxygen reactor, steam heated, and injected with gaseous oxygen. Thereby the pulp is delignified by oxidation. Afterwards, it is washed again to remove the dissolved lignin and finally pumped to the bleaching plant. Oxygen delignification can reduce the lignin content in the pulp by 50%. It can be used in combination with any other delignification process. In combination, extended delignification and oxygen delignification can provide significant savings in bleaching chemicals. They tend to penetrate pulp mills more and more in the course of retrofits as they offer good brightness at comparably low cost and unimpaired pulp strength.

Range of application:	All pulp mills
Ease of implementation:	High
Magnitude of impact:	Low

(86) Save chemicals costs through using state-of-the-art technology at bleaching

Consumption of bleaching chemicals and specific bleaching costs depend heavily on sequence and technology. Certain bleaching results (especially brightness), however, can be achieved with different bleaching sequences. In this case, costs, environmental impact, and space requirement are drivers for the decision. Beyond the afore-mentioned oxygen delignification prior to the "official" bleaching stages which has been proposed, for example, in the EU BAT reference document (Commission of the European Communities, 2001) and by the research group "The Eco-Cyclic Pulp Mill" (STFI, 2000), the addition of oxygen in the first caustic extraction stage of lignin is suggested by Martin et al. (2000). This addition of oxygen reduces the requirement for chlorine in the (C) stage or chlorine dioxide in the (D) stage. Alternatively or in addition, Martin et al. suggest cost savings by substitution of the chlorine dioxide (D) stage by an ozone (Z) stage. Whereas for many mills, cheaper and also more environmentally friendly bleaching sequences compared to the ones in place could be designed, retrofits are usually conducted in comparably long cycles only. Nevertheless, there is still savings potential to be tapped.

Range of application: Chemical pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(87) Save chemicals costs through using advanced technology at bleaching

The use of fungi and enzymes as advanced energy savings opportunity at mechanical pulping has been described in action (48). However, enzymes can help save bleaching chemicals too. Xylanases are capable of breaking bonds between lignin and hemicelluloses in pulp and, thus, can substitute bleaching chemicals (EPA, 2002). Investigations indicate up to 50% reduction in chlorine requirement without damage to the cellulose. The enzyme is added to the pulp after brownstock washing, when it enters a high density storage tank. After a reaction time of 30-180 minutes, the pulp is extracted and washed again. Enzymes can also be used for de-inking recovered fibre. Cellulase is capable of binding ink to smaller fibre particles, facilitating recovery of the ink sludge. The use of enzymes may also reduce the energy costs and chemical use in retrieving ink sludge from de-inking effluent (EPA, 2002). However, the use of enzymes in bleaching has not reached commercial scale. Although first results appear promising, the development will still take some years and financial favourability still needs to be proven.

Range of application: Chemical pulp mills and fibre recovery
Ease of implementation: Medium
Magnitude of impact: Medium

(88) Save chemicals costs through improving retention in the wire section

Another lever for chemical and also fibre cost savings is retention improvement in the wire section of paper machines which primarily aims at fillers and fines. Retention is based on electrostatic and adsorptive forces (van-der-Waals forces) and applies coagulation and flocculation, whereas the classical flocculation is being increasingly amended, respectively replaced by micro-particle flocculation. Chemical retention aid, tailored to specific production conditions, becomes increasingly important due to increasing levels of fillers, higher speeds of paper machines, higher shares of recovered fibre, reduced grammages, and increasing closure of white water systems (Gallagher, 1990).

Classical retention systems use cationic coagulants and high molecular weight flocculants. Due to dissociation of carboxyl- and sulphonic-acid groups, fibres have an anionic surface charge in water. Cationic coagulants are attached in two layers, neutralising the particles in the first layer and allowing them to get closer to each other and closer to the fibre. Subsequently, high molecular weight polymers, the flocculants, span bridges between the particles building agglomerates which can be retained by filtration through the forming web. The most common inorganic coagulant is alum (Al_2SO_4), organic coagulant are typically low molecular weight polymers. Flocculants do not need to be ionic. They are added either as powders or as liquids (Gallagher, 1990). In the case of high retention requirements or difficult process conditions (see above), this standard approach may be insufficient. Additionally, alum does not apply to acidic papers as they deteriorate over time causing grey dust. In this case, a dual polymer programme – low molecular weight polymeric coagulant plus high molecular weight ionic flocculant – can be chosen.

However, the use of micro-particles in retention-aid systems is more advanced, and has meanwhile become a well established practice. Bentonite clays and colloidal silica micro-particles are state-of-the-art (Main and Simonson, 1999). These micro-flocs, enhancing small particle retention building strong ionic bonds with cationic additives, are favourable compared to conventional flocs as they can obviously reflocculate after disruption by shear. Due to increasing requirements as a result of increasing machine speeds, chemical suppliers are searching for ways to increase floc strength. The latest generation of colloidal silica micro-particles can be used in combination with cationic polymers or starches. In this case, particles help create smaller, denser, and stronger flocs.

Applying tailored state-of-the-art retention chemistry – and using proper wires and felts, of course – helps paper manufacturers save fibre and chemical costs. Spending on retention aid is well invested in most cases, as the above-mentioned cost savings exceed expenditures significantly.

Range of application:	All paper mills
Ease of implementation:	Medium
Magnitude of impact:	Medium

5.2.5.2 Cost savings – chemicals price

Similar to the preceding chapters on fuel, electricity, and fibre prices, this chapter focusing on chemicals price savings comprises commercial measures, changes in mix, and specifications as well as actions looking at chemicals logistics.

(89) Save chemicals costs through extending the potential supplier base

As noted when looking at fibre costs in action (74), the extension of the potential supplier base is the primary commercial action aimed at cost savings. The higher the number of potential suppliers, the higher the potential for price savings is. Whereas the number of theoretical suppliers for base chemicals used for cooking and bleaching is acceptably high, specialty chemicals such as certain pigments and retention agents can only be supplied by a very small number of companies. Thus, a wide geographical scope of sourcing is important especially for these chemicals, particularly as the relative transport costs are lower than for base chemicals and simple fillers. Global sourcing of the latter is difficult unless the paper mill is located at a sea or at least a domestic port. Thus, pulp and paper mills should spend efforts to identify further potential suppliers, especially for specialty chemicals.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Low

(90) Save chemicals costs through regularly conducting requests for quotation
Again, the afore-suggested extension of the potential supplier base is only the first step towards lower chemicals prices. The consecutive step is the regular conduct of requests for quotation (RFQs) which ought to be done out about once a year depending on the respective market situation. Besides existing suppliers, potential new suppliers should be detected (see preceding action (89)) and approached. Standardised processes, potentially levering e-procurement, limit the efforts per request. The impact of this action depends heavily on the supply/demand dynamics in the market and the number of producers.

Range of application: All pulp and paper mills
Ease of implementation: Very high
Magnitude of impact: Low

(91) Save chemicals costs through bundling volumes
As emphasised in the context of fuel purchasing in action (30), volume bundling increases negotiation power in purchasing. The levers are consolidation of the supplier base – easily feasible with all non-strategic goods – and the formion of buying consortia. Depending on the speciality of pulp and paper chemicals consumed, the consolidation lever may be exhausted quickly. As special pigments or retention aids are produced by very few companies only, the remaining consolidation potential will be limited. In basic pulping chemicals, in turn, this consolidation may allow cost savings. More savings potential can be achieved using consortia buying. While volume bundling across different mills of one company should be good practice, buying consortia with other companies can be considered. In certain forest industry clusters, not necessarily all pulp or paper mills are competitors and some base chemicals may be purchased in cooperation with consumers from other industries too.

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: Low

(92) Save chemicals costs through changing chemicals mix
In certain applications, the substitution of pulp and paper chemicals is feasible – gradual or entirely – without endangering the product properties. Whereas this appears difficult in

cooking and bleaching, substitution in paper chemicals, fillers as well as functional chemicals, ought to be possible. An example is the switch from more expensive PCC to cheaper GCC (ground calcium carbonate), except if the PCC is manufactured on-site at low cost (see action (95)). Though some of the substitution potential will have been used in the past, technicians and procurement managers may be able to identify further cost savings potential from substitution case by case.

Range of application: All paper mills
Ease of implementation: Medium
Magnitude of impact: Low

(93) Save chemicals costs through reducing chemicals specifications
As described in action (34) when looking at fuels, the reduction of specifications (purity, concentration) is a cost savings lever and effective at chemicals too. In general, this applies to all chemicals used in pulp cooking and bleaching as well as in paper manufacturing. Again, it can be assumed and there is evidence from plant visits that mills have utilised this lever to some extent but there is further potential which can be identified in cooperation between operations and purchasing personnel.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Very low

(94) Save chemicals costs through reducing inventories
A reduction in working capital and, thus a cost saving can be achieved with a reduction in inventory levels (see action (35) on fuels). Consignment stocks, common for some chemicals already, may allow small own inventories. However, the actual cost saving may be limited as joint costs with the supplier decrease only marginally.

Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: Very low

(95) Save chemicals costs through reducing joint costs with suppliers
From a total-cost-of-ownership perspective, costs of pulp and paper chemicals consist of the actual purchase price, freight and all costs occurring during further processing in the mill. At least in the long run, no supplier will sell goods at a price below full costs. Accordingly, the reduction of joint costs with suppliers offers cost savings potential also for the pulp and paper manufacturer. A typical example is the on-site production of gases used for bleaching (oxygen, ozone, chlorine dioxide) by suppliers. Dedicated gas manufacturers have specific

knowledge and can produce gases more efficiently than pulp and paper manufacturers. Due to transportation costs, it is favourable to produce these gases on-site at the pulp mill. Joint costs are minimised. Another similar example is production of PCC by an embedded supplier with the specific knowledge, typically a pigment manufacturer, or by the pulp and paper manufacturer itself (for the latter case see action (108)). CO_2 occurs from boilers at no cost and PCC can be produced with limited effort. Only calcium oxide (CaO) needs to be transported to the mill. The advantages of on-site production are saved transport costs and saved CO_2 emissions.

Range of application:	All pulp and paper mills
Ease of implementation:	Medium
Magnitude of impact:	Low

5.2.6 Cost savings – other costs

As illustrated in Fig. 44 (page 176), pulp and paper manufacturers can take actions aimed at maintaining or re-establishing profitability along various levers. These actions can refer to current business, i.e., to current products and current production network, or to new businesses. They can be price-related or cost-related. Within the cost lever, actions aimed at energy and raw material cost savings have been described in the preceding chapters 5.2.1 and 5.2.5. These cost categories account for the preponderant share of total costs. Looking at Paperloop's Cornerstone benchmarking (see Fig. 32 on page 71 and Fig. 33 on page 72, referring to Paperloop (2005)), energy and raw material costs amount to 57-71% of full costs (excluding EBIT). The remainder splits into mill-related and corporate-decided costs, both accounting for approximately half. Mill-related are primarily labour costs, other materials and services; corporate-decided are basically depreciation, leasing, and corporate fees.

Although it has been stressed in the introduction to chapter 5.2 that it is absolutely irrelevant if energy and raw materials costs are addressed by the actions aimed at profitability – 5 EUR/t saved in consumables or personnel are as valuable as 5 EUR/t saved in fuels or electricity – these remaining cost categories will be factored out intentionally. Indeed, an implementation of a lean manufacturing approach, for example, could provide valuable cash-cost savings, respectively a higher production output, and an extension of calculatory depreciation periods would increase a company's EBIT. Nevertheless, the discussion of actions referring to these remaining cost categories is out of the focus of the existing investigation and would exceed its intended scope.

5.2.7 Price increases

As shown in Fig. 44 (page 176), the price is the second main lever for maintaining or re-establishing the profitability of pulp and paper manufacturers' current business besides the cost savings actionsdescribed in the preceding chapters 5.2.1-5.2.6. According to Kopka and Michaelis (2006) who investigated various categories of consumer goods, pricing is even more effective than cost saving. They calculated that a 1% price increase results on average in a 9.4% profit increase, while a 1% reduction in variable costs accounts for only 6.2% profit.

Whereas a product's price is without doubt an important driver for its sales, it is not the only one. Every marketing textbook puts it in one line with place, i.e., the decision on sales channels, promotion and, of course, the product's properties and quality as the "four P" marketing instruments. Over time, price has lost its predominant role as a marketing instrument, while product and promotion have gained share. Rather than focusing on price alone, product, place, promotion, and price should be regarded as an integrated system (Meffert, 1986). Nevertheless, the price deserves prominent treatment here due to its direct and tangible effect on profitability.

The success of executing price increase actions depends heavily on the structure of competition in the respective market, i.e, on the market form and on the degree of perfection of the market. Morphologic characterisations determine market forms by the number of participants, active either as potential sellers or as potential buyers. They span a matrix whose polar cases are bilateral monopoly and atomistic competition, sometimes also called polypoly (Simon, 1992). Another approach characterising market forms is the economic one focusing on the degree of competition sellers or buyers are exposed to: no competition, competition with a few others, competition with entirety of others (Simon, 1992). All markets, irrespective of the market form, can be either perfect or imperfect. Prerequisites of a perfect market, going back to Gutenberg (1984), are maximum principle (acting as homo oeconomicus), infinite reaction velocity, homogeneous goods, and full transparency (Meffert, 1986). However, very few existing markets are perfect. Probably only exchanges come close to it (Simon, 1992).

These different structures of competition require different pricing approaches. Meffert (1986) suggests the following to suppliers:

- Monopoly – irrespective of perfection: set optimal price (see below)
- Oligopoly – imperfect market: create acquisitive potential and use limited autonomy within available price range
- Oligopoly – perfect market: set price considering reactions of competitors
- Atomistic competition – imperfect market: create acquisitive potential and use limited autonomy within available price range
- Atomistic competition – perfect market: accept price, adapt volume

The structures of competition in pulp and paper markets differ between grades and countries. Though relative transportation costs of pulp and paper are lower than, for example, for wood or fillers, transport costs create a certain entry barrier, especially in countries with a limited transport infrastructure (inland, i.e., no access to capable ports, and mountains, i.e. no capable railway network). Accordingly, it would be a laborious exercise to locate each grade/country combination in the matrix of morphologic market forms and assess the individual degree of perfection. However, the exercise can be limited to some degree as for almost no grade/ country combination can a monopolistic structure be assumed – neither from the supply nor from the demand side.Even in specialties such as photo paper at least some competition arises from imports, partially from outside the EU. Thus, nearly all grade/country combinations are located between bilateral oligopolies and atomistic competition. A recent investigation by the European Commission looking at putative collusion in the fine paper business (newsprint, magazine) was stopped in 2006. However, increasing concentration on the supply side as well as on the demand side, measured in the market share of the top five players and number of players, does not activate competition (Simon, 1992). Furthermore, all pulp and paper markets can be regarded as imperfect.

The price is, irrespective of the afore-mentioned limitation, only one out of four determinants within the marketing mix, and, independently from the structure of competition, an important driver for the sales volume. In monopoly as in atomistic competition: the demand reacts to the price – it is elastic. For every individual good of every individual supplier, there is an individual price-consumption curve. Only in the case of a supply monopoly, does the individual and general price-consumption curve coincide. In this case, the curve is either linear, having a maximal price, a saturation volume, and variable elasticity, or multiplicative, having a hyperbolic form and constant elasticity (Simon, 1992). In the case of competition, in turn, two more forms of price-consumption curves are used. Both of them reflect attraction, however, in opposite directions. While the "attraction model" assumes strong demand reaction to price changes close to the original price and a comparably lower reaction distant from the original price, the "Gutenberg model" considers an acquisitive potential around the original price (price autonomous interval). According to Simon (1992), none of the functions predominates empirically. In practice, price changes are typically within a "quasi-linear interval". The elasticity η (eta) describes the relative demand change per relative price change at a certain point on the price-consumption curve. In the case of a linear curve (not a linear interval), η ranges between 0 at low prices and high volumes and minus infinite at high prices and low volumes. Thus, any given elasticity is valid only for an infinitesimal small price/volume variation (Meffert, 1986). The other price-consumption curves have partially constant elasticities. Looking at consumer goods, Simon (1992) notes that the price elasticities largely range between 0 and -5, in most cases between -2 and -2.5. Values between 0 and -1 are improbable from a normative perspective. Any gradual price increase would result in a profit increase.

Whereas knowledge of the price-consumption curve is a prerequisite for the calculation of the optimal price, it is not a sufficient condition. The individual cost curve is of equal importance.

Again, different shapes are feasible. In 90% of cases, the cost functions are linear or degressive, in only 10% of the cases are they progressive or follow the law of diminishing returns (Simon, 1992). Although some cost components may increase with higher capacity utilisation, economies of scale prevail due to a better utilisation of fixed costs (Meffert, 1986). Irrespective of market form and precise calculation (see below), a price can be optimal only if marginal costs equal the marginal revenue. The fixed costs do not – in no market form – influence the optimal price (Simon, 1992). In the case of the Gutenberg function, there are usually two intersections of marginal costs and marginal revenue. The respective profits need to be compared. A similar general rule can be given for the price floor in a product company: from a long-term perspective, each manufacturer needs to cover full costs, but the bottom price is determined by the short term variable or marginal costs (Simon, 1992).

In the case of a monopoly with a linear price-consumption curve and a linear cost curve, the optimal price can be calculated as described in the following equations Eq. 8-Eq. 11.

$$q = a - bp$$

Eq. 8: Linear price-consumption curve

$$C = C_{fix} + cq$$

Eq. 9: Cost function

$$C' = R'$$

Eq. 10: Optimality condition

$$p_{opt} = \frac{1}{2} \cdot \left(\frac{a}{b} + c \right)$$

Eq. 11: Optimal price in monopoly

q:	Sales volume [EUR/t]
a:	Saturation volume [t]
b:	Slope of linear price-consumption curve [t^2/EUR]
p:	price [EUR/t]
C:	Total costs [EUR]
C_{fix}:	Fixed costs [EUR]
c:	Variable unit costs [EUR/t]
C':	Marginal costs [EUR]
R':	Marginal revenue [EUR]
p_{opt}:	Optimal price [EUR/t]

From Eq. 11 it becomes obvious that the fixed costs do not influence the optimal price. Accordingly, a monopolistic supplier, facing a linear price-consumption curve and a linear cost curve, should pass on exactly 50% of any increase in variable manufacturing costs (see subsequent Eq. 12). If the supplier had charged the optimal price in the past (status 1), passing on half of the cost increase safeguards the optimal price for the future (status 2). However, the contribution margin also reduces by half of the cost increase (Eq. 13). Due to the additional reduction in the sales volume (Eq. 14), the profit is affected twice. The exact effect can be calculated by integration of the equations, but the result, containing only parameters a, b, c_1, c_2, C_{fix} and q_1 is quite complex and hardly self-explanatory.

$$p_{opt2} = p_{opt1} + \frac{1}{2} \cdot (c_2 - c_1)$$

Eq. 12: Change in optimal price as result of change in variable costs

$$p_{opt2} - c_2 = \frac{1}{2} \cdot (p_{opt1} - c_1)$$

Eq. 13: Change in margin as result of change in variable costs

$$q_2 = q_1 - \frac{1}{2} \cdot b \cdot (c_2 - c_1)$$

Eq. 14: Change in sales volume as result of change in variable costs

Whereas in theory, the optimal price, respectively the optimal price change, as a result of a manufacturing cost increase can be determined for the monopolistic case, the situation is much more difficult in practice. In-depth data on the price-consumption curve function and on the cost function is required. While the latter should be accessible or can be properly assumed, reliable data for computing a price-consumption curve will hardly be available. If the monopolistic case with the assumptions of linear curves is left and real life market conditions are considered, further data for competitors, respectively assumptions on their behaviour (reactions), is required (Meffert, 1986). Meffert concludes that classic models of price theory are based on unrealistic premises causing results which are not useful for practical pricing decisions. He sees particular weaknesses in the numerous unrealistic assumptions such as: short-term horizon, profit maximisation as single target, full information (deterministic approach), single product enterprise, missing of trade/wholesale sector, infinite reaction velocity, rational behaviour (homo oeconomicus) of producers and potential consumers, price as single marketing instrument and unregulated price setting. In practice, most of these simplifying assumptions are violated.

Anyway, even from theoretical considerations, the calculation of optimal prices applies to a supply monopoly only. As noted above, all other structures of competition require different pricing approaches depending on market form and perfection. Imperfect markets always invite suppliers to create acquisitive potentials in order to benefit from limited autonomy within the available price range. Looking at oligopolies in imperfect markets, Simon observed a 2-6% range without reaction of competitors (Simon, 1992).

In the oligopolistic case, especially in perfect markets but also in imperfect markets beyond the autonomous range, game theory needs to be considered. Typically, fear of reactions results in constant or foreseeable behaviour. Prices or markups are usually static (Simon, 1992). The easiest price-setting approach is the cost-plus pricing which often applies if all players have similar cost structures and weights. All player use markups customary for the respective industry. This "silent cooperation" can result in prices close to the monopolistic optimal price, although it formally neglects the sales effect of price known from the price-consumption curves. Target-return pricing is a variant of cost-plus pricing. Another strategy is adaptation, typically applied as price leadership or signalling. In the first case, one player, with a high market share and accepted by their competitors as the price leader, increases or decreases prices promptly followed by the others. In the latter case, the players assume equitable rights and the signalling position circulates.

In the case of atomistic competition, again perfect and imperfect market conditions need to be differentiated. In the case of perfect markets, there is no pricing range. The price for a homogeneous good is determined by the market. A supplier offering the good for an infinitesimally higher price loses their entire sales, while a supplier offering slightly below market price attracts the entire demand. The player cannot influence the price. The production volume is their only independent variable. In imperfect markets in turn, the afore-mentioned acquisitive potential emerges. The autonomous price range observed by Simon looking at the oligopolistic case also applies to imperfect atomistic competition.

In chapters 2.2 and 4.2.2.4.3.3 attempts to determine the adequate price increase for recovery of the out-of-pocket effect of emission trading have been described. Reinaud (2005) stresses the trade-off between maintaining market share and maintaining profitability. As mentioned in chapter 4.2.2.4.3.3, Quirion and Hourcade (2004) as well as Reinaud (2005) discuss the effects of price increases applying various demand elasticities ranging between -0.40 and -1.88, referring to earlier publications[1]. Their considerations have been questioned inform at least three aspects: (1) insufficient differentiation of product groups, (2) assumption of joint pricing decision of entire industry neglecting independent pricing by each company, and (3) significant variance of assumed elasticities requiring contrarious pricing strategy. Thus, they hardly help in determining an "optimal" pass-on percentage.

[1] According to Fouquin et al. ((2001) p. 66), a demand elasticity of -0.4 should be applied for exports to outside the EU, while imports change by -1.05,. Erkel-Rousse and Mirza (2002) calculate a demand elasticity of -1.5 for pulp and paper, the GTAP model (GTAP team, 2002) applies -1.8. Marsh et al. (2003) finally consider -1.88 for newsprint.

However, even if the obstacles listed above could be overcome, according to all the aforementioned theoretical considerations a determination of optimal prices, respectively optimal price increases, for different pulp and paper grades and markets is impossible. Paper markets are no supply monopolies. Even in small countries with only one manufacturer of a certain grade, imports safeguard competition. As noted above, nearly all grade/country combinations are from their morphology located somewhere between bilateral oligopolies and atomistic competition. Thus, only one consideration is unquestionable: in practice at most 50% of the manufacturing cost increase caused by emission trading will be passed on by pulp and paper manufacturers. If all suppliers faced linear cost and price-consumption curves, respectively remained in the linear interval, and colluded acting as a "virtual monopoly", they would pass on exactly 50% of the cost increase (see Eq. 12 above). However, in practice each manufacturer's pass-on capability is presumably below 50%. Whereas collusion is difficult even in the case of a few manufacturers, it is almost impossible in the case of numerous manufacturers and at the presence of importers. The latter typically have a very limited incentive to join the group.

Although pricing decisions need to be made case by case, i.e., for each grade/country combination, some recommendations can be given to pulp and paper manufacturers aimed at recovering part of the manufacturing cost increase by marking up prices.

(96) Increase sales prices through establishing acquisitive potential and differentiating prices

All real and, thus, imperfect markets allow suppliers to create acquisitive potentials in order to benefit from limited autonomy within an available price range. As noted above, Simon observed a 2-6% range without any reaction from competitors (Simon, 1992). Here, the other three components of the marketing mix – product and service, place or channel and promotion – ought to be utilised. Wherever prices are not just set by the producer but negotiated, numerous decisions to be made in price setting (e.g., discounts and payment conditions). Thus, there is not one price but a divergence between official and real prices. Simon (1992) summarises "List prices are pure myths, real prices are negotiated individually". Here, strategic and tactical pricing decisions need to be closely interlinked. Clear guidance is required for the day-to-day execution of the strategic decisions. An example is the introduction of a simple but efficient sales stimulation program. All sales personnel ought to be incentivised by a contribution-margin-based bonus system. Customer segmentation and price differentiation must be successfully applied. The competency of closing sales transactions below the defined bottom price needs to be strictly limited. Although the aforementioned measures may sound very straightforward, significant profitability potential is still unused. Price increases, either hidden or in line with other manufacturers affected by cost increases in the same way, can provide a considerable contribution to maintaining or re-establishing the profitability of pulp and paper manufacturers, even if cost increases can only partially be passed on.

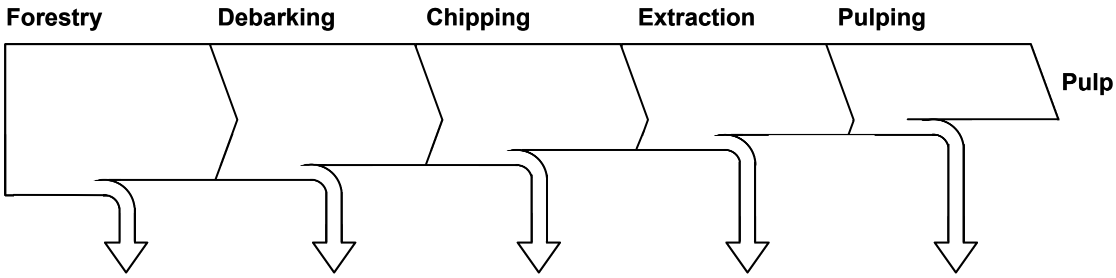
Range of application: All pulp and paper mills
Ease of implementation: High
Magnitude of impact: High

5.2.8 Reactions beyond current business

The lastlever aimed at maintaining or re-establishing the profitability of pulp and paper manufacturers (see Fig. 44 page 176) sums up all the actions beyond current business. Chapter 5.2.8 clusters these actions into three groups with increasing distance to a manufacturer's current business. Chapter 5.2.8.1 looks at options creating additional value from producing and selling fuels and other chemical products as a supplement to the existing production network and product mix. 5.2.8.2 considers changing the production network and product mix. The third group, described in chapter 5.2.8, comprises actions beyond pulp and paper manufacturing, in as far as they are at least somewhat related to forest industry or emission trading.

5.2.8.1 Profit increase from producing and selling fuels and other chemical products as a supplement to the existing production network and product mix

The options of producing fuels and other chemicals as by-products along the fibre chain are numerous. As Fig. 47 summarises with the example of chemical pulping, most process steps from forestry to paper manufacturing offer potentials for generating value-added products. The majority of these productsare sold but a few can also be used internally.



	Forest residues	Bark	Screening dust	Hemicelluloses, polymeric lignin	Black liquor
Current use	• Unused	• Combustion for steam and electricity generation	• Combustion for steam and electricity generation	• Not separately used, combustion with black liquor	• Combustion for steam and electricity generation
Value added use	• Combustion for steam and electricity generation • Pellets, briquettes	• Pellets, briquettes • Ethanol • Suberin for sun blockers • Syngas as feedstock for bio-refinery	• Pellets, briquettes • Syngas as feedstock for bio-refinery	• Fermentable sugars for ethanol and higher value chemicals (adhesives, films, polymers, food additives) • Modified lignin	• Turpentine • Tall oil • Methanol • Xylan for fibre bonding • Soaps for resins and fatty acid esters (bio-diesel) • Lignin as solid fuel or phenolic chemical used in binders and dispersants • Syngas as feedstock for bio-refinery

Fig. 47: Value-added products along the fibre chain

As noted in action (56) looking at electricity generation form black liquor gasification, one caveat needs to be made: neither black liquor gasification nor other value-added processes are perpetual motions violating the laws of thermodynamics. They cannot maximise yields of electricity, steam, chemicals, and wood at the same time. Wherever carbon is extracted from the chain for by-products, either less carbon is available for the subsequent process step or more carbon needs to be fed into the chain at the beginning. Nevertheless, the production of by-products adds value in many cases if comparably cheap fibrous raw materials (e.g., forest residues, bark) are available.

The subsequent actions outline measures which can be taken by pulp and paper manufacturers to tap these additional sources of profitability. Due to the manifold options of gaining chemicals as by-products especially in chemical pulping, this list does not strive for exhaustiveness but provides examples only.

(97) Increase profitability through producing pellets and briquettes

Currently almost all pulp mills burn the accruing bark and screening dust from chipping in separate bark- and solid-materials boilers. In this way, they cover a comparably small share of their demand for primary steam. An alternative would be integration into the production of pellets or briquettes as suggested by the Swedish research group "The Eco-Cyclic Pulp Mill" (STFI, 2000). The strong increase in decentralised pellet-fired heating and the corresponding pellet price increase in Central Europe may make pellet production a profitable business for pulp manufacturers even if they need to buy additional low-cost biomass (bark, forest residues) to safeguard the steam supply. Their comparably favourable role in the fibre chain (see action (76) on fibre purchase) may provide them with good access to this biomass.

Range of application:	All pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(98) Increase profitability through producing ethanol fermenting bark
A second, only at first view unusual, option for gaining value from bark is the production of ethanol in a fermentation process as again proposed in the "The Eco-Cyclic Pulp Mill" report (STFI, 2000). Subsequently ethanol is used either for motor fuels – very common already in America (especially the US based on corn and in Brazil based on sugar) but also gaining share in Central Europe – or as feedstock for other chemicals. Although the action exceeds quite a bit of current business of most pulp manufacturers, it offers a further valuable revenue potential accessible with today's technology.

Range of application:	All pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(99) Increase profitability through extracting suberin from bark
Another bark-related value-added product, indeed quite specific, is the extraction of suberin and unique fatty acids from birch bark. The fatty acids can be used for polyesters, suberin provides skin protection as an ingredient of sun blockers (Axegård, 2006a). Although the action provides another value creation opportunity for pulp manufacturers, it ought to be regarded as a niche measure only.

Range of application:	Pulp mills using birch logs
Ease of implementation:	Medium
Magnitude of impact:	Low

(100) Increase profitability through extracting hemicelluloses and lignin from chips
A higher penetration amongst pulp manufacturers may find the separation and extraction of selected components of wood chips. According to Perine (2006), this approach called "value prior to pulping" is one of the columns of the "Agenda 2020" of the US Technology Alliance

of the Forest Products Industry. The desired components, primarily soluble hemicelluloses but also polymeric lignin fractions, are leached out of the chips and processed into commercially attractive chemical and liquid fuel products such as fuels (ethanol), adhesives, films and polymers from fermentable sugars, as well as modified lignin and modified fibres. The various "value prior to pulping" processes have not yet reached commercial scale. They still need to prove technical feasibility at industrial scale and financial favourability compared to the classical production routes of the accruing products.

Range of application: All pulp mills
Ease of implementation: Medium
Magnitude of impact: Medium

(101) Increase profitability through extracting lignans from softwood knots
Similar to the preceding action (100) of leaching out chips, the existing action utilises extracted polymeric lignin components. Compression wood of softwood knots and branch bases contains about 10% lignans. According to Axegård (2006a), these lignans can be used as food additives, e.g., in margarine, due to their nature as antioxidants. Due to practical difficulties (e.g., in collecting only the zones of compression wood), the close commercial applicability may be doubted. Extraction of ignans still appears to be a very small niche only.

Range of application: All pulp mills
Ease of implementation: Low
Magnitude of impact: Low

(102) Increase profitability through extracting glucomannans from TMP white water
Another action aimed at generating additional profit from using sugars is the extraction of glucomannans from TMP white water. Especially glucomannans from spruce have a unique ability predestined for building barriers with low oxygen permeability as needed in food packaging materials (Axegård, 2006a). The extraction of glucomannans can be linked to existing TMP equipments at comparably low efforts. Though, commercial favourability still needs to be proven at industrial scale.

Range of application: TMP mills
Ease of implementation: Medium
Magnitude of impact: Low

(103) Increase profitability through extracting turpentine, tall oil, and methanol from black liquor
The technical feasibility of producing turpentine, tall oil, and methanol as by-products at chemical (sulphate) pulping, in turn, has been proven. Nevertheless, the penetration in the

industry is only moderate. About a third of the sulphate pulp mills extracts one or several of the above-mentioned chemicals at processing of black liquor. The chemicals can be either sold, e.g., as feedstock for lacquer manufacturing, or used internally as comparably cheap fuels. An example of the latter use is the replacement of purchased mineral oil in the lime kiln, as mentioned in action (28). Still only about two thirds of the sulphate pulp mills can implement the proposed action. As noted, the technology is proven although the financial effect is rather limited.

Range of application: Sulphate pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(104) Increase profitability through extracting xylan from black liquor
Another rather specific action is the removal and purification of xylan accruing in a significant share in black liquor. Axegård (2006a) suggests its use in paper manufacturing. When adsorbed onto fibre surfaces, it enhances fibre bonding and, thus, reduces the refining requirement. The technology is largely mature for industrial application, but has not achieved considerable penetration yet.

Range of application: Sulphate pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(105) Increase profitability through extracting soaps from black liquor
A further opportunity for creating additional value from black liquor is the removal of soaps. If black liquor gasification is the future large step towards a bio-refinery, this process is a smaller but quicker one. Hurdles for scaling up current trials to industrial scale tend to be much smaller than at black liquor gasification. Axegård (2006a) mentions as final products resins for binder formulations, fatty acid esters (bio-diesel) and β-sitosterol. Due to the limited research status, profitability still needs to be proven at large-scale applications.

Range of application: Sulphate pulp mills
Ease of implementation: Medium
Magnitude of impact: Low

(106) Increase profitability through precipitating lignin from black liquor
A fourth black-liquor related action creating additional value is the precipitation of lignin. As lignin removal at the evaporation stage is also a low capital-cost alternative for de-bottlenecking recovery boilers (Axegård, 2006b), the technology is somewhat established. Lignin is precipitated by the use of sulphuric acid (H_2SO_4), followed by dewatering and

washing. However, it is only economical under this condition (Axegård, 2006a). The Financials ought to improve with the commercial application of the newly developed LignoBoost process which has recently completed demonstration scale trials in a Portuguese kraft pulp mill. Different to the existing process, the lignin is precipitated by the use of CO_2. It can be used in liquid form (raw phenol or feedstock for binders and dispersants) or pressed to pellets of about 65% dry solids. Like turpentine and tall oil, it can replace purchased fossil fuels in the lime kiln or be sold on the market. Axegård (2006b) assumes about a three-year pay-back time for lignin removal and pellet production.

Range of application:	Sulphate pulp mills
Ease of implementation:	Medium
Magnitude of impact:	Low

(107) Increase profitability through using syngas from black liquor and bark gasification as a feedstock for bio-refinery

Black liquor gasification has already been described in action (56) when looking at options for increasing the electricity yield from black liquor. All the general description of syngas generation, requirements for causticising, and development status refer to both electricity optimised BLGCC as well as the chemical pathway. The latter option, i.e., the use of syngas as a feedstock for advanced bio-refinery, is sometimes called simplifying BLGMF (black liquor gasification aimed at motor fuels). However, many more products can be made of the synthesis gas, as Fig. 48 reveals.

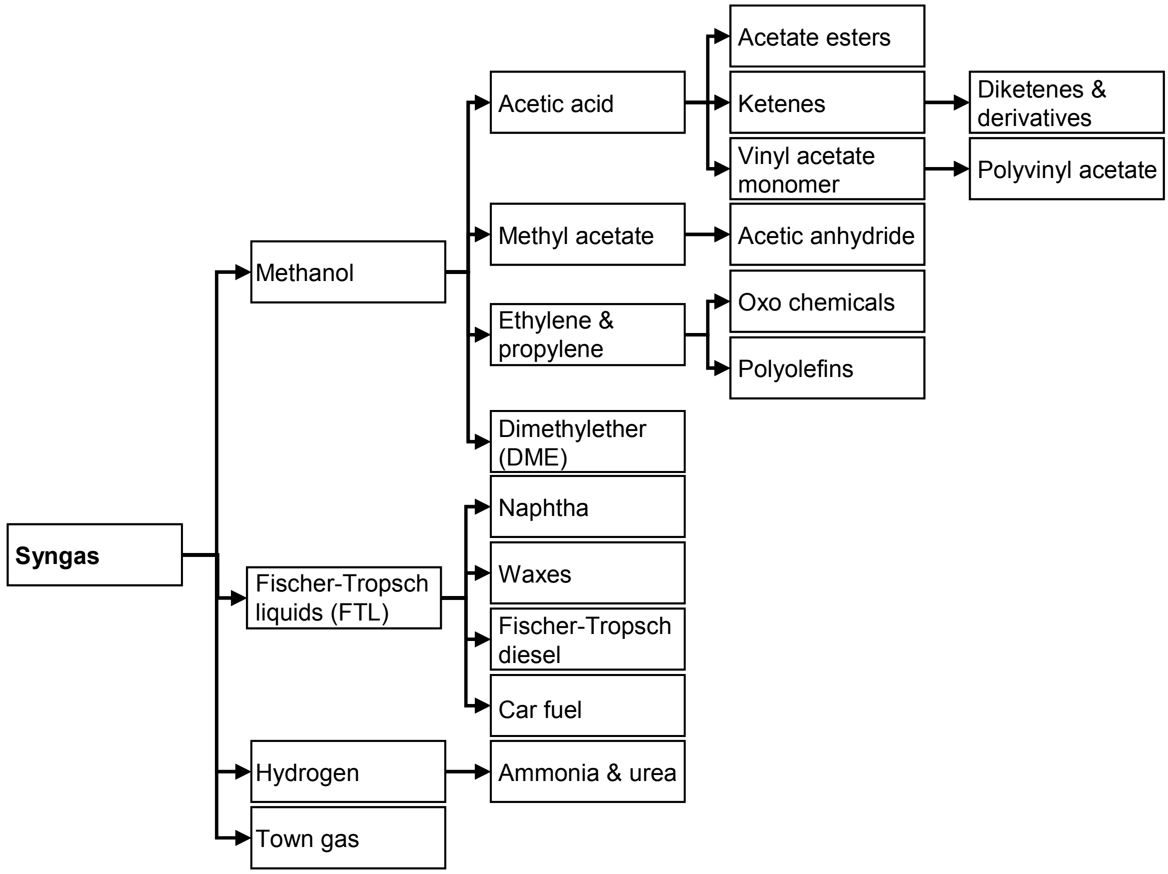


Fig. 48: Fuels and chemical products from gasification[1]

As noted at the beginning of this chapter, the extraction of carbon from the chain for by-products either reduces the carbon available for the subsequent process steps or causes the need to feed more carbon into the chain. Hence, black liquor gasification, irrespectively if optimised for electricity generation or as feedstock for a bio-refinery, induces the need for additional biomass. However, this biomass is not necessarily valuable fibre in the form of chips or logs. Moreover, cheap biomass in the form of bark, forest residues, agricultural products or even waste should be utilised. There are significant synergies in co-locating black liquor and solid (bio) mass gasification (Perine, 2006). The research group "The Eco-Cyclic Pulp Mill" recently suggests gasifying bark for power generation or as a feedstock for chemicals (STFI, 2000). Thereby, it is advantageous that the gasification technology can be kept simple as no chemicals need to be recovered. In Finland, an industrial consortium comprising various big pulp and paper as well as equipment manufacturers applies pressurised fluidised bed boiler generating synthesis gas using bark, forestry residues, and waste fibre (McKeough and Kurkela, 2006).

Gebart has calculated, that 55% of Sweden's gasoline and diesel consumption could be replaced by liquid bio-fuels in 2050 under perpetuation of the current forestry strategy

[1] Display according to Eastman (2005).

(Gebart, 2006). He sees strong economic arguments for BLGMF and estimates production costs of fuels lower than current prices of gasoline and diesel. Others, in turn, assume that bark gasification is not yet conomically feasible (STFI, 2000).

Range of application: Sulphate pulp mills
Ease of implementation: Very low
Magnitude of impact: Very high

(108) Increase profitability through producing PCC on-site
Other than all the afore-mentioned measures of value creation, this last action in the context of gaining additional profit from fuels and other chemicals utilises the biogenous carbon for production of an inorganic chemical: precipitated calcium carbonate. Although inorganic chemicals tend to bear less additional value than more complex organic chemicals, production of PCC on-site has already proven commercial applicability in many mills. As noted in action (95), CO_2 occurs from boilers at no – or due to the allowance requirement even negative – costs and PCC can be produced with limited effort. This can be done either by an embedded supplier, typically a pigment manufacturer, or by the pulp and paper manufacturer itself. Due to the comparably limited need for specific knowledge, this value-creating opportunity can be tapped by the producers with limited efforts. Whereas the lime (CaO) usually needs to be purchased as feedstock, manufacturers of recovered fibre are privileged. If they burn the accruing sludge (about 20% of recovered paper input), the ash is a valuable calcium source. If it is diluted in water, calcium appears as calcium hydroxide ($Ca(OH)_2$) which can be dried to calcium oxide. A significant share of lime purchase can be saved (Commission of the European Communities, 2001). Savings in emission allowances employed and avoided landfill costs are additional benefits contributing to the favourability of on-site PCC manufacturing.

Range of application: All pulp and paper mills combusting fuels
Ease of implementation: Medium
Magnitude of impact: Low

5.2.8.2 Profit increase from changing the production network and product mix

As the production network and production mix are major influencing factors for the profitability of pulp and paper manufacturers, they should be reviewed regularly and at any time if required by external shocks. Chapters 4.2.2.4, 4.2.2.5 and 4.2.2.6 and, in particular, Tab. 5-Tab. 7 (pages 144 ff.) reveal: the introduction of emission trading is such a shock.

A very first glance indicates moderate growth for pulp and paper consumption and production in Europe. However, if the picture becomes more detailed, differences attract attention. Paper production has grown fairly steadily with an average annual rate of 2.9% since 1991 (CEPI, 2006b). Europe is still a net exporter with consumption growth of 2.4%. Looking at pulp, the growth rates are lower. Production has increased on average by 1.5% since 1991, consumption by 1.8%. Europe is a net importer and tends to enlarge the trade deficit. Two things are alarming for European pulp producers – both closely related: growth in pulp production significantly lags behind growth in paper production and secondary fibre is constantly gaining share. Since 1991, utilisation of recovered paper has grown by 4.6% on average. Meanwhile, secondary pulp has about an equal share as primary pulp and the trend is continuing. Further, among paper grades weights are shifting. Consumption of newsprint is declining and advertising, in turn, is growing.

Overall pulp and paper manufacturers in Europe face two primary challenges: (1) profitability is endangered by a deteriorating price-to-cost ratio, with some grades suffering more than others. (2) Developing countries, still largely importers, may become exporters – also to Europe.

The deteriorating price-to-cost ratio is a result of changes in both levers, price pressure and cost increases. Substitution among grades takes place in pulp as in paper. While paper customers increasingly demand higher grades – smoother, brighter, better printable etc. – their price willingness does not keep pace with the requirements. At pulp, in turn, a downgrade takes place in the "volume" segment.Increasingly, mechanical pulps such as SGW and PGW are being replaced by cheaper recovered fibre. TMP appears to be substitutable by Super-PGW (see action (47)). Only "quality" chemical pulps tend to be largely irreplaceable. Here increasingly imports, especially from Brazil, set the price (see trade flows in Fig. 23-Fig. 25). – On the supply side, in turn, cost increases put pressure on pulp and paper manufacturers. The out-of-pocket effects of emission trading have been derived in chapters 4.2.2.4, 4.2.2.5 and 4.2.2.6 (for a summary of "most-likely" effects see Tab. 5-Tab. 7 on pages 144 ff.). Whereas some grades are winners from these developments, others are clear losers. Differences in profitability are significant.

(109) Increase profitability through adapting product mix
The aforementioned deterioration in the price-to-cost ratio of many pulp and paper grades and resulting differences in grade profitability strongly suggest pulp and paper manufacturers reviewing their product mix. They ought to set the course for profitability through investing in profitable grades – and mills – only. Repositioning comprises production switches, retrofits of existing mills, divestments of losing grades, and investments into promising ones. A simplifying example may be the closure of SGW and PGW lines in favour of an extension of fibre recovery. However, these grade changes need to be based on in-depth market research and modelling, especially if they affect the production network. One tool for the modelling required is Pöyry's "Periodic Table of Paper Grades", presented by Jokinen et al. (2004).

Range of application: All pulp and paper mills
Ease of implementation: Medium
Magnitude of impact: High

The second challenge for European pulp and paper manufacturers is the emergence of developing countries. RISI experts assume a largely unchanged growth in overall paper demand in Europe within the next 15 years (2-3%). Whereas growth rates for graphic and packaging papers will fall below current levels, Eastern Europe will grow faster and make up for the slowdown in Western Europe. North America will be hit harder. Growth rates are forecast to even fall below 1% due to a decline in graphics grades and only limited growth in packaging. Also in Asia (excluding China), paper consumption will grow below average (1-2%). The Japanese market is very mature, India obviously has no significant paper market yet and growth expectations are very moderate. Global growth is borne by Latin America and especially China with rates of 4-5 respectively 6-7%. In China press and advertising tend to be growth drivers. However, also in pulp and paper markets developing countries cannot be reduced to the consumer position. Currently, about 40% of new paper capacity is being built in Asia, mainly in China. If this trend should continue, emerging markets may swing from net importers to net exporters – also to Europe. According to RISI, China has already become a newsprint exporter. Chinese, other Asian, and Latin American companies will become major players in global pulp and paper production. According to Hawkins Wright (cited in Mielisch and Ridder (2006)), Brazilian Aracruz has surpassed US/Canadian Weyerhaeuser as the biggest market pulp producer with a share of almost a third of the global market in BHKP.

(110) Increase profitability through acting on emerging markets
Against the background of these global growth trends, it is crucial – at least for large, multinational pulp and paper manufacturers – to participate in the right markets with the right products. Thus, each major manufacturer should pay attention to and consider the aforementioned trends in grades and markets in its mid- and long-term strategy. Depending on the focus, business plans for Eastern Europe, China, and Latin America (Brazil) should be made. Divestments of mills which are in continued deficit producing "losing" grades in mature countries ought not to be factored out of the considerations. Decisions, however, can be made case by case only as result of a very thorough analysis of opportunities for and threats to long-term profitability.

Range of application: All pulp and paper mills
Ease of implementation: Low
Magnitude of impact: Very high

5.2.8.3 Profit increase from activities beyond pulp and paper manufacturing

Theoretically, the number of activities aimed at profit generation beyond pulp and paper manufacturing is infinitely high. However, in order to remain within the focus of the investigation, only four actions related to energy and fibrous raw material, respectively emission trading, are described in the following sections.

As noted in chapter 2.1.2.1, the Kyoto Protocol opens up to its signatories three so-called Flexible Mechanisms of climate protection: Emission Trading, Joint Implementation (JI), and Clean Development Mechanisms (CDM). The Marrakesh Accords (United Nations, 2001a), adopted at the COP 7 meeting, detail the clauses on CDM and "land use, land use change and forestry" (LULUCF) actions, i.e., on the accountability of CO_2 sinks within the Kyoto scheme. Whereas the three flexible mechanisms were initially designed at the level of nations, in the meanwhile they are also accessible to individuals. Looking at emission trading, the individualisation is the European emission trading scheme. But also JI and CDM are accessible to companies in Europe. A link of these three instruments and an at least unidirectional exchangeability of EUAs (EU emission allowances), ERUs (emission reduction units originating from JI projects), and CERs (certified emission reductions originating from CDM projects) has been provided by the so-called EU Linking-Directive 2004/101/EC[1] (see chapter 2.1.2.2). Thus, JI and CDM can be regarded as derivatives of emission trading. As noted in chapter 2.1.1.4, both are project based, i.e., they refer to emission sources that are not subject to the emission trading scheme anyway. These projects have two partners domiciled in different countries. While a project is conducted in country A, it is financed by a partner B in country C or by country C itself. The CERs respectively ERUs are credited to the financing partner. They use them either for compliance with their emission target or sell CERs or ERUs on the market. The basic difference between CDM and JI is that in JI projects both partners are domiciled in a country listed in Annex I of the UNFCCC (United Nations Framework Convention on Climate Change), while in CDM measures the project is conducted in a non-Annex-I country. CERs can already be converted in the European emission trading scheme since 2005, ERUs cannot be used before 2008. The two main problems related to crediting ERUs and CERs are the definition of the baseline against which the reductions are counted and the proof of additionality compared to any development which would have taken place anyway. The interpretation of the additionality requirement is still disputed in CDM and in JI. In the strict sense of "project additionality" the project's business case is unprofitable without the revenue from ERUs or CERs and only gains profitability with certification. In a more moderate sense of "environmental additionality", the project only needs to reduce CO_2 emissions or increase absorption compared to the baseline. Whereas all doubt-free cases are

[1] Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms (European Parliament and Council of the European Union, 2004b)

accredited by an independent certifier in accordance with UNFCCC rules, all doubtful cases are decided by the highest authorities referring to JI and CDM, the JI Supervisory Committee, respectively the CD Executive Board at the UN.

(111) Increase profitability through conducting JI measures
As noted above, JI projects are conducted in countries listed in Annex I of the UNFCCC. These countries are largely industrialised or in transition to industrialisation. However, due to the mutual exclusiveness of JI and emission trading (to avoid double-counting), projects conducted in (Eastern) Europe are either subject to the EU ETS scheme or JI measures. Potential JI partners outside the EU 25 characterised by significant economic size are Switzerland and Norway, Russia, Ukraine and Turkey, Canada, the United States, Australia and Japan.

European pulp and paper manufacturers need to balance the opportunities versus the costs and risks inherent in assuming the role of financing partner in JI projects. The upside is composed of three aspects: (1) access to cheap emission certificates, (2) easement of speculation with emission certificates, and (3) insights into or even access to foreign markets.

The first advantage of JI as well as of CDM projects is the potential for emission reductions at low costs. The wider the range of potential emission reduction projects, the lower the costs. Any geographical extension beyond the EU provides additional projects with low abatement costs. However, as transparency on the market for ERUs increases, it continuously becomes easier to get access to these emission reductions also as a not actively involved partner. ERUs can be bought by anybody irrespective if they are the financing partner of a JI project or not. Nevertheless, being the financing partner saves half of the margin the seller of ERUs would otherwise earn. It can be expected that only those JI projects are conducted whose abatement costs are somewhat below the market price of ERUs – at least if volatility in ERU markets is excluded and actual abatement costs equal those expected in the project's business plan. The hosting partner and financing partner typically share the margin. An additional reason for becoming the financing partner in a JI project is knowledge-related – directed from financing partner to hosting country: If the project is closely related to the core business of the financing partner, i.e., to pulp and paper manufacturing in this case, knowledge can be transferred enabling low specific emission abatement costs which would not have been achieved without this knowledge. The inherent risk will be discussed some lines below.

The second advantage is the easement of speculation with emission certificates. As noted above, ERUs and CERs can be transferred unidirectionally into EUAs. Due to the general impossibility of banking EUAs from the first EU emission trading phase (2005-2007) to the second phase (2008-2012) prices of both types of EUAs may differ. In February 2007, the deviation exceeded a factor of 10. Due to a warm winter and other reasons, the EUAs of the first phase dropped to 1-2 EUR/t CO_2, while phase two allowances are quotes at about 15 EUR/t CO_2. Whoever gets access to ERUs from JI projects below the price of phase two EUAs could sell phase two EUAs going short and cover the deficit with ERUs. However, this and other imaginable speculations are not bound to being the financing partner of JI projects. At best, active involvement in JI projects eases access to cheap ERUs.

The third advantage of engaging in JI projects is the insight or even access the financing partner can get to foreign markets. Thus, engagements are valuable if the projects are conducted in countries that fit into the financing partner's expansion strategy (see action (110)). Again, getting insights usually requires giving insights which means that there is a risk too.

As noted above, the upsides from becoming the financing partner in JI projects need to be balanced versus inherent costs and risks. Two major costs are absorption of capital and management capacity, both at least opportunity costs. It ought to be considered thoroughly if a JI project is the best available investment for both scarce resources.

There are risks inherent to the project itself and to partnering with an unknown company in a foreign country. Looking at the project itself, commercial failure is a risk which should not be neglected. Besides all the problems that can occur with the implementation of the project, the uncertainty of crediting is a significant risk. As mentioned, baseline and additionality are crucial. If the JI eligibility requirements are met, a simplified verification by a certifier accredited from the hosting country is feasible ("track 1"). Otherwise, a special verification by the JI Supervisory Committee is required ("track 2"). The risk inherent in cooperation arises from the information asymmetry with the implementing partners. They are based in the respective country and know national legislation and customs far better than the financing partner. Moreover, any technology transfer causes the risk that the recipient might abuse the management and technology knowledge gained.

In the end, each pulp and paper manufacturer needs to balance the costs and risks against the benefits for each individual JI project. A general recommendation to engage in Joint Implementation cannot be made.

Range of application:	Multinational pulp and paper manufacturers
Ease of implementation:	Medium
Magnitude of impact:	Medium

(112) Increase profitability through conducting CDM measures

Other than JI projects, CDM projects are conducted in non-Annex-I countries, i.e., primarily in developing countries. Furthermore, projects of afforestation and reforestation ("A/R") may also be verified in favour of individuals, while LULUCF-actions otherwise count on a national level only. However, these are the only two basic differences. Aspects such as baseline and additionality deviate rather moderately. Accordingly, pulp and paper manufacturers face fundamentally the same up- and downsides from CDM projects as from JI projects.

The major upsides are (1) access to cheap emission certificates, (2) easement of speculation with emission certificates, and (3) insights into or even access to foreign markets. Compared to JI, it can be assumed that especially developing countries, respectively partners for CDM projects, offer more emission reductions at very low or even negative costs (e.g., fuel switch). The option of crediting forestry projects may also be valuable, although the usability of the wood growing under these projects as a raw material source for pulping tends to be limited to a few exceptional cases. The time horizon and transportation costs may be prohibitive. Even if the European-based company built a pulp mill close to these forests it might either take 15 years or more until the wood can be harvested or the accruing volumes are negligible compared to the annual consumption of the mill. Thus, synergies with existing business tend to be low or at least limited to exceptions.

The costs and risks also remain basically the same as for JI projects. Scarce capital and management capacity are absorbed. Risks arise from partnering with an unknown company in a foreign country whose legislation may lag behind those of established democracies. Implementation of the project and crediting of the emission reductions or CO_2 sinks are not easier than in JI projects. The risk inherent in knowledge transfer may be subject to a different understanding of intellectual property.

Again, each pulp and paper manufacturer needs to balance the costs and risks against the benefits for each individual CDM project. A general recommendation to engage in CDM cannot be made. Still only very few (if any) pulp and paper producers seem to have invested in CDM. On February 10th 2007, 496 projects had been registered at the UNFCCC office. Almost 48% of the CERs issued originate from the project category "energy industries" and only 0.15% from "afforestation and reforestation" (UNFCCC CDM Executive Board, 2007). Looking at the project titles, none or at least hardly any projects appear to refer to pulp or paper manufacturing.

Range of application:	Multinational pulp and paper manufacturers
Ease of implementation:	Low
Magnitude of impact:	Medium

(113) Increase profitability through integrating into forestry

The third action aimed at profit generation beyond pulp and paper manufacturing is backward-integration into forestry. It can be favourable inform three aspects: (1) as a general investment, (2) to safeguard fibrous raw material supply and (3) to generate emission certificates.

The first aspect, i.e., the general investment into forestry without the aim of capturing synergies with pulp and paper manufacturing will be neglected, although it may be worthwhile against the background of increasing wood prices.

The scarcity of fibrous raw material and the increasing need to extend the potential supplier base to mobilise sufficient volumes at acceptable prices has been discussed extensively under actions (74) and (76). The tighter the supply situation in the wood markets gets, the more beneficial it is for pulp and paper manufacturers to be backward-integrated into forestry. Own forests can provide valuable contributions to safeguarding supply. In action (82) the favourability of interdivisional supplies has been stressed. Even if own forests can not cover the entire wood demand, they help buffer price volatility in purchasing.

The third aspect potentially arguing for own forests are benefits from flexible mechanisms codified in the Kyoto Protocol. However; expectations need to be scaled down in this respect. Other than for nations, individuals can only be credited with emission certificates for CO_2 sinksif the sinks are located in non-Annex 1 countries of the UNFCCC. The Bonn Agreement on the Buenos Aires Plan of Action (United Nations, 2001b) adopted at the COP 6.2 meeting codifies that countries can take some emission reductions and sinks from LULUCF actions into account against their national Kyoto target. For each country, the CO_2 respective carbon volume, which can be rendered as a domestic LULUCF action, has a ceiling. Typically, the ceiling is well below the actual sink effect. Germany, for example, may account for 1.24 Mt C/a, whereas the annual increment of German forests amounts to 8 Mt C/a (Frühwald et al., 2002). Furthermore, a part of the required emission reduction, 1% of the 1990 emission level, can be achieved by the use of Flexible Mechanisms. As noted above, individuals can benefit from forestalling carbon sinks only, if the forests are located in non-Annex 1 countries. There is no promotion of afforestation or reforestation by JI. Thus, forests in Europe do not generate emission certificates for their owners. This is reserved for forests that are a part of CDM projects.

Based on these three aspects, pulp and paper manufacturers can decide to integrate into forestry. While the generation of emission certificates obviously does not play a major role in this decision, the business case will be driven by safeguarding wood supply and the development in wood prices. Similarly as noted looking at JI and CDM above, companies need to balance the benefits versus the costs and risks case by case. A general recommenddation for integration cannot be made.

Range of application: Especially large pulp manufacturers
Ease of implementation: Low
Magnitude of impact: Medium

(114) Increase profitability through investing in electricity generation
The very last action aimed at profit generation beyond pulp and paper manufacturing is related to the strong increase inelectricity prices within the last two years: pulp and paper manufacturers can capture the margins that utility companies earn in generation – not least due to emission trading – by investing in electricity generation. Of course, there are considerable synergies if the generation is embedded in the energy system of a pulp or paper mill. However, even stand-alone power plants without the intention of using electricity and steam in their own mills are conceivable, in particular as biomass-fired power plants. Although pulp and paper manufacturers would increase the scarcity of fibrous raw material at first view, the action can be favourable due to the volume bundling effects described in action (76) and "preferred customer" position outlined in action (81). The manufacturer should try to capture as much as possible of the available fibre, from log at the upper end to forest residues at the lower end, and allocate fibre internally according to paying power. Whether the biomass-fired power plant applies gasification technology (see action (56)) or conventional CFB or BFB boilers should depend on the course and speed of technological development. Theoretically, other fuel types are feasible too. An investment in nuclear power, however, as made by Stora Enso and UPM-Kymmene as major shareholders (besides the utility company Fortum) in the Finnish TVO-Olkiluoto-3 project, tends to be rather exceptional.

Range of application: All pulp and paper manufacturers
Ease of implementation: Low
Magnitude of impact: Medium

As noted at the beginning of the chapter, the number of activities aimed at profit generation beyond pulp and paper manufacturing is theoretically infinitely high. Any financial investment or investment in other business areas could count as such an action. To remain within the focus of the investigation, only the four energy and fibrous raw related actions have been described.

5.2.9 Summary of recommendations to the industry

Chapter 5.2 aims to answer the third key question of this investigation: Which actions can be taken by pulp and paper manufacturers to make the best of the changes in the political and economic environment? In chapters 5.2.1 and 5.2.8, 114 actions have been described addressing the levers shown in Fig. 44 (page 176). These actions are largely exclusive but cannot be exhaustive. They are intentionally limited to the cost categories of energy and raw materials, to pricing, and to selected measures beyond current business. All 114 actions aim at maintaining or re-establishing the profitability of pulp and paper manufacturers against the background of the manufacturing cost increases induced by the introduction of emission trading. An overview of the 114 actions is provided in Fig. 49.

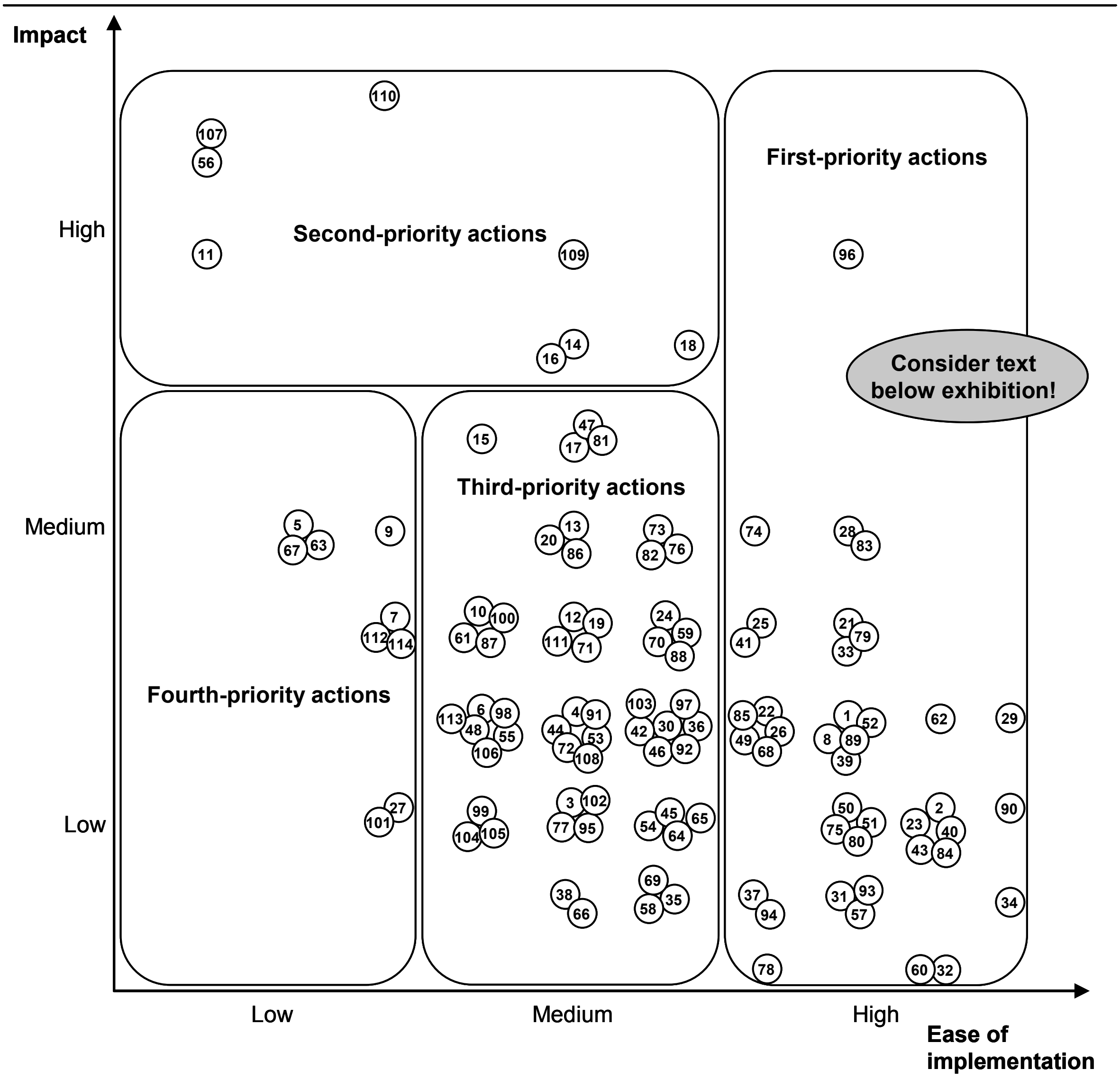


Fig. 49: Overview of potential actions maintaining or re-establishing profitability

Fig. 49 requires the same caveats as noted at the beginning of chapter 5.2: Although assessments of "ease of implementation" (based on aspects such as requirement for investment vs. pure management action, availability of required technology, short-term/operational vs. long-term/strategic) and "impact" (effect on profitability) are based on a ten-point scale, the positioning of an action within the matrix ought to be understood qualitatively not quantitatively. All assessments have been made outside-in and provide orders of magnitude only.

Thus, formally the points in Fig. 49 are areas with certain extensions. In a specific mill, both ease and impact can deviate significantly from this assessment. Furthermore, not all 114 actions can be applicable to every specific mill. A first indication is given in the assessment of "range of application", but a thorough check needs to be carried out case by case. Qualitative appraisal of "range of application", "ease of implementation" and "impact" are intended as starting points for company- or mill-internal discussions, which actions are applicable in the given situation, how they can be implemented, and at what costs and benefits in the specific case. The 114 actions are clustered into four categories which ought to be treated differently.

"First-priority actions"

Due to the presence of the profitability threat evoked by the introduction of emission trading, the 40 actions with high ease of implementation deserve the highest priority. Most of them rapidly provide valuable contributions to profitability, some rather prevent additional cost increases. Though the impact of many of these "quick-win" actions is moderate only, there are at least eight actions with medium and one with even high impact. This "very-first" priority measure is pricing described under action (96).

(1) Save fuel costs through reducing consumpt. of steam and direct heat automating monitoring, controlling and steering
(2) Save fuel costs through reducing consumptions of steam and direct heat regularly maintaining equipment
(8) Save fuel costs through using state-of-the-art technology at causticising
(21) Save fuel costs through increasing primary steam yield automating monitoring, controlling and steering
(22) Save fuel costs through increasing primary steam yield minimising energy of exhaust gases
(23) Save fuel costs through increasing primary steam yield regularly maintaining equipment
(25) Save fuel costs through increasing primary steam yield increasing dry solids content of burned bark
(26) Save fuel costs through increasing primary steam yield increasing dry solids content of burned sludge
(28) Save fuel costs through using low-cost internal fuel by-products
(29) Save fuel costs through regularly conducting requests for quotation
(31) Save fuel costs through using timing effects
(32) Reduce fuel cost risk through hedging purchases
(33) Save fuel costs through changing fuel mix
(34) Save fuel costs through reducing fuel specifications
(37) Save costs of emission trading through indicating direct effects
(39) Save electricity costs through automating monitoring, controlling and steering
(40) Save electricity costs through regularly maintaining equipment
(41) Save electricity costs through properly sizing the equipment
(43) Save electricity costs through adapting efforts to requirements
(49) Save electricity costs through using state-of-the-art technology in the forming section
(50) Save electricity costs through using state-of-the-art technology in the wire section
(51) Save electricity costs through using state-of-the-art technology at lighting
(52) Save electricity costs through incr. el. yield at intern. generat. properly monitoring, controlling and steering turbines
(57) Save electricity costs through regularly conducting requests for quotation or purchasing electricity at exchange
(60) Reduce electricity price risk through hedging purchases
(62) Save electricity costs through avoiding consumption of balancing power
(68) Save steam costs through leveraging negotiation power in purchases
(74) Save fibre costs through extending potential supplier base
(75) Save fibre costs through regularly conducting requests for quotation
(78) Reduce fibre cost risk through hedging purchases
(79) Save fibre costs through changing fibre mix
(80) Save fibre costs through reducing fibre specifications
(83) Save fibre costs through indicating indirect effects of political instruments
(84) Save chemicals costs through adapting efforts to requirements at bleaching
(85) Save chemicals costs through extending delignification prior to bleaching
(89) Save chemicals costs through extending potential supplier base
(90) Save chemicals costs through regularly conducting requests for quotation
(93) Save chemicals costs through reducing chemicals specifications
(94) Save chemicals costs through reducing inventories
(96) Increase sales prices through establishing acquisitive potential and differentiating prices

"Second-priority actions"

All those actions which are characterised by high impact but only medium or low ease of implementation are second priority. This refers to eight actions illustrated in Fig. 49. Each four of them have medium and low ease. Although implementation of these actions requires significant efforts and may even take some years, the actions are worth launching. Participation in the growth of emerging markets (action (110)) can be highlighted as the action with presumably the highest impact. The follow-ups are black liquor gasification as a feedstock for a bio-refinery (action (107)) and for electricity generation (action (56)).

(11) Save fuel costs through reducing cons. of steam and direct heat using advanced technology in the forming section
(14) Save fuel costs through reducing cons. of steam and direct heat using advanced technology in the press section
(16) Save fuel costs through reducing consumption of steam and direct heat integrating pulp and paper manufacturing
(18) Save fuel costs through increasing heat recovery at mechanical pulping
(56) Save electricity costs through increasing electricity yield at internal generation using black liquor gasification
(107) Increase profitability through using syngas from black liquor and bark gasification as feedstock for bio-refinery
(109) Increase profitability through adapting product mix
(110) Increase profitability through acting on emerging markets

"Third-priority actions"

All actions with medium ease of implementation and medium or low impact are of third priority. With 56 actions, this is the largest cluster, comprising 22 actions, which are presumed to have medium impact, and 34 actions with lower impact. Although these actions are not first or second priority, companies may be urged to implement them, especially, if first-priority actions do not contribute enough to remain profitable and second-priority actions need time to take effect.

(3) Save fuel costs through reducing consumption of steam and direct heat minimising production interruptions
(4) Save fuel costs through reducing consumption of steam and direct heat improving insulation
(6) Save fuel costs through reducing consumption of steam using state-of-the-art technology at washing
(10) Save fuel costs through reducing consumption of steam using advanced technology at pulp drying
(12) Save fuel costs through reducing cons. of steam and direct heat using state-of-the-art technology in the wire section
(13) Save fuel costs through reducing cons. of steam and direct heat using state-of-the-art techn. in the press section
(15) Save fuel costs through reducing cons. of steam and direct heat using advanced technology in the drying section
(17) Save fuel costs through reducing consumption of steam and direct heat reducing water consumption
(19) Save fuel costs through increasing heat recovery at chemical pulping
(20) Save fuel costs through increasing heat recovery at paper making
(24) Save fuel costs through increasing primary steam yield increasing dry solids content of burned black liquor
(30) Save fuel costs through bundling volumes
(35) Save fuel costs through reducing inventories
(36) Save fuel costs through optimising interdivisional flows
(38) Save costs of energy/emission taxation on fuels through indicating overlap with emission trading
(42) Save electricity costs through optimising consistencies in each process step
(44) Save electricity costs through using state-of-the-art technology at debarking
(45) Save electricity costs through using state-of-the-art technology at chip transport
(46) Save el. costs through using state-of-the-art techn. at mechanical pulping (grinder and refiner design and materials)
(47) Save el. costs through using state-of-the-art technology at mechanical pulping (grinding and refining conditions)
(48) Save electricity costs through using advanced technology at mechanical pulping
(53) Save electricity costs through increasing el. yield at internal generation maximising enthalpy of generated steam
(54) Save electricity costs through increasing electricity yield at internal generation using external superheating
(55) Save electricity costs through increasing electricity yield at internal generation using advanced boiler materials
(58) Save electricity costs through bundling volumes
(59) Save electricity costs through using timing effects
(61) Save electricity costs through switching grid level
(64) Save costs and generate profits from RES legislation
(65) Save costs and generate profits from CHP legislation

(66) Save costs of energy/emission taxation on electricity through indicating overlap with emission trading
(69) Save costs through properly managing administrative requirements of emission trading
(70) Save fibre costs through using state-of-the-art screening technology prior to cooking
(71) Save fibre costs through using state-of-the-art technology at fibre screening of mechanical pulping
(72) Save fibre costs through improving white water filtration
(73) Save fibre costs through increasing share of fillers
(76) Save fibre costs through bundling volumes
(77) Save fibre costs through using timing effects
(81) Save fibre costs through controlling fibre chain
(82) Save fibre costs through optimising interdivisional flows
(86) Save chemicals costs through using state-of-the-art technology at bleaching
(87) Save chemicals costs through using advanced technology at bleaching
(88) Save chemicals costs through improving retention in the wire section
(91) Save chemicals costs through bundling volumes
(92) Save chemicals costs through changing chemicals mix
(95) Save chemicals costs through reducing joint costs with suppliers
(97) Increase profitability through producing pellets and briquettes
(98) Increase profitability through producing ethanol fermenting bark
(99) Increase profitability through extracting suberin from bark
(100) Increase profitability through extracting hemicelluloses and lignin from chips
(102) Increase profitability through extracting glucomannans from TMP white water
(103) Increase profitability through extracting turpentine, tall oil and methanol from black liquor
(104) Increase profitability through extracting xylan from black liquor
(105) Increase profitability through extracting soaps from black liquor
(106) Increase profitability through precipitating lignin from black liquor
(108) Increase profitability through producing PCC on-site
(111) Increase profitability through conducting JI measures

"Fourth-priority actions"

Ten actions, finally, are of fourth priority. All of them are comparably difficult to implement. Eight of them are assessed as having medium impact, two even low impact. Accordingly, most companies will hesitate to approach these actions. For some actions, pulp and paper manufacturers may just wait until others have increased the ease of implementation and then jump on the bandwagon. An example could be the introduction of advanced causticising (action (9)). As soon as it has reached commercial applicability, it will be implemented, first in greenfield mills than at retrofits of existing mills.

(5) Save fuel costs through reducing consumption of steam using advanced technology at cooking
(7) Save fuel costs through reducing consumption of steam using state-of-the-art technology at bleaching
(9) Save fuel costs through using advanced technology at causticising
(27) Save fuel costs through increasing heat yield of fuels using direct heating instead of indirect heating
(63) Increase profitability through supplying balancing power
(67) Save costs of emission trading through indicating indirect effects
(101) Increase profitability through extracting lignans from softwood knots
(112) Increase profitability through conducting CDM measures
(113) Increase profitability through integrating into forestry
(114) Increase profitability through investing in electricity generation

Although only a proportion of the 114 actions described will be applicable to any individual mill or company, the actions provide valuable contributions to maintaining or re-establishing the profitability of pulp and paper manufacturers. The companies need to select the measures applicable to the individual case and reassess the ease of implementation (availability of technology, investment, duration of implementation etc.) and impact based on the specific conditions. Typically, even the implementation of only five to fifteen actions, with different ease and impact, will be sufficient to remain or become profitable. However, wherever more resources (management capacity, funds) are available, more actions ought to be implemented to increase profitability.

5.3 Recommendations II – what politicians should do

The direct and indirect effects of emission trading on the pulp and paper industry in Europe have been quantified thoroughly in chapters 4.2.2.4, 4.2.2.5 and 4.2.2.6. The key findings are summarised for different pulping and paper making processes in Tab. 5, Tab. 6 and Tab. 7 (pages 144-146). It becomes obvious that the direct out-of-pocket effect, i.e., the direct effect lessened by the opportunity value of the allowances received for free, is by far less threatening for the competitiveness of pulp and paper manufacturing in Europe than the indirect effects. Especially the increase in electricity prices, largely a result of the actual design of the European ETS, and the increase in fibre prices, influenced by emission trading and RES promotion schemes, put serious pressure on the profitability of pulp and paper manufacturing. It can be assumed that the direct effect was intended, while the indirect effect was either not foreseen or foreseen but accepted. However, facing the partially hectic reactions to developments as logical results of the actual design of the EU ETS and respective national allocation plans, the latter, i.e., the knowing toleration of severe side effects, appears unlikely. Obviously not enough analytical expertise from economists has been obtained or lobbyists have influenced decisions.

In order to reduce malfunctions for the second and following phases of the European emission trading scheme from 2008 onwards, some recommendations will be given to politicians dealing with energy and the respective environmental politics on a European or national level. The recommendations refer to the design of an emission trading scheme, to energy and emission taxes, to RES and CHP policies, and to the liberalisation of electricity markets.

5.3.1 Legislation on emission trading

Important aspects in the design of emission trading schemes have been introduced in chapter 2.1.1.2 and summarised in Fig. 6 (page 17). One of the most fundamental decisions is the one on the allocation mode for the existing emission allowances, but details of other aspects can also be crucial for the efficiency of an emission trading scheme.

When politicians designed the EU emission trading scheme and subsequent national legislation with national allocation plans in 2003 and 2004, some experience with emission trading schemes was available from certain countries and companies (see chapter 2.1.1.3), but in several aspects they broke new ground. Accordingly, the first phase of the EU ETS was intended as a test phase prior to the global emission trading scheme in the course of the Kyoto Protocol. Against this background, a short test period and the furthest possible safeguarding of degrees of freedom for the design of the scheme for future periods was appropriate. On the other hand, political instruments need to provide companies with a long-term planning horizon if the companies are to adapt their investment decisions to the instruments. The longer the perspective provided, the better companies can react with innovative processes or technologies. Against this background, in turn, a clear predefinition of the design of the emission trading scheme for future phases was appropriate. As a compromise, politicians on a European level adopted EU Directive 2003/87/EC[1] which determines most aspects of the design until 2012, the end of the phase II (see chapter 2.1.2.2). The obviously most crucial decision was the granting of prevalence to grandfathering and benchmarking over auctioning as allocation mode. For phase I, member states could decide to auction up to 5% of their allowances, for phase II the ceiling is 10%. As displayed in Tab. 1 (page 47), only very few countries have used this option in the first national allocation plans.

For European pulp and paper manufacturers, the assessment of the design of EU ETS and subsequent national legislation is sobering. As noted above, the intended direct effect is minor and hardly influences strategic decision making on energy-related aspects (see chapter 4.2.3), while the (presumably unintended) indirect effects seriously endanger the international competitiveness of European producers. The electricity and wood price increases are the most threatening, both not solely but significantly influenced by emission trading.

The electricity price development discussed in chapter 2.1.3.2 and illustrated in Fig. 35 (page 77) is a result of two factors. Increasing fuels costs and the introduction of emission trading in its existing design. The general mechanics behind electricity price setting and the effect of emission trading have been described in chapter 2.1.2.4 in the context of CO_2 prices. The existing design of the EU ETS allows utility companies to reason the electricity price increase in two ways. In the case of scare allocation, they need to purchase the marginal allowance. Its costs increase the short term variable costs for the marginal MWh of the marginal power plant in the merit order and thus the electricity price. RWE's CEO Roels used this argument for the UK power market (Anon., 2005c). The reasoning in the case of long allocation is different. In this case, utility companies argue using the opportunity costs of the marginal allowance. Such costs arise if an emission allowance is employed covering emissions from generating the marginal MWh but could be used alternatively (e.g., sold) if it were not employed. This is irrespective if allocation was free (grandfathering or benchmarking) or not (auctioning). As none of the national legislation on emission trading reduces the allocation ex-post, if the production of the installation is reduced by a marginal unit only, the option of using the allowance alternatively exists. Accordingly, many utility companies use this argument of opportunity costs as a reason for the price increase (RWE, 2007). For concerns referring to this argumentation, see again chapter 2.1.2.4. Although the German Federal Cartel Office has

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Parliament and Council of the European Union, 2003c)

investigated electricity pricing against the background of emission trading and made a "preliminary evaluation" with exemplary character that RWE abused its market-dominating position within its control area in 2005 charging industrial customers too high electricity prices, the entire disappearance of pricing in the value of the marginal allowance cannot be expected under the current design of the EU ETS and subsequent national legislation. Even the Federal Cartel Office has accepted a threshold of 25% of the value of the marginal allowance (Bundeskartellamt of the Federal Republic of Germany, 2006).

Looking at the wood price increase, emission trading is one factor amongst others (globally increasing prices of fossil fuels and RES promotion) for the development described in chapter 2.1.3.2 and shown in Fig. 34 (page 74). The mechanism behind this is the unlocking of emission allowances by switching from fossil fuels to bio-fuels. The unlocked allowances increase purchasing power for the fibrous raw materials. In both cases – electricity and wood – an exact determination of what share of the price increase originates from emission trading and what share from other factors is difficult. Estimates can be found in chapter 4.2.2.3 describing the scenarios used for modelling.

These two indirect effects of emission trading on pulp and paper manufacturers beg the question of how the design of the EU ETS needs to be modified to avoid such unintended side effects. Looking at the fibre price issue first, the problem cannot be solved by changing the design of the emission trading scheme. Production, i.e., in this case generation of electricity, remains unchanged, while the fuel mix is changed. No emission trading scheme would prohibit such an action, as fuel mix change towards cleaner fuels is one of the intended levers of emission trading. Accordingly, politicians may approach the other drivers for the fibre price increase if they prefer physical over thermal use. The two instruments to hand are energy taxes and RES promotion (see below). Thus, only the electricity price increase as a side effect of the existing emission trading scheme can be approached.

All economists in the field, but probably not all lobbyists, agree that auctioning 100% of the allowances is the best allocation principle. However, as noted above, EU Directive 2003/87/EC excludes this option until 2012. Member states could auction up to 5% of their allowances for phase I and up to 10% for phase II. Thus, first a reduction in the malfunction under the given circumstances (prevalence of grandfathering and benchmarking) will be sketched.

As long as the vast majority of the allowances needs to be allocated for free, it is very difficult to prevent utility companies from pricing in a value of the marginal allowance. The problem are the two opposing reasonings outlined above for short and long allocation. Only if every single power plant which could become a marginal power plant at any point of time received a long allocation (preventing the first argument) and any marginal production reduction inevitably resulted in ex-post correction of the allocation, pricing in a value for the marginal allowance could be prevented. However, this theoretically feasible way of prohibiting an emission-trading-induced electricity price increase while still leaving utility companies an incentive to reduce emissions should be checked thoroughly by capable independent economists to avoid any "escape through the back door". Here, almost any effort spent pays off against the background of windfall profits which have been calculated as 5.7 billion EUR for 2005 and are expected to be 10.6, respectively 10.3 billion EUR, for 2007 and 2008 (Schlemmermeier and Schwintowski, 2006). The discussed reduction of the compliance factor for energy installations under grandfathering allocation mode (the current version of the second German national allocation plan intends to apply a 15% reduction) neither limits the electricity price increase nor generates funds for public budgets. In the case of a largely unchanged total amount of available emission allowances, it only redistributes resources slightly from utility companies to industrial participants in the emission trading scheme. However, the effect is minor and the plan not favourable compared to the approach outlined above. Another "second-best solution" is the plan to tax away windfall profits as currently discussed in Sweden and Finland. On the one hand, it would raise significant funds which could be returned to consumers of electricity from the grid as a kind of "flat negative electricity tax" or used for climate protection or national budgets. On the other hand, it is very doubtful on what legal justification such a tax could be introduced. Although most countries have chosen grandfathering as a primary allocation principle (see Tab. 1 on page 47), all the afore-mentioned applies to a benchmark base allocation to the same degree. The only additional comment in this respect is that benchmarks for power plants do not need to differentiate lignite and hard coal firing, as currently discussed. Even if lignite-fired power plants received emission allowances sufficient for hard-coal-fired power plants, no further increase in electricity prices ought to be expected. At basically no point of time lignite-fired power plants are the marginal power plants in the merit order.

As noted before, the outlined approach of preventing utility companies pricing in costs of marginal allowances at a grandfathering or benchmark based allocation mode is a workaround only until 2012. Afterwards, all allowances should be auctioned within the entire EU. This allocation principle has major advantages over the current one, which almost invites abuse or more correctly "unintended use of intended exceptions". Auctioning is easy to handle compared to the current allocation mode comprising numerous exceptions (early action bonus, closures, new entrants etc.) introduced by lobbyists. It provides the maximum emission savings incentive and, finally, avoids the appearance of windfall profits. However, the last aspect requires some attention. Auctioning does not prevent an electricity price increase. Utility companies need to purchase the marginal allowance as all other allowances before. Thus, the electricity price will reflect the full costs of the marginal allowance. This raises two questions: (1) will the costs of the marginal allowance, i.e., the market price of allowances, be higher or lower than today? (2) What happens to the funds raised by the governments from auctioning the allowances? The first question is somewhat difficult to answer, but there is some indication that the market price of allowances will be lower than under the current scheme. No participant is long of allowances, every participant needs to buy allowances and, thus, every participant has an interest in low prices (also utility companies). Only pure speculators can benefit from high prices. For the second question, in turn, there is no compelling answer. The use of generated funds can be decided by governments. As noted above looking at taxing away windfall profits, funds could be returned to consumers of electricity from the grid as a kind of "negative electricity tax" or used for climate protection or national budgets. If funds were used for a "negative electricity tax", the resulting electricity prices would probably end up only slightly above the level they were without emission trading. A pure reduction in existing energy taxes on electricity, in turn, would not have the same effect, as industrial customers usually benefit from a gap between nominal energy taxes and effective energy taxes (see chapter 4.2.3). A use aimed at climate protection could be the active subsidisation of emission savings technology. Promotion of RES and CHP could be financed with these funds instead of fees or markups on the electricity price (see Fig. 43 on page 167). However, compliance with EU legislation on subsidisation needs to be safeguarded. One final consideration on auctioning appears required: any auctioning of significantly less than 100% of the allowances bears a high risk for the allowance price. If only 10% or even 5% of the allowances were auctioned, a few players could bid very high prices. Utility companies might actively push CO_2 prices in these auctions aiming at high electricity prices. Whereas similar activities could already be assumed today (see the inquiry of Germany's former Federal Minister for the Environment Jürgen Trittin to RWE (Gammelin and Hecking, 2005)), a justification for electricity price increases would be served "on a silver platter" in the case of limited auctions.

5.3.2 Legislation on energy and emission taxes

The interference between emission trading and other instruments of environmental politics have been described in chapter 2.1.1.5. Against the background of anyway low real energy or emission taxation of energy intensive industries in Europe (see chapter 4.2.3), to exempt all industries subject to emission trading from energy or emission taxation should be considered. This proposal is supported by numerous economists such as e.g., Wackerbauer (2003). Others, such as e.g., Rehbinder and Schmalholz (2002) regard this exemption as critical. They raise the issue of disturbed competition due to unjust subsidisation in the form of exemption from energy taxation.

A second aspect is the differentiation between emission taxes and energy taxes. While the first directly use pollution as a tax basis, the latter penalise a preliminary stage that may result in pollution. The differentiation is irrelevant if the tax is levied just to raise funds for public budgets without any ecological intention such as VAT. However, if environmental governance is intended, emission taxation prevails over energy taxation. Whereas the first is efficient in any case as outlined in chapter 2.1.1.4, the latter may be efficient rather by chance, i.e., if the tax rates for the different fuels exactly represent the pollution arising from combustion of those fuels. In almost no country is this the case. Thus, emission taxation, although more difficult to implement, is economically favourable compared to energy taxation.

The third aspect is directly connected to the second. Electricity generated from renewable energy sources (RES) ought to be exempted from energy taxation. It would be counter-productive to penalise the politically intended use of renewable energy sources which can be combusted without any (fossil) emission. There is no reason to promote RES with specific instruments (see chapter 4.2.3, especially Fig. 42 on page 164 and Tab. 8 on page 168) and tax the electricity generated from renewable energy sources at the same time. This conflicting incentivation would only make some sense if energy taxes were levied without any ecological intention but just to raising funds for public budgets.

Finally, a fourth aspect is the consideration of reducing energy or emission taxes on fossil fuels to reduce the competition between the physical and thermal use of fibre. However, this consideration is surely theoretical. Furthermore, the effect on fibre (wood and potentially waste paper) prices would be very low, if visible at all, while the governing effect on fossil fuels would disappear.

5.3.3 Legislation on promotion of RES and CHP

The promotion of electricity generation from renewable energy sources (RES) and partially also of combined heat and power generation (CHP) affects the European pulp and paper industry in two ways. On the one hand, they are consumers and in many cases also generators of electricity. On the other hand, they are competing for fibre with thermal users benefiting from RES promotion.

From the energy perspective, most pulp and paper producers benefit from RES and CHP legislation. Fig. 42 (page 164) provides an overview of energy costs of the mills investigated. Fees for RES and CHP account for 2.3% of total energy costs[1], while the income from RES and CHP amounts to 8.9%[2]. Nevertheless, the legislation could be improved in some countries in favour of pulp and paper manufacturers. Primarily, the subsidy should be granted irrespective if the electricity is sold to the public grid or consumed internally. The CO_2 saving for the environment is unaffected, wherever the generated electricity is consumed. The load

[1] In some countries, RES and CHP promotion are not financed by (visible) fees but by an (invisible) markup on electricity prices or green certificates required by utility companies. As these invisible fees could not be surveyed, the actual percentage is slightly above 2.3%, and probably still well below 4%.

[2] The average of 8.9% includes one mill located in the Czech Republic earning a high green bonus from RES promotion. If this mill is excluded, the average would decrease to about 6%.

relief of public grids should be a welcome advantage of de-central generation. Another example is the combustion of sludge accruing at paper recovery. In some countries, it is prohibited (e.g., Poland), in others it is allowed but not promoted as RES (e.g., Germany). Partially the legislation differs considerably between countries (see Tab. 8 on page 168 for RES and Tab. 9 on page 169 for CHP).

From the fibre perspective, RES promotion is a threat for the pulp and paper industry. Thermal use of fibrous raw material (wood and recovered paper) competes with physical use. Not all of the wood price increase shown in Fig. 34 (page 74) can be traced to thermal use, promoted by high fossil fuel prices, energy taxes on fossil fuels, emission trading, and RES promotion. But at least a significant share of the price increase tends to originate from the competition between thermal and physical use. Whereas the effect is somewhat limited as far as small-scale dedicated biomass-fired power plants are concerned, a tremendous threat arises from co-firing in lignite- or hard-coal-fired power plants of utility companies. A discussion of the potential fibre price increase can be found in chapter 4.2.2.3. Accordingly, one thing is crucial to safeguard the fibre for physical use in pulp production and bio-refineries: co-firing of physically usable fibrous raw material (wood and recovered paper) in non-biomass dedicated power plants must not be promoted as RES. Moreover, the current self-commitment of the European pulp and paper industry to ensure a recycling rate of paper and board products of at least 66% by 2010, starting from 55.4% in 2005 (CEPI and ERPA, 2006) needs to be properly observed. [1] If the rate should fall below commitment and significant amounts of recoverable paper were burned in waste incineration power plants, the authorities should take action promoting physical use respectively banning thermal use. It needs to be stressed that physical use of fibre for pulping or as feedstock for a bio-refinery creates more economic value than the (un-refined) thermal use.

5.3.4 Legislation on electricity markets

The legislation on electricity markets and their liberalisation does not directly interfere with the legislation on emission trading. Furthermore, the current electricity pricing scheme and with it the price increase originating from the costs of a marginal allowance is rather a result of an almost inelastic demand for an unstorable product than of concentration of generators or a still often bundled generation and transmission grid operation. Nevertheless, the current structures of electricity markets in Europe can be regarded as aiding or even enabling some of

[1] The self-commitment obliges the industry not to make extensive use to the degrees of freedom the EU Directive 2001/77/EC (European Parliament and Council of the European Union, 2001) allows. Its definition of biomass, whose combustion is promoted, implicitly includes also recovered paper, whereas some subsidiary national legislations, in turn, explicitly exclude recovered paper (e.g. German Biomass Regulation (Biomasseverordnung, (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2001))). – In case of a full switch-over in the European waste treatment strategies from prevalence of physical to the prevalence of thermal utilisation the prices of recovered paper would increase significantly.

the above-mentioned developments such as the electricity price increase and the limitation in supplying balancing power (see recommendation (63) on page 221 made to pulp and paper manufacturers). Another aspect are grid fees charged by the transmission system operator which regularly initiate cartel offices to investigate abuse of natural monopolies. Accordingly, electricity market structures deserve some attention.

All member states of the EU started liberalising their national electricity markets since late 1990s. The degree of liberalisation and success, measured in the reliability of the electricity supply and the development of electricity costs for consumers, differs significantly between the countries. In many countries, the transition from national monopolists with regulated prices to oligopolists with ex-post abuse control has not caused sustainable price decreases for customers. In order to safeguard the achievement of the above-mentioned objectives, a reliable and affordable electricity supply, the EU has adopted Directive 2003/54/EC[1]. A core aspect is Article 10 requiring the unbundling of "transmission system operator" from other parts "of a vertically integrated undertaking" in terms of a legal form, organisation, and decision making. It accepts that electricity grids are natural monopolies inviting abuse, i.e., in this case discrimination of power generators. However, there is no requirement in the Directive "to separate the ownership of assets of the transmission system from the vertically integrated undertaking". It only defines some minimum criteria to ensure the independence of the transmission system operator.

Whereas the unbundling of generation and transmission system operation may solve the problem of discriminatory access of power generators, at least if countries – going beyond Directive 2003/54/EC – required the entire separation of transmission system operation from any other activities, it would not solve the other issues arising from natural monopolies. Irrespective if transmission system operators are is the owners and operators or just operators of the grid, they have interests which deviate from the consumer's or government's interests. They strive for the maximisation of profits arising from the difference between the grid fees and the costs of maintaining and expanding grid and interconnections with other grids. Thus, they tend to invest significantly less than they charge as fees. Consumers and governments, in turn, are interested in a well maintained and potentially expanded grid with interconnections to other grids at minimal fees. This divergence of interests cannot be solved by unbundling. Grid operation will still invite abuse of the monopolistic position. Though practiced in many European countries, ex-post abuse control is of rather limited efficiency. Lawsuits oftentimes take two or more years and penalties have hardly exemplary character. A slightly better but still "second-best" solution is the definition of profitability (measured as return on investment)

[1] Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC (European Parliament and Council of the European Union, 2003a)

for a grid operator, as practiced in Austria. Transmission system operators have to prove fees and investments to the regulator.

The best solution for the operation of transmission systems arises if they are considered as club goods, a term introduced to economic theory by Tiebout (1956) and Buchanan (1965). Club goods are characterised by excludability (other than public goods) and non-rivalry (or partial non-rivalry depending on the congestion). The club is a group of individuals deriving mutual benefits from sharing the costs of producing the club good. The members take the voluntary decision to belong to the club anticipating benefits from the collective provision of the membership. Thus, the excludability is the main characteristic. The characteristic of non-rivalry is kept until congestion happens and the utility of any individual is affected by the presence of more members in the club. Accordingly either the club size is limited or the members of the club establish rules to manage any arising rivalry. Hence, this results in the ideal solution for operation of electricity transmission systems. They should be owned by the club they are providing their service to, i.e., by electricity customers or per procurationem by the countries themselves. Electricity customers as principals and authorities as their agents have a high interest in a well-functioning grid and low grid fees. Authorities can take action if congestion emerges. Thus all countries, which have not yet privatised electricity transmission grids, should observe developments in the other countries very thoroughly and weight if privatisation of monopolies is favourable against the background of the consumers' above-mentioned interests. Even those countries, which have privatised electricity transmission systems within the last decade, should consider renationalising them. As noted above, ex-post abuse control has turned out to be an insufficient means to safeguard well-maintained grids at minimal costs. The definition of the profitability of grid operation is also only a suboptimal approach.

5.3.5 Summary of recommendations to politicians

Looking at emission trading and the liberalisation of energy markets but to some degree also at energy and emission taxation as well as at RES and CHP promotion, an unpleasant conclusion needs to be drawn: mistakes have been made in the respective legislation during the last decade that seriously endanger the competitiveness of the European pulp and paper industry compared to non-European producers. If legislation does not change in the aspects detailed in chapter 5.3, some pulp and paper manufacturing processes will presumably withdraw from Europe.

Thus, for future legislative procedures, politicians should involve more analytical expertise from independent economists and become aware of the specific interests of lobbyists, who will continuously reattempt to exert influence on the outcome. Due to the potentially large redistribution effect (see the calculation on windfall profits for German utility companies noted above: 5.7 billion EUR in 2005, 10.6 billion EUR in 2007 (Schlemmermeier and

Schwintowski, 2006)), almost any effort spent on understanding the effects of laws prior to their adoption pays off.

5.4 Outlook – any changes?

An outlook on the energy and emission trading related political and economic environment has been given in chapter 4.2.2.3 defining the scenarios for the modelling with a mid-term perspective. An outlook with a long-term perspective is inevitably slightly more blurred. Nevertheless, some considerations on the key issues – legislation on climate protection, energy markets, and fibre supply – will close the investigation.

Global, European and the EU member states' political instruments aimed at climate protection are relatively well defined until 2012. Most European countries have submitted their national allocation plans for phase II (2008-2012) to the European Commission (see chapter 2.1.2.3). Compared to phase I (2005-2007), changes in emission caps, allocation mode and other aspects will be rather moderate, as the EU Directive 2003/87/EC[1], valid until 2012, allows only limited degrees of freedom. Even the option to include other greenhouse gases besides CO_2 tends to remain unused. As opposed to these moderate changes, the future of climate protection beyond 2012, the last year covered by the Kyoto Protocol, is vague. Though, two assumptions can be made with very high probabilities: (1) emission caps will be significantly lower than today and (2) emission trading will maintain or expand in importance as an instrument of environmental politics.

Scientists and meanwhile also many politicians agree that global emissions of greenhouse gases need to be reduced significantly if climate change is to be diminished. A climate change of less than 2°C compared to pre-industrial levels is not even a political target anymore. It is far beyond reality. Even a limitation to 2°C requires high efforts from industrialised countries as well as from countries in transition to industrialisation, and developing countries. Accordingly, the continued COPs of the UNFCCC are aim to define a route for climate protection beyond 2012, the last year covered by the Kyoto Protocol (see chapter 2.1.2.1). On December 21st 2006, the EU Council adopted an 18-month programme assessing climate change as one of the most important challenges for the future and recommending the EU to take a leading role. The member states are called on to find a balanced and fair solution for climate protection beyond 2012 and to limit the global temperature increase to 2°C compared to the pre-industrial level (Council of the European Union, 2006). In line with the programme for the German EU Council Presidency (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2006b), the Council of EU member states' ministers for environment adopted new ambitious reduction targets for greenhouse gas

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Parliament and Council of the European Union, 2003c)

emissions on February 20th 2007 (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit of the Federal Republic of Germany, 2007). The EU obliges itself to reduce emissions by 20% compared to the 1990 level until 2020 irrespective of pledges made by other nations or groups of nations. Though, if an international post-Kyoto agreement were made, the EU would be willing to contribute with a reduction of even 30%. These targets are much more ambitious than the current commitment for 2010. Currently, EU Council Decision 2002/358/EC (Council of the European Union, 2002) obliges the EU as an entity to a 8% reduction compared to the 1990 level, whereas the burdens are shared differently between the individual member states (Luxembourg -28%, Greece +25%). Thus, the stand-alone obligation means a reduction which is on average 1.5 times higher than the current agreement for 2010 (2008-2012), whereas the obligation valid if an international agreement came into effect meant a reduction of even 2.75 times the current agreement. Again, it can be expected that burdens will be shared disproportionately between member states.

As emission trading has been introduced and established as an instrument of climate politics with considerable efforts during the past few years and numerous statements of environmental politicians in Europe have acclaimed this procedure as successful, it should be expected that emission trading will also continue beyond 2012. Presumably, it will even gain share in the political toolbox alongside energy taxation, RES and CHP promotion, and regulation. The exact design cannot be foreseen, of course. However, there is good reason for some assumptions: the emission cap will be significantly lower than in the first and second trade phase. The boundaries will be extended to other industries (presumably aviation) and gases. The allocation mode will change from grandfathering and benchmarking to auctioning. Joint Implementation and especially Clean Development Mechanisms will gain share to meet the obligations of European countries. These developments will increase the direct as well as the indirect effects on the pulp and paper industry. Auctioning will increase the costs of scarce allowances significantly and keep electricity prices high. Some relief, in turn, could be expected if funds raised from auctioning were recycled in a reasonable way.

Developments on energy markets are flagged with question marks. Any forecast of oil, gas and coal prices beyond 2012 needs to remain somewhat speculative. However, even if new oil and gas fields were found, renewable energies gained share, the efficiency of energy use in industry and households in industrialised countries increased, and environmental politics penalised emission of CO_2 and, thus, put pressure on prices, significant fuel price increases are much more probable than significant decreases. Economic growth in industrialised but especially in transition countries and still developing countries will increase demand. Existing cartels may regain old strengths, respectively new cartels (natural gas) may be founded. Directly, increases in fossil fuel prices mean increasing energy costs for pulp and paper manufacturers, especially for the non-integrated paper mills. Indirectly, the competition for fibrous raw material increases. More and more biomass may be used thermally.

More pressure from the fibre side will arise from all kinds of fuel and chemical production from ligno-cellulose in bio-refineries. However, as noted in chapter 5.2.8.1, bio-refineries also comprise upside potential for pulp and paper manufacturers. Beyond current business, profit can be made from producing and selling fuels and chemicals gained from syngas accruing at black liquor or other gasification. An overview of other by-products obtainable from the pulping fibre chain can be found in Fig. 47 (page 254). Accordingly, threats and opportunities from bio-refinery appear largely balanced for pulp and paper manufacturers. Progressive companies will benefit rather than suffer.

5.5 Critical assessment – has methodology affected the results?

As a last step of the investigation prior to the subsequent summary, a critical assessment of the applied methodology appears to be indicated. Has the methodology used affected the results? To answer this question, the three key questions the investigation was intended to answer and the methodology applied needs to be recapitulated (see chapter 3). The key questions were:

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in political and economic environment?

Methodologically these three questions were approached differently. The first question was investigated mainly empirically, while the second and third question were approached theoretically using the results of the first question and theory from literature. Overall, the investigation can be characterised as inductive generalisation from a multiple case study, i.e., it follows a qualitative research design (see chapter 3.3)

For the first key question, which could be broken down into a "What are the effects…on…?" and a quantification of the single effects, three preliminary hypotheses were formulated, pre-tested, adopted, and subsequently researched empirically in a multiple case study:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters as according to the manufacturing process, level of integration, energy mix etc.
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

The sample of the multiple case study, the term is used although it rather refers to a quantitative investigation, comprised 22 pulp and paper mills in Central Europe and Scandinavia. They account for 7.7% of the primary pulp production, 4.0% of the secondary pulp production (fibre recovery), and 7.1% of paper production in the CEPI countries. However, not only the overall coverage of production backs up a wide generalisability. Additional criteria such as pulp and paper production processes, countries in Eastern and Western Europe, different levels of integration between pulp and paper manufacturing, and even the additional "nice-to-have" criteria, such as e.g., types of boilers and turbines, are also fully represented. Nevertheless, generalisation has been made by replication, as is common for qualitative research, not by statistical evidence as applicable to quantitative investigations (see chapter 3.4).

Each case has been investigated using an open, subject-oriented and semi-structured interview based on a defined interview guide. Questions were answered using oral answers, drawings and the provision of quantitative data in a standardised Excel-based form or as existing reports.

Finally, looking at the operationalisation, the Excel-based form needs to be referred to again. It was used to collect data on fuels and chemicals input, energy, emissions, and manufacturing costs in a standardised and easy-to-analyse way. One major hurdle needed to be overcome in this context. Internal reports of the mills typically regarded the mill as an entity, whereas the investigation required separated data for pulp, paper and, in some cases, other manufacturing processes. Central functions needed to be allocated to different manufacturing processes.

Although good care has been taken in each of the methodical aspects – the formulation of questions and hypotheses, pre-testing, research design, sample, research methods, and operationalisation – to consider all the respective quality measures (see Mayring (2002) for social research in general and Yin (2003b) for case study research), five concerns may be raised when looking at the methodology of the investigation:

- Sample limited to certain countries and processes
- Quantitative data not entirely accessible
- Allocation of data to manufacturing processes requires judgement
- Generalisation requiring different degrees of induction
- Actions outlined with limited details

Although the sample comprises 22 mills in nine countries in Eastern and Western Europe and covers each more than 7% of primary pulp and paper production and 4% of fibre recovery in CEPI countries, it has some "white spots". France, Italy, and the UK as the third to sixth biggest paper producers, Spain and Portugal as significant producers of chemical pulp, and Norway rank three in mechanical pulp production are not covered (see Fig. 22 on page 63 and

Fig. 37 on page 94). Process-wise, white spots are SGW, PGW, and RMP – which are probably excusable as the three processes together account for less than 7% of European pulp production (see Fig. 19 on page 61). These white spots are obviously tolerable. Nevertheless, they imply a slight limitation for the external validity of the investigation (see Yin (2003b))

Another limitation of the external validity arises from the restricted accessibility of certain quantitative data in some mills. Especially cost data, but in a few cases also energy and consumption data, was not made accessible, due to confidentiality reasons. These data gaps resulted in the fact that certain analyses could not be made in these cases. As a result, not all the potential effects of emission trading could be calculated for all the processes investigated. In chapter 4.2, the respective gaps or numbers of cases to which certain results refer have been highlighted.

Other than both aforementioned, the third concern causes a limitation of construct validity (Yin, 2003b). The problem of allocating central functions to the investigated pulp and paper manufacturing processes has been discussed in detail in chapter 3.6. Due to the different perspectives between the process-centred view in the investigation and the mill-centred view in many available reporting systems, the allocations require some judgement even if they are based on defined allocations principles. The problem has been foreseen but was inevitable.

The fourth concern refers to the generalisation. Other than in quantitative research where statistical evidence is used for generalisation, qualitative research and especially case studies use the – regrettably less tangible – replication approach, i.e., the continued testing of a theory case by case and method by method. In the investigation, the generalisation required "different degrees of induction". Whereas for most processes, inductive generalisation was based on a few investigated mills, a higher degree of induction was necessary for the three mechanical pulping processes (SGW, PGW, RMP), which were not part of the sample. Here results needed to be induced from the findings made for TMP and CTMP. This is a clear limitation of external validity, although it has been made obvious wherever statements on the mechanical pulp grade were made and these grades account for less than 7% of European primary pulp production. A similar limitation arises for the regional perspective. Nine countries were investigated but findings should be largely applicable for entire Europe.

The final concern refers to the limited detailing of the 114 actions outlined aimed at maintaining or re-establishing the profitability of pulp and paper manufacturers in Europe. The detail level is definitely a compromise between width and depth. All the actions should be described to a degree that the reader can make at least a first assessment of applicability for specific mill conditions, ease of implementation, and impact. However, it would completely exceed the scope of the investigation to detail actions to a degree of being "ready to implement". The necessity for a compromise was foreseen and the existing level of detailing chosen intentionally.

Although all five above-mentioned concerns are valid, they limit the objectivity, reliability, and validity of the investigation only marginally. It cannot be assumed that a different methodology would have revealed findings significantly deviating from the results, implications, and recommendations given based on the methodology applied. Diekmann answers critics as follows (Diekmann, 2003, p. 18, translated):

> *"If it is the objective of social sciences to solve scientific (especially in basic research) or practical problems (especially in applied research), normally the methods should not determine the problem, but conversely the problem the choice of methods."*

Whereas the first and second key question have been answered completely, the third question asking for recommendations to pulp and paper manufacturers on how to cope with changes in the political and economic environment provides practically unlimited space for continued in-depth research. Some of the remaining questions have a rather economic character (e.g., pricing and purchasing), while others require research into technical developments (e.g., black liquor gasification aimed at electricity generation or as feedstock for bio-refinery).

6. Summary – meet the challenge

The existing investigation on the effects of emission trading on the pulp and paper industry in Europe was initiated in 2004, one year ahead of the actual start of the European emission trading scheme. Its objective was to give detailed and reliable answers to the following three key questions (see chapters 2.3 and 3.1):

- What is the effect of emission trading on the manufacturing costs of pulp and paper?
- What implications does the effect on manufacturing costs have for the profitability and competitiveness of the affected companies?
- Which actions can be taken by pulp and paper manufacturers to make the best of the changes in political and economic environment?

The scope was set to all commercial relevant manufacturing processes, principally all countries within the meanwhile formed EU 27 and the time period 2005-2012. The temporal boundary originates from the horizon of global and European-wide treaties and legislation on climate protection which have only been defined until 2012. High uncertainty for the time post-2012 argued for limiting modelling to the defined period. However, in chapter 5.4 an outlook is given for the time after this.

Emission trading is only one amongst several instruments environmental politicians have at their disposal to counteract climate change (see chapter 2.1.1). The set ranges from encouraging voluntary actions to compulsory command-and-control legislation. Regulation, subsidisation, taxation and labelling are well-known. Emission trading goes back to Pigou (1920), was rediscovered by Coase and Dales in the 1960s, and found its first applications in the 1990s in the USA. Equally to emission taxation but different to all other instruments, emission trading is characterised by economic efficiency. A defined emission reduction is achieved at the lowest possible costs.

The introduction of emission trading in the EU and its member states followed global discussions on climate change and protection of more than 20 years. On the global level, the cornerstones were the adoption of the United Nations Framework Convention on Climate Change in Rio de Janeiro 1992 and the adoption of the Kyoto Protocol 1997. On a European level, it took another five years until the EU Parliament and Council adopted Directive 2003/87/EC which is the fundament of the actual emission trading scheme in Europe and the link between national obligations reducing greenhouse gas emissions and individual emission reduction measures. The Directive defines two phases for emission trading in Europe. The first one, reaching from 2005 to 2007, was intended as pre-phase to the global emission trading scheme introduced by the Kyoto Protocol. The second phase, reaching from 2008 to 2012, corresponds to the period defined in the Kyoto Protocol. After adoption of EU Directive

2003/87/EC and supportive acts, the member states implemented the European legislation into national legislation. Key elements are the national allocations plans, which have been notified to and approved by the EU for the first phase, respectively are currently in process for the second phase (see chapters 2.1.2.2 and 2.1.2.3).

Meanwhile, the market for EU emission allowances has been in place for more than two years. During that time, it has undergone considerable development. At initially moderate trade, volume prices increased from below 7 EUR/t CO_2 mid January 2005 to over 29 EUR/t CO_2 mid July. A correction by about 10 EUR/t CO_2 was followed by a fairly horizontal price development until spring 2006. An all-time high was reached on April 19th 2006 with about 32 EUR/t CO_2. After publication of national 2005 emission reports, prices dropped by about two thirds within a week, recovered slightly, and floated within a range of 15-20 EUR/t CO_2 until November 2006. Afterwards, phase II allowances remained fairly stable having quoted at 12 EUR/t CO_2 at the end of February 2007. Phase I allowances, in turn, have dropped by more than 90% since the end of November 2006. Holders obviously fear a surplus of allowances over emissions at the end of phase I (see chapter 2.1.2.4).

Against the afore-mentioned developments and the existing status of research, the following three hypotheses appeared probable with respect to the first key question named above:

- There are several direct and indirect effects of emission trading on the manufacturing costs of the pulp and paper industry in Europe
- The magnitude of these effects differs by various parameters as according to the manufacturing process, level of integration, energy mix etc.
- Emission trading is not a stand-alone influencing factor in the operational and strategic decision making of pulp and paper companies but interacts with other recent energy-related developments

The first key question and its respective hypotheses were investigated empirically in a multiple case study, i.e., following a qualitative research design (see chapter 3). The sample, although the term is rather applicable for quantitative investigations, comprised 22 pulp and paper mills in Central (Western and Eastern) Europe and Scandinavia. The mills accounted for 7.7% of the primary pulp production, 4.0% of fibre recovery and 7.1% of paper production in the CEPI countries. Despite this good coverage and representativeness, generalisation has been made by replication, as is common for qualitative research. The mills were investigated in late 2004 and early 2005. The quantitative data gathered (consumptions, supply structures, costs etc.) refer largely to 2004, i.e., the last year prior to the introduction of the European emission trading scheme. The second and third key questions were approached theoretically using results from the first question and theory from literature. Overall, the investigation can be characterised as inductive generalisation from a multiple case study.

The direct and indirect effects of emission trading on the manufacturing costs of pulp and paper have been modelled using three scenarios: a "best case", a "most-likely case", and a "worst case". The cases differ in seven independent scenario variables such as degree of free allocation, price increases in fibrous raw materials, chemicals, and fuels as well as utility companies' abilities to pass on costs of marginal emission allowances required to supply electricity. Details can be found in chapter 4.2.2.3 and Tab. 4 on page 126.

Based on the three above-mentioned scenarios, the direct and indirect effects on the manufacturing costs of the investigated mills have been calculated. Detailed quantifications of direct effects, comprising costs of scarce emission allowances, opportunity costs of allowances received for free, and administrative costs, and indirect effects, originating from price increases in raw materials (fibrous raw material and chemicals) and energy (fuels and electricity), can be found in chapters 4.2.2.4, 4.2.2.5, and 4.2.2.6 for the three scenarios. The direct and indirect effects jointly make up the total gross effect. By deduction of the opportunity value of allowances received for free – the other side of the coin of the respective opportunity costs – the out-of-pocket effect can be calculated. It is the most important indicator for the effect of emission trading on the manufacturing costs as it has direct impact on profitability. Furthermore, it is the basis for all considerations and decisions about passing on a cost increase in the form of a price increase. The severity of the out-of-pocket effect significantly varies with the scenario chosen.

Under the "best-case", scenario the out-of-pocket effect was moderate for pulp as well as for paper manufacturing. The cost increase was typically well below 1.0%, in many cases below 0.5%, in a few cases even negative due to an overallocation of emission allowances.

Under the "most-likely" scenario, the out-of-pocket cost effect was much more severe for most pulping processes and many paper mills, whereas differentiation was required. The key overview of the different processes can be found in Tab. 5-Tab. 7 on pages 144-146. In the six investigated chemical pulp mills, the out-of-pocket effect ranged between 27.99 and 47.65 EUR/t (8.9-19.0% of manufacturing costs). The effect on the mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp lines was in the same order of magnitude. In two investigated CTMP lines, it was 36.91, respectively 39.97 EUR/t (18.3 respectively 18.4% of manufacturing costs). Although no fully analysable data sets existed from TMP and mechanical pulp lines, approximately the same out-of-pocket cost increase could be expected there. In the investigated fibre recovery lines, the out-of-pocket effect was comparably minor (0.48 to 3.72 EUR/t or 0.6-2.0% of manufacturing costs). Finally, looking at paper manufacturing mills needed to be differentiated by their fibre mix. Paper mills depending on primary pulp had to bear higher cost increases than those relying primarily on recovered fibre. The ten mills using significant shares of primary pulp were burdened with an out-of-pocket effect of between 10.91 and 29.28 EUR/t (1.7-5.5% of manufacturing costs) assuming a 50%

pass-on of pulp cost increase. Switching to a 100% pass-on, the out-of-pocket effect increased to 25.41-48.40 EUR/t (3.9-10.6% of manufacturing costs). At the four investigated paper lines primarily relying on recovered fibre, the out-of-pocket effect under the "most-likely" scenario was much smaller of course. Assuming a 50% pass-on, it ranged between 1.83 and 8.61 EUR/t (0.4-1.3% of manufacturing costs). The limited contribution of the fibre cost lever could be seen at the results of 100% pass-on: the out-of-pocket effect increases only very moderately to 2.54-9.38 EUR/t.

Under the "worst-case" scenario, finally, the out-of-pocket effect becomes very severe, even for the processes which have been affected moderately only under the "most-likely" scenario.

Whereas the profound analysis of the out-of-pocket effects, i.e., the differentiation of the contributions of the single direct and indirect levers, requires more detail than deliverable in a summary (see chapters 4.2.2.4, 4.2.2.5 and 4.2.2.6 for the three scenarios with the overview of the "most-likely" scenario in Tab. 5-Tab. 7 on pages 144-146 and details on all scenarios in Appendix 5 and Appendix 6), at least some key findings can be given at this point:

- Until 2012, the direct effect of emission trading on the manufacturing costs of pulp and paper in Europe will be comparably minor, primarily due to the high degree of free allocation. Mills in Eastern Europe can even benefit from over-allocation.
- Chemical pulp mills face significant threats of manufacturing cost increases especially from rising fibre prices.
- Mechanical-, thermo-mechanical-, and chemi-thermo-mechanical pulp mills face significant threats of manufacturing cost increases especially from observable electricity price increases.
- Fibre recovery is comparably less affected, at least as far as physical use of used paper is politically preferred over thermal use.
- Effects on paper manufacturing arise primarily from potentially increasing pulp prises and the observable electricity price increase. Mills depending on primary pulp will be hit harder than mills using large shares of recovered fibre.

Although the effects of emission trading on pulp and paper manufacturing tend to be severe – depending on which scenario commences – they are not stand-alone influencing factors in the operational and strategic decision making of pulp and paper companies. Moreover, emission trading is one factor amongst recent energy-related developments (fuel and electricity prices, taxes, fees and income from RES and CHP promotion etc.) as outlined in detail in chapter 4.2.3. Thus, also the third hypothesis could be adopted.

The question on the implications of emission trading on the profitability and competitiveness of the pulp and paper industry requires a comparison of out-of-pocket manufacturing cost increases and margins earned in the industry. As displayed in Tab. 5-Tab. 7 (pages 144-146), typical values for the out-of-pocket effect under the "most-likely scenario" are 11.2% of manufacturing costs at chemical pulping, 22.6% at mechanical pulping, 20.7% at thermo-mechanical pulping and 1.2% at fibre recovery. The effect on paper manufacturing significantly differs depending on the source of fibre. If primary pulp is used, the typical out-of-pocket effect ranges between 3.1 and 7.5%, if solely secondary pulp is used, it's 1.0-1.8%. These increases directly compare to an average EBITDA of 15.8 % (calculated as a percentage of manufacturing costs), respectively 4.6% EBIT earned by the top five European pulp and paper manufacturers in 2004 (see chapter 5.1). The numbers immediately reveal that profitability and competitiveness are seriously endangered.

Against this threat, immediate action needs to be taken by pulp and paper manufacturers to maintain or re-establish profitability. In chapter 5.2 114 actions are sketched, primarily related to energy or raw material costs, to pricing and to selected aspects beyond current business. Chapter 5.2.9 and especially Fig. 49 on page 269 provide an overview of these actions with a qualitative assessment of range of application, ease of implementation, and potential impact. The assessments have been made outside-in and, thus, can provide orders of magnitude only. Actions are grouped into four categories starting with "first-priority actions" characterised by high ease of implementation, over "second-priority actions" with high impact but limited ease to finally "fourth-priority actions" with low ease and limited impact. Of course, not every action can be applicable to every individual mill, but company or mill management receives support in identifying actions which provide valuable contributions to maintain or re-establish profitability.

However, recommendations have not been limited to affected pulp and paper manufacturers. Politicians active on a European or national level also receive guidance for future legislation referring to the design of an emission trading scheme, to energy and emission taxation, to RES and CHP promotion, and to liberalisation of electricity markets. Crucial are an allocation mode, which avoids windfall profits of utility companies in the second phase of the EU ETS and, thereafter (chapter 5.3.1), a RES promotion scheme, which does not withdraw fibrous raw material from physical use by imprudently subsidising thermal use of wood (chapter 5.3.3), and an unbundling of electricity generation and transmission system operation, probably resulting in renationalisation of grids (chapter 5.3.4).

At the end of the investigation (chapter 5.4), an outlook is given on phase II of the European emission trading scheme and the time beyond 2012. Whereas key aspects of the time period 2008-2012 appear predictable and have been included in modelling the effects as noted above, there is high uncertainty for the time post-Kyoto, i.e., post-2012. Although, two assumptions can be made with very high probabilities: (1) emission caps will be significantly lower than today and (2) emission trading will maintain or expand in importance as an instrument of environmental politics. Presumably, it will even gain share in the political toolbox alongside energy taxation, RES and CHP promotion, and regulation. The exact design cannot be foreseen, of course, but there is good reason for the following assumptions: emission caps will be significantly lower than in the first and second trade phase. Boundaries will be extended to other industries (presumably aviation) and gases. Allocation mode will change from grandfathering and benchmarking to auctioning. Joint Implementation and especially Clean Development Mechanisms will gain share for meeting the obligations of European countries. – These developments will increase the direct as well as the indirect effects on the pulp and paper industry. Auctioning will increase costs of scarce allowances significantly and keep electricity prices high. Some relief, in turn, could be expected if funds raised from auctioning were recycled in a reasonable way.

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The 25 national allocation plans for the first phase of the EU emission trading scheme and the 27 national allocation plans for the second phase of the EU emission trading scheme have not been included in the reference list above. Their references can be found in subsequent Appendix 1 and Appendix 2 below.

8. Appendices

Appendix 1: Status of national allocation plans phase I of 25 EU member states

Country	Name of national allocation plan	Date (last)	EU Decision	Date	Approval[1]
Austria	Nationaler Zuteilungsplan für Österreich gemäß § 11 EZG - endg. last amended by Korrigendum zur konsolidierten Fassung vom 22. Dezember 2004	2005-01-24	COM(2004) 2515/3	2004-07-07	Conditionally approved
Belgium	Belgian National Allocation Plan	2004-06-23	COM(2004) 3982	2004-10-20	Approved
Cyprus	National Allocation Plan (2005-2007)	2004-10-19	COM(2004) 5295	2004-12-27	Approved
Czech Republic	National Allocation Plan of the Czech Republic 2005 to 2007 - Compromise Draft of the Deputy Prime Minister for Economy, MZP and MPO - Revised text	2005-02-17	COM(2005) 1083	2005-04-12	Approved
Denmark	Danish National Allocation Plan	2004-03-31	COM(2004) 2515/6	2004-07-07	Approved
Estonia	Kasvuhoonegaaside lubatud heitkoguste Eesti riiklik jaotuskava aastateks 2005-2007	2004-05-10	COM(2004) 3982/8	2004-10-20	Approved
Finland	Government Decision on the Proposal for a National Allocation Plan	2004-08-19	COM(2004) 3982/2	2004-10-20	Conditionally approved
France	Plan National D´affectation Des Quotas - Periode de reference 2005-2007	2004-07-06	COM(2004) 3982/7	2004-10-20	Conditionally approved
Germany	National Allocation Plan for the Federal Republic of Germany 2005-2007	2004-03-31	COM(2004) 2515/2	2004-07-07	Conditionally approved
Greece	National Allocation Plan for the Period 2005-2007	2004-12-30	COM(2005) 1788	2005-06-20	Approved
Hungary	Draft National Allocation Plan of Hungary	2004-10-08	COM(2004) 5298	2004-12-27	Approved
Ireland	Ireland's Draft National Allocation Plan 2005-2007 - Public Consultation	2004-02-23	COM(2004) 2515/5	2004-07-07	Approved
Italy	Italian National Allocation Plan of July 21st 2004 last amended by letter of February 25th 2005	2005-02-25	COM(2005) 1527	2005-05-25	Conditionally approved
Latvia	National Allocation Plan 2005-2007 of April 27th 2004 last amended May 19 2005	2005-05-19	COM(2004) 3982/5	2004-10-20	Approved
Lithuania	Lithuania's National Allocation Plan for greenhouse gas emission allowances for the period 2005 to 2007	2004-12-15	COM(2004) 5292	2004-12-27	Approved
Luxembourg	Nationaler Allokationsplan für Luxemburg of April 6th 2004 last amended October 6th 2004	2004-10-06	COM(2004) 3289/4	2004-10-20	Approved
Malta	National Allocation Plan for Malta 2005-2007	2004-10-18	COM(2004) 5287	2004-12-27	Approved
Netherlands	Allocation Plan for CO2 Emission Allowances 2005-2007 - Dutch national allocation plan regarding the Allocation of greenhouse gas emission allowances to companies	2004-04-16	COM(2004) 2515/1	2004-07-07	Approved

[1] Conditional approval means that the NAP is approved as soon as certain conditions named in the respective EU Decision are met.

Poland	National Allocation Plan for CO2 Emission Allowances - 2005-2007 Trading Period	2004-08-20	COM(2005) 549	2005-03-08	Conditionally approved
Portugal	National Allocation Plan for CO2 Emission Allowances (NAP) 2005-2007	2004-05-04	COM(2004) 3982/4	2004-10-20	Approved
Slovakia	Národný alokačný plán na roky 2005-2007 - k zákonu č. 572/2004 Z.z. o obchodovaní s emisnými kvótami	2005-02-07	COM(2004) 3982/6	2004-10-20	Approved
Slovenia	Slovenian National Allocation Plan for 2005-2007	2004-04-29	COM(2004) 2515/8	2004-07-07	Approved
Spain	National Allowance Allocation Plan of August 9th 2004 last amended by letter of December 3rd 2004	2004-12-03	COM(2004) 5285	2004-12-27	Conditionally approved
Sweden	Sweden's National Allocation Plan	2004-04-22	COM(2004) 2515/7	2004-07-07	Approved
United Kingdom	Approved National Allocation Plan 2005-2007	2005-05-10	COM(2004) 2515/4 and COM(2005) 1081	2005-04-12	Not approved, approval of updated version pending

Appendix 2: Status of national allocation plans phase II of 27 EU member states

Country	Name of national allocation plan	Date (last)	EU Decision	Approval[1]
Austria	Nationaler Zuteilungsplan für Österreich gemäß § 11 Emissions-zertifikategesetz für die Periode 2008-2012	2007-01-10	Open	Not approved, notified to the Commission only
Belgium	Belgian National Allocation Plan for CO2-emission allowances 2008-2012	2006-09-30	Commission Decision of January 16th 2007	Conditional approval
Bulgaria	КОНСУЛТАТИВЕН ДОКУМЕНТ ЗА БЪЛГАРСКИЯ НАЦИОНАЛЕН ПЛАН ЗА РАЗПРЕДЕЛЕНИЕ НА КВОТИ ЗА ТЪРГОВИЯ С ЕМИСИИ НА ПАРНИКОВИ ГАЗОВЕ ЗА УЧАСТИЕ НА БЪЛГАРИЯ В ЕВРОПЕЙСКАТА СХЕМА ЗА ТЪРГОВИЯ С ЕМИСИИ НА ПАРНИКОВИ ГАЗОВЕ	2006-03-15	Open	Not approved, published for public consultation only
Cyprus	Not available	None	none	Submission announced for end of January 2007, yet not available
Czech Republic	Národní alokační plán České republiky 2008 az 2012	2006-09-30	Open	Not approved, notified to the Commission only
Denmark	Not available	None	none	Infringement procedure started by EU
Estonia	National allocation plan of Estonia for greenhouse gas emission trading for the years 2008-2012	2006-06-12	Open	Not approved, notified to the Commission only
Finland	SUOMEN ESITYS PÄÄSTÖOIKEUKSIEN KANSALLISEKSI JAKOSUUNNITELMAKSI VUOSILLE 2008–2012	2006-09-29	Open	Not approved, notified to the Commission only
France	PROJET DE PLAN NATIONAL D'AFFECTATION DES QUOTAS D'EMISSION DE GAZ A EFFET DE SERRE (PNAQ II) (PERIODE : 2008 à 2012)	2006-12-28	Open	Not approved, notified to the Commission only
Germany	National Allocation Plan for the Federal Republic of Germany 2008-2012	2006-06-28	Commission Decision of November 29th 2006	Conditional approval
Greece	ΕΘΝΙΚΟ ΣΧΕΔΙΟ ΚΑΤΑΝΟΜΗΣ ΔΙΚΑΙΩΜΑΤΩΝ ΕΚΠΟΜΠΩΝ ΓΙΑ ΤΗΝ ΠΕΡΙΟΔΟ 2008 – 2012	2006-09-30	Commission Decision of November 29th 2006	Conditional approval
Hungary	A Magyar Köztársaság 2008-2012 időszakra szóló Nemzeti Kiosztási Terve	2007-01-17	Open	Not approved, notified to the Commission only
Ireland	Ireland's National Allocation Plan 2008-2012	2006-07-12	Commission Decision of November 29th 2006	Conditional approval
Italy	Piano Nazionale d'Assegnazione per il periodo 2008-2012 elaborato ai sensi dell'articolo 8, comma 2 del D.lgs. 4 aprile 2006, n. 216	2006-04-04	Open	Not approved, notified to the Commission only
Latvia	Emisijas kvotu sadales plāns 2008.–2012.gadam	2006-08-09	Commission Decision of November 29th 2006	Conditional approval

[1] Conditional approval means that the NAP is approved as soon as certain conditions named in the respective Decision are met.

Lithuania	LIETUVOS NACIONALINIS APYVARTINIU TARŠOS LEIDIMU PASKIRSTYMO 2008-2012 METU LAIKOTARPIUI PLANAS	Unknown	Commission Decision of November 29th 2006	Conditional approval
Luxembourg	Nationaler Allokationsplan 2008-2012 für Luxemburg	2006-07-18	Commission Decision of November 29th 2006	Conditional approval
Malta	National Allocation Plan for Malta 2008-2012	2006-09-30	Commission Decision of November 29th 2006	Conditional approval
Netherlands	Netherlands national allocation plan for greenhouse gas allowances 2008-2012	2006-09-26	Commission Decision of January 17th 2007	Conditional approval
Poland	KRAJOWY PLAN ROZDZIAŁU UPRAWNIE DO EMISJI CO2 na lata 2008 – 2012	2006-06-23	Open	Not approved, notified to the Commission only
Portugal	Plano Nacional de Atribuição de Licenças de Emissão de CO2 (PNALE) 2008-2012	2006-12-18	Open	Not approved, notified to the Commission only
Romania	ROMANIAN NATIONAL ALLOCATION PLAN for the periods 2007 and 2008-2012	2006-12-12	Open	Not approved, notified to the Commission only
Slovakia	Národný alokačný plán na roky 2008 – 2012	2006-07-31	Commission Decision of November 29th 2006	Conditional approval
Slovenia	DRŽAVNI NAČRT RAZDELITVE EMISIJSKIH KUPONOV za obdobje od 2008 do 2012	2006-10-31	Commission Decision of February 5th 2007	Conditional approval
Spain	Plan Nacional de Asignación de derechos de emisión de gases de efecto invernadero, 2008-2012	2006-11-24	Open	Not approved, notified to the Commission only
Sweden	Sveriges nationella fördelningsplan avseende utsläppsrätter år 2008-2012	2006-08-31	Commission Decision of November 29th 2006	Conditional approval
United Kingdom	UK National Allocation Plan 2008-2012	2006-08-21	Commission Decision of November 29th 2006	Conditional approval

Appendix 3: Interview guide for mill visits

Interview guide for mill visits:

All of the following questions will be asked during the interview if they are applicable to the specific mill and the time allows that. The order of the questions may be changed if the course of the interview suggests that. All questions refer to 2004 unless stated otherwise.

1. Mill overview

1.1 Please describe the **production processes** in the mill and name the major components of the **equipment** for each line of production (e.g., for sulphate pulping, waste paper recovery, paper making etc.).

1.2 What are the **production capacities** of each line, what was the actual production in 2004?

1.3 What are the **major products** or product categories the mill produces? Please name all relevant products even if they are consumed in another line within the mill (e.g., internally generated sulphate pulp which is consumed for paper making).

2. Raw materials

Which **raw materials** are used for the production processes? What share of the internally produced fibre material (pulp, recovered fibre) is used for paper manufacturing?

3. Energy

3.1 Please describe the overall **energy configuration** of the mill. Do you generate steam and electricity in your own power plant? Does the internal generation meet the total demand?

3.2 **Which fuels** are consumed in the mill? Please name all fuels that are purchased or generated internally independently if they are of fossil origin or bio fuels. Please also mention internally generated fuels which are sold to other companies. Which fuels are used for steam and electricity generation in the power plant, which are used in the production (e.g., lime kiln, IR-dryers etc.)?

3.3 What was the actual **fuel consumption** (if possible: by department) in 2004?

3.4 Which **fuels** are **generated internally**? Where are the internally generated fuels used? Which fuels are sold to others?

3.5 Which fuels were purchased in 2004? What were the volumes? What were **prices** and **conditions of purchase** like? To which taxes, fees etc. were the fuels subject? Please differentiate by type of fuel.

3.6 Please provide an overview of the **steam balance** of the mill (may also include hot water). Which energy quantities have been consumed by department? What energy quantities have been provided by the single boilers and steam blocks? What quantities of steam have been purchased or sold? What were the conditions and prices of steam purchase and sales?

3.7 Please provide an overview of the **electricity balance** of the mill. Which energy quantities have been consumed by department? What energy quantities have been provided by the single turbines? What electricity quantities have been purchased or sold? What were the conditions and prices of electricity purchase and sales? To which taxes, fees etc. was the electricity subject?

3.8 Summarizing: which lines of production should we define for the investigation?

3.9 Do we have to consider recent **developments** concerning the energy configuration of the mill? Will the mill be subject to such changes in the near future?

4. Environmental instruments

4.1 Please describe the effect of **emission trading** on your mill. What are the sources of fossil CO2 relevant for emission trading? How did you **apply** for allocation of certificates? Did you use consultants for this application? Which **allocation principle** (grandfathering, benchmarking etc.) did you base your application on? What is your **actual allocation** of certificates? What drove this allocation? Were production forecasts considered? How do you handle the **administrative** tasks related to emission trading? To what degree are you supported by the head-quarter of your company concerning emission trading?

4.2 **Eco taxes** can be separated into **energy taxes** and **emission taxes**. Which of your fuels are subject to energy and/or emission taxation? Are the taxes (partially) reimbursed for certain reasons (e.g., reduced for big consumers, counted against pension insurance, capped etc.)? How do the real taxes affect the total costs of energy gained from these fuels? What is the situation concerning electricity? Please describe in detail.

4.3 According to a certain EU directive, generation of **green electricity** (usually called RES) is supported. The member states can choose different mechanisms to guarantee this support. Please give an overview of the respective legislation in your country. What are the actual costs of this legislation for your mill? Do you benefit from this legislation too? How do you take advantage of this support for green electricity generation?

4.4 According to a certain EU directive, **cogeneration** (usually called CHP) is supported. The member states can choose different mechanisms to guarantee this support. Please give an overview of the respective legislation in your country. What are the actual costs of this legislation for your mill? Do you benefit from this legislation too? How do you take advantage of this support for CHP electricity generation?

5. Other

Summarizing: Do we have to consider any special things with regard to this investigation?

Appendix 4: Data query form PULP R 1.6

INPUT Please address questions to: Jan-Henrik Hübner / +49 (0) 40 - 36 12 - 13 78 / jan-henrik_huebner@mckinsey.com **PULP - PRODUCTION**

(1) IDENTIFICATION

Company	Please enter	Method of pulping	Please choose	
Mill	Please enter	Raw material	Please choose	
Contact Person	Please enter	Bleaching	Please choose	
Country	Please choose	Mill Grade	Please enter	
Base year	Please choose	Total production	Please enter	ADt
Date of last edit	2004-01-01	Total capacity	Please enter	ADt

MILL LEVEL

(2) FUEL AND CHEMICALS INPUT

Fuels (= purchased or generated internally; consumed)

Defined fuels	Activity rate	Net caloric value	Energy content	Emission factor	Conversion factor	Emission
Please choose further fuel						

Not defined fuels

Please enter further fuel

Fuels (= by-products; sold)

Please enter further fuel

Total fuels (net) 0 GJ 0 t CO2

Make-up chemicals

Defined make-up chemicals	Activity rate	Emission factor	Conversion factor	Emission
Please choose further chemical				

Not defined make-up chemicals

Please enter further chemical

Total make-up chemicals 0 t CO2

(3) EMISSION

Emission from fuels (net)	0	t CO2
Emission from make-up chemicals	0	t CO2
CO2 purchased	Please enter	t CO2
CO2 bound in PCC (if PCC is manufactured internally)	Please enter	t CO2
CO2 sold	Please enter	t CO2
Total emission		**t CO2**
Annual allocation	**Please enter**	**t CO2**
Annual scarcity (-) or surplus (+)		**t CO2**

(4) ENERGY

Energy available from fuels

Fuels (before sales of fuel by-products)	0	GJ

Purchase of energy (other than fuels)

Direct heat	Please enter	GJ
Steam	Please enter	GJ
Electricity	Please enter	MWh
Others	Please enter	GJ
Total	0	GJ

Steam generation	**Energy content**		**Direct heat consumption**		**Electricity consumption**	
Steam generation in boilers from direct heat						
Live steam generated	Please enter	GJ	Please enter	GJ		
Return ("Condensate")	Please enter	GJ				
Net steam generation in boilers	0	GJ				
Steam generation in boilers from electricity						
Live steam generated	Please enter	GJ			Please enter	MWh
Return ("Condensate")	Please enter	GJ				
Net steam generation in boilers	0	GJ				
Steam generation in process	Please enter	GJ				
Total steam generation	0	GJ				

Electricity generation	**Generation**		**Direct heat consumption**		**Steam consumption**		**Nominal capacity**	
Please enter further turbine								
Total electricity generation	0	MWh	0	GJ	0	GJ	0.0	MW

Energy consumption	**Direct heat**		**Steam**		**Electricity**		**Other forms**	
Other auxiliary services								
Water treatment (raw and waste water treatment, incl. sludge processing)	Please enter	GJ	Please enter	GJ	Please enter	MWh	Please enter	GJ
Offices/workspace mill (incl. light, heating and compressed air)	Please enter	GJ	Please enter	GJ	Please enter	MWh	Please enter	GJ
Others (including losses)	Please enter	GJ	Please enter	GJ	Please enter	MWh	Please enter	GJ
Generation								
Boilers (generation of steam from direct heat or electricity)	0	GJ			0	MWh		
Turbines (generation of electricity from direct heat or steam)	0	GJ	0	GJ				
Total consumption	0	GJ	0	GJ	0	MWh	0	GJ

Sales of energy (other than fuels)

Direct heat	Please enter	GJ
Steam	Please enter	GJ
Electricity	Please enter	MWh
Others	Please enter	GJ
Total	0	GJ

Balance direct heat

Direct heat available as fuels	0	GJ
Purchase of direct heat	0	GJ
Available direct heat	0	GJ
Consumption of direct heat		
Process	0	GJ
Boilers	0	GJ
Turbines	0	GJ
Sales of direct heat	0	GJ
Balance direct heat	0	GJ

Balance steam

Generation of steam	0	GJ
Purchase of steam	0	GJ
Available steam	0	GJ
Consumption of steam		
Process	0	GJ
Turbines	0	GJ
Sales of steam	0	GJ
Balance steam	0	GJ

Balance electricity

Generation of electricity	0	GJ	0	MWh
Purchase of electricity	0	GJ	0	MWh
Available electricity	0	GJ	0	MWh
Consumption of electricity	0	GJ	0	MWh
Sales of electricity	0	GJ	0	MWh
Balance electricity	0	GJ	0	MWh

Balance other energy (other than fuels)

Purchase of other energy (other than fuels)	0	GJ
Consumption of other energy (other than fuels)	0	GJ
Sales of other energy (other than fuels)	0	GJ
Balance other energy (other than fuels)	0	GJ

(5) MANUFACTURING COST

Raw materials	Volume		Cost	Purch. currency	Unit price	Unit price	Sum	Share
Fiber materials							0 EUR	
Softwood, round	Please enter	Please choose						
Softwood, chips	Please enter	Please choose						
Softwood, saw mill waste	Please enter	Please choose						
Hardwood, round	Please enter	Please choose						
Hardwood, chips	Please enter	Please choose						
Hardwood, saw mill waste	Please enter	Please choose						
Other soft and hardwood	Please enter	Please choose						
Waste paper	Please enter	Please choose						
Make-up chemicals							0 EUR	

Other chemicals						0 EUR	
Please enter further chemical							
Total raw materials						**0 EUR**	
Utilities (consumed)	**Volume**	**Cost**	**Purch. currency**	**Unit price**	**Unit price**	**Sum**	**Share**
Fuels						0 EUR	
Direct energy						0 EUR	
Direct heat							
Steam							
Electricity							
Others							
Other utilities						0 EUR	
Please enter further utility							
Utilities (sold)	**Volume**	**Revenue**	**Sales currency**	**Unit price**	**Unit price**	**Sum**	**Share**
Fuels (=by product)						0 EUR	
Direct energy						0 EUR	
Direct heat							
Steam							
Electricity							
Others							
Total utilities before adjustment for eco instruments						0 EUR	
Adjustment for Direct environmental instruments aiming at reduction of CO2 emission						0 EUR	
Total utilities						**0 EUR**	

	Cost		Sum	Share
Consumables & maintenance material and service			**0 EUR**	
Consumables/maintenance material	Please enter	Please choose		
	Please enter	Please choose		
Maintenance Service	Please enter	Please choose		
	Please enter	Please choose		

	Cost		Sum	Share
Packaging & logistics material and service			**0 EUR**	
Packaging/logistics material	Please enter	Please choose		
	Please enter	Please choose		
Packaging/logistics Service	Please enter	Please choose		
	Please enter	Please choose		

	Cost		Sum	Share
Personnel			**0 EUR**	
	Please enter	Please choose		
	Please enter	Please choose		

	Cost		Sum	Share
Direct Taxes & overhead expenses & corporate expenses	Please enter	Please choose	**0 EUR**	

	Cost		Sum	Share
Capital (depreciation, leasing, etc.)	Please enter	Please choose	**0 EUR**	

	Cost		Sum	Share
Direct environmental instruments aiming at reduction of CO2 emission			**0 EUR**	
Ecotax on fuels	Please enter	Please choose		
Ecotax on electricity	Please enter	Please choose		
Ecotax on other direct energy	Please enter	Please choose		
Part of electricity cost originating from subsidization of green electricity	Please enter	Please choose		
Part of electricity revenue originating from subsidization of green electricity	Please enter	Please choose		
Other eco instruments included in cost of utilities	Please enter	Please choose		
Estimate for administrative cost emission trading (internal personnel, accountants etc.)	Please enter	Please choose	0 EUR	

	Cost		Sum	Share
Other manufacturing cost	Please enter	Please choose	**0 EUR**	
Total manufacturing cost			**0 EUR**	

(6) POTENTIAL CO2 EMISSION AVOIDANCE MEASURES

Currency for measures Please choose

Title of measure	Number	Effect on Emission	One Time Cash Effect	Annual Cash Effect	Useful Life	Specific cost	Description of improvement measure
		t CO2/a	Please choose	Please choose	a	EUR/t CO2/a	
Please name further measure							

Appendix 5: Financial effect of emission trading on pulping processes

Scenario: BEST CASE Administrative: DEFAULT		Chemical pulping				Mechanical pulping				Thermo-mechanical pulping				Fibre recovery			
	Unit	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	EUR/t	-1.87	-0.60	0.00	7	0.00	0.00	0.00	0	-0.03	0.00	0.00	4	-0.17	-0.10	0.00	6
Opportunity costs of free allowances	EUR/t	1.66	2.30	2.76	7	0.00	0.00	0.00	0	0.00	0.05	0.13	4	0.00	0.40	0.77	6
Administrative costs	EUR/t	0.25	0.25	0.25	7	0.00	0.25	0.00	0	0.00	0.25	0.25	5	0.00	0.25	0.25	7
DIRECT EFFECT	**EUR/t**	**0.74**	**1.95**	**3.01**	**7**	**0.00**	**0.25**	**0.00**	**0**	**0.00**	**0.30**	**0.38**	**4**	**0.00**	**0.55**	**0.85**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	EUR/t	0.00	0.00	0.00	6	0.00	0.00	0.00	0	0.00	0.00	0.00	2	0.00	0.00	0.00	6
Cost increase chemical raw materials	EUR/t	0.00	0.00	0.00	6	0.00	0.00	0.00	0	0.00	0.00	0.00	2	0.00	0.00	0.00	5
Total cost increase raw materials	**EUR/t**	**0.00**	**0.00**	**0.00**	**6**	**0.00**	**0.00**	**0.00**	**0**	**0.00**	**0.00**	**0.00**	**2**	**0.00**	**0.00**	**0.00**	**5**
Cost increase fuels	EUR/t	0.00	0.00	0.00	7	0.00	0.00	0.00	0	0.00	0.00	0.00	3	0.00	0.00	0.00	6
Cost increase electricity	EUR/t	0.11	0.25	0.48	7	0.00	2.00	0.00	0	1.06	2.00	2.71	4	0.04	0.15	0.23	6
Total cost increase energy	**EUR/t**	**0.11**	**0.25**	**0.48**	**7**	**0.00**	**2.00**	**0.00**	**0**	**1.06**	**2.00**	**2.71**	**3**	**0.04**	**0.15**	**0.23**	**6**
INDIRECT EFFECT	**EUR/t**	**0.11**	**0.25**	**0.48**	**6**	**0.00**	**2.00**	**0.00**	**0**	**1.06**	**2.00**	**1.34**	**2**	**0.04**	**0.15**	**0.23**	**5**
3. GROSS EFFECT	**EUR/t**	**0.87**	**2.20**	**3.33**	**6**	**0.00**	**2.25**	**0.00**	**0**	**1.44**	**2.30**	**1.61**	**2**	**0.31**	**0.70**	**0.96**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**1.66**	**2.30**	**2.76**	**7**	**0.00**	**0.00**	**0.00**	**0**	**0.00**	**0.05**	**0.13**	**4**	**0.00**	**0.40**	**0.77**	**6**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**-1.50**	**-0.10**	**0.73**	**6**	**0.00**	**2.25**	**0.00**	**0**	**1.31**	**2.25**	**1.57**	**2**	**0.18**	**0.30**	**0.48**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% Recovery from price increase	EUR/t	-0.15	-0.01	0.07	6	0.00	0.23	0.00	0	0.13	0.23	0.16	2	0.02	0.03	0.05	5
50% Recovery from price increase	EUR/t	-0.75	-0.05	0.37	6	0.00	1.13	0.00	0	0.66	1.13	0.78	2	0.09	0.15	0.24	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	EUR/t	-1.35	-0.09	0.66	6	0.00	2.03	0.00	0	1.18	2.03	1.41	2	0.17	0.27	0.43	5
Net effect at 50% recovery from price increase	EUR/t	-0.75	-0.05	0.37	6	0.00	1.13	0.00	0	0.66	1.13	0.78	2	0.09	0.15	0.24	5

Scenario: BEST CASE Administrative: DEFAULT		Chemical pulping				Mechanical pulping				Thermo-mechanical pulping				Fibre recovery			
	Unit	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	%**	-1.1%	-0.2%	0.0%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.0%	3	-0.1%	-0.1%	0.0%	6
Opportunity costs of free allowances	%**	0.5%	0.7%	1.4%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.1%	3	0.0%	0.3%	0.5%	6
Administrative costs	%**	0.1%	0.1%	0.1%	6	0.0%	0.1%	0.0%	0	0.0%	0.1%	0.1%	3	0.0%	0.2%	0.3%	6
DIRECT EFFECT	**%****	**0.3%**	**0.6%**	**0.8%**	**6**	**0.0%**	**0.1%**	**0.0%**	**0**	**0.0%**	**0.1%**	**0.2%**	**3**	**0.0%**	**0.4%**	**0.6%**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	%**	0.0%	0.0%	0.0%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.0%	6
Cost increase chemical raw materials	%**	0.0%	0.0%	0.0%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.0%	5
Total cost increase raw materials	**%****	**0.0%**	**0.0%**	**0.0%**	**6**	**0.0%**	**0.0%**	**0.0%**	**0**	**0.0%**	**0.0%**	**0.0%**	**2**	**0.0%**	**0.0%**	**0.0%**	**5**
Cost increase fuels	%**	0.0%	0.0%	0.0%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.0%	3	0.0%	0.0%	0.0%	6
Cost increase electricity	%**	0.0%	0.1%	0.1%	6	0.0%	1.0%	0.0%	0	0.5%	0.9%	1.0%	3	0.0%	0.1%	0.1%	6
Total cost increase energy	**%****	**0.0%**	**0.1%**	**0.1%**	**6**	**0.0%**	**1.0%**	**0.0%**	**0**	**0.5%**	**0.9%**	**1.0%**	**3**	**0.0%**	**0.1%**	**0.1%**	**6**
INDIRECT EFFECT	**%****	**0.0%**	**0.1%**	**0.1%**	**6**	**0.0%**	**1.0%**	**0.0%**	**0**	**0.5%**	**0.9%**	**0.6%**	**2**	**0.0%**	**0.1%**	**0.1%**	**5**
3. GROSS EFFECT	**%****	**0.4%**	**0.6%**	**0.9%**	**6**	**0.0%**	**1.1%**	**0.0%**	**0**	**0.7%**	**1.0%**	**0.7%**	**2**	**0.4%**	**0.5%**	**0.7%**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**0.5%**	**0.7%**	**1.4%**	**6**	**0.0%**	**0.0%**	**0.0%**	**0**	**0.0%**	**0.0%**	**0.1%**	**3**	**0.0%**	**0.3%**	**0.5%**	**6**
5. OUT-OF-POCKET EFFECT	**%****	**-0.8%**	**0.0%**	**0.2%**	**6**	**0.0%**	**1.1%**	**0.0%**	**0**	**0.7%**	**1.0%**	**0.7%**	**2**	**0.1%**	**0.2%**	**0.3%**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% recovery from price increase	%**	-0.1%	0.0%	0.0%	6	0.0%	0.1%	0.0%	0	0.1%	0.1%	0.1%	2	0.0%	0.0%	0.0%	5
50% recovery from price increase	%**	-0.4%	0.0%	0.1%	6	0.0%	0.6%	0.0%	0	0.3%	0.5%	0.4%	2	0.1%	0.1%	0.1%	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	%**	-0.8%	0.0%	0.2%	6	0.0%	1.0%	0.0%	0	0.6%	0.9%	0.6%	2	0.1%	0.2%	0.2%	5
Net effect at 50% recovery from price increase	%**	-0.4%	0.0%	0.1%	6	0.0%	0.6%	0.0%	0	0.3%	0.5%	0.4%	2	0.1%	0.1%	0.1%	5

* Investigated lines
** Percent of manufacturing costs

Scenario: "Best case"

Scenario: MOST LIKELY Administrative: DEFAULT	Unit	Chemical pulping Min*	Typical	Max*	n *	Mechanical pulping Min*	Typical	Max*	n *	Thermo-mechanical pulping Min*	Typical	Max*	n *	Fibre recovery Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	EUR/t	-7.46	-2.00	0.64	7	0.00	0.00	0.00	0	-0.11	0.00	0.04	4	-0.69	-0.40	0.07	6
Opportunity costs of free allowances	EUR/t	6.65	9.00	10.92	7	0.00	0.00	0.00	0	0.00	0.20	0.49	4	0.00	1.80	3.09	6
Administrative costs	EUR/t	0.25	0.25	0.25	7	0.00	0.25	0.00	0	0.00	0.25	0.25	5	0.00	0.25	0.25	7
DIRECT EFFECT	**EUR/t**	**2.19**	**7.25**	**11.28**	**7**	**0.00**	**0.25**	**0.00**	**0**	**0.00**	**0.45**	**0.78**	**4**	**0.00**	**1.65**	**2.66**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	EUR/t	32.68	36.00	38.93	6	0.00	17.00	0.00	0	15.96	17.00	17.90	2	0.00	0.00	0.00	6
Cost increase chemical raw materials	EUR/t	0.04	0.50	0.71	6	0.00	0.00	0.00	0	0.14	0.20	0.25	2	0.00	0.10	0.20	5
Total cost increase raw materials	**EUR/t**	**32.96**	**36.50**	**39.29**	**6**	**0.00**	**17.00**	**0.00**	**0**	**16.21**	**17.20**	**18.04**	**2**	**0.00**	**0.10**	**0.20**	**5**
Cost increase fuels	EUR/t	0.00	0.50	0.85	7	0.00	0.00	0.00	0	0.00	0.05	0.13	3	0.00	0.05	0.13	6
Cost increase electricity	EUR/t	1.59	4.00	8.47	7	0.00	28.00	0.00	0	18.55	28.00	37.79	4	0.57	1.50	3.23	6
Total cost increase energy	**EUR/t**	**1.93**	**4.50**	**8.79**	**7**	**0.00**	**28.00**	**0.00**	**0**	**18.57**	**28.05**	**37.79**	**3**	**0.59**	**1.55**	**3.23**	**6**
INDIRECT EFFECT	**EUR/t**	**35.04**	**41.00**	**46.76**	**6**	**0.00**	**45.00**	**0.00**	**0**	**36.62**	**45.25**	**39.83**	**2**	**0.59**	**1.65**	**3.40**	**5**
3. GROSS EFFECT	**EUR/t**	**37.24**	**48.25**	**56.05**	**6**	**0.00**	**45.25**	**0.00**	**0**	**37.39**	**45.70**	**40.14**	**2**	**0.93**	**3.30**	**5.55**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**6.65**	**9.00**	**10.92**	**7**	**0.00**	**0.00**	**0.00**	**0**	**0.00**	**0.20**	**0.49**	**4**	**0.00**	**1.80**	**3.09**	**6**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**27.99**	**39.25**	**47.65**	**6**	**0.00**	**45.25**	**0.00**	**0**	**36.91**	**45.50**	**39.97**	**2**	**0.48**	**1.50**	**3.72**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% Recovery from price increase	EUR/t	2.80	3.93	4.77	6	0.00	4.53	0.00	0	3.69	4.55	4.00	2	0.05	0.15	0.37	5
50% Recovery from price increase	EUR/t	13.99	19.63	23.83	6	0.00	22.63	0.00	0	18.45	22.75	19.98	2	0.24	0.75	1.86	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	EUR/t	25.19	35.33	42.89	6	0.00	40.73	0.00	0	33.22	40.95	35.97	2	0.43	1.35	3.35	5
Net effect at 50% recovery from price increase	EUR/t	13.99	19.63	23.83	6	0.00	22.63	0.00	0	18.45	22.75	19.98	2	0.24	0.75	1.86	5

Scenario: MOST LIKELY Administrative: DEFAULT	Unit	Chemical pulping Min*	Typical	Max*	n *	Mechanical pulping Min*	Typical	Max*	n *	Thermo-mechanical pulping Min*	Typical	Max*	n *	Fibre recovery Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	%**	-4.3%	-0.6%	0.1%	6	0.0%	0.0%	0.0%	0	-0.1%	0.0%	0.0%	3	-0.4%	-0.3%	0.0%	6
Opportunity costs of free allowances	%**	2.0%	2.6%	5.4%	6	0.0%	0.0%	0.0%	0	0.0%	0.1%	0.2%	3	0.0%	1.4%	2.0%	6
Administrative costs	%**	0.1%	0.1%	0.1%	6	0.0%	0.1%	0.0%	0	0.0%	0.1%	0.1%	3	0.0%	0.2%	0.3%	6
DIRECT EFFECT	**%****	**1.1%**	**2.1%**	**3.1%**	**6**	**0.0%**	**0.1%**	**0.0%**	**0**	**0.0%**	**0.2%**	**0.4%**	**3**	**0.0%**	**1.3%**	**1.8%**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	%**	8.2%	10.3%	19.2%	6	0.0%	8.5%	0.0%	0	7.3%	7.7%	8.9%	2	0.0%	0.0%	0.0%	6
Cost increase chemical raw materials	%**	0.0%	0.1%	0.2%	6	0.0%	0.0%	0.0%	0	0.1%	0.1%	0.1%	2	0.0%	0.1%	0.1%	5
Total cost increase raw materials	**%****	**8.4%**	**10.4%**	**19.3%**	**6**	**0.0%**	**8.5%**	**0.0%**	**0**	**7.4%**	**7.8%**	**9.0%**	**2**	**0.0%**	**0.1%**	**0.1%**	**5**
Cost increase fuels	%**	0.0%	0.1%	0.3%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.1%	3	0.0%	0.0%	0.1%	6
Cost increase electricity	%**	0.6%	1.1%	2.0%	6	0.0%	14.0%	0.0%	0	9.3%	12.7%	13.3%	3	0.7%	1.2%	1.7%	6
Total cost increase energy	**%****	**0.7%**	**1.3%**	**2.1%**	**6**	**0.0%**	**14.0%**	**0.0%**	**0**	**9.3%**	**12.8%**	**13.3%**	**3**	**0.7%**	**1.2%**	**1.7%**	**6**
INDIRECT EFFECT	**%****	**9.1%**	**11.7%**	**20.5%**	**6**	**0.0%**	**22.5%**	**0.0%**	**0**	**18.3%**	**20.6%**	**18.3%**	**2**	**0.7%**	**1.3%**	**1.8%**	**5**
3. GROSS EFFECT	**%****	**11.4%**	**13.8%**	**22.5%**	**6**	**0.0%**	**22.6%**	**0.0%**	**0**	**18.4%**	**20.8%**	**18.7%**	**2**	**1.1%**	**2.5%**	**2.9%**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**2.0%**	**2.6%**	**5.4%**	**6**	**0.0%**	**0.0%**	**0.0%**	**0**	**0.0%**	**0.1%**	**0.2%**	**3**	**0.0%**	**1.4%**	**2.0%**	**6**
5. OUT-OF-POCKET EFFECT	**%****	**8.9%**	**11.2%**	**19.0%**	**6**	**0.0%**	**22.6%**	**0.0%**	**0**	**18.3%**	**20.7%**	**18.4%**	**2**	**0.6%**	**1.2%**	**2.0%**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% recovery from price increase	%**	0.9%	1.1%	1.9%	6	0.0%	2.3%	0.0%	0	1.8%	2.1%	1.8%	2	0.1%	0.1%	0.2%	5
50% recovery from price increase	%**	4.5%	5.6%	9.5%	6	0.0%	11.3%	0.0%	0	9.2%	10.3%	9.2%	2	0.3%	0.6%	1.0%	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	%**	8.0%	10.1%	17.1%	6	0.0%	20.4%	0.0%	0	16.5%	18.6%	16.6%	2	0.5%	1.0%	1.8%	5
Net effect at 50% recovery from price increase	%**	4.5%	5.6%	9.5%	6	0.0%	11.3%	0.0%	0	9.2%	10.3%	9.2%	2	0.3%	0.6%	1.0%	5

* Investigated lines
** Percent of manufacturing costs

Scenario: "Most likely"

Scenario: WORST CASE Administrative: DEFAULT	Unit	Chemical pulping				Mechanical pulping				Thermo-mechanical pulping				Fibre recovery			
		Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	EUR/t	0.00	1.00	3.90	7	0.00	0.00	0.00	0	0.00	0.05	0.07	4	0.00	0.10	0.15	6
Opportunity costs of free allowances	EUR/t	10.98	18.00	21.50	7	0.00	0.00	0.00	0	0.00	0.50	0.98	4	0.00	4.00	6.04	6
Administrative costs	EUR/t	0.25	0.25	0.25	7	0.00	0.25	0.00	0	0.00	0.25	0.25	5	0.00	0.25	0.25	7
DIRECT EFFECT	**EUR/t**	**13.54**	**19.25**	**22.30**	**7**	**0.00**	**0.25**	**0.00**	**0**	**0.00**	**0.80**	**1.30**	**4**	**0.00**	**4.35**	**6.44**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	EUR/t	130.74	140.00	155.72	6	0.00	67.00	0.00	0	63.85	67.00	71.60	2	37.20	40.00	45.06	6
Cost increase chemical raw materials	EUR/t	0.10	1.00	1.90	6	0.00	0.00	0.00	0	0.38	0.50	0.66	2	0.00	0.20	0.52	5
Total cost increase raw materials	**EUR/t**	**131.46**	**141.00**	**156.68**	**6**	**0.00**	**67.00**	**0.00**	**0**	**64.51**	**67.50**	**71.98**	**2**	**37.20**	**40.20**	**45.52**	**5**
Cost increase fuels	EUR/t	0.00	3.00	6.77	7	0.00	0.00	0.00	0	0.00	0.50	1.01	3	0.00	0.30	1.02	6
Cost increase electricity	EUR/t	4.25	10.00	22.59	7	0.00	75.00	0.00	0	49.46	70.00	100.78	4	1.53	5.00	8.61	6
Total cost increase energy	**EUR/t**	**6.81**	**13.00**	**25.11**	**7**	**0.00**	**75.00**	**0.00**	**0**	**49.68**	**70.50**	**100.78**	**3**	**1.66**	**5.30**	**8.61**	**6**
INDIRECT EFFECT	**EUR/t**	**138.27**	**154.00**	**176.54**	**6**	**0.00**	**142.00**	**0.00**	**0**	**121.66**	**138.00**	**128.17**	**2**	**39.44**	**45.50**	**54.13**	**5**
3. GROSS EFFECT	**EUR/t**	**157.02**	**173.25**	**194.86**	**6**	**0.00**	**142.25**	**0.00**	**0**	**122.96**	**138.80**	**128.76**	**2**	**42.91**	**49.85**	**58.19**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**10.98**	**18.00**	**21.50**	**7**	**0.00**	**0.00**	**0.00**	**0**	**0.00**	**0.50**	**0.98**	**4**	**0.00**	**4.00**	**6.04**	**6**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**138.52**	**155.25**	**178.07**	**6**	**0.00**	**142.25**	**0.00**	**0**	**121.98**	**138.30**	**128.42**	**2**	**39.78**	**45.85**	**54.53**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% Recovery from price increase	EUR/t	13.85	15.53	17.81	6	0.00	14.23	0.00	0	12.20	13.83	12.84	2	3.98	4.59	5.45	5
50% Recovery from price increase	EUR/t	69.26	77.63	89.03	6	0.00	71.13	0.00	0	60.99	69.15	64.21	2	19.89	22.93	27.26	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	EUR/t	124.67	139.73	160.26	6	0.00	128.03	0.00	0	109.79	124.47	115.58	2	35.80	41.27	49.08	5
Net effect at 50% recovery from price increase	EUR/t	69.26	77.63	89.03	6	0.00	71.13	0.00	0	60.99	69.15	64.21	2	19.89	22.93	27.26	5

Scenario: WORST CASE Administrative: DEFAULT	Unit	Chemical pulping				Mechanical pulping				Thermo-mechanical pulping				Fibre recovery			
		Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																	
Costs of scarce emission allowances	%**	0.0%	0.3%	0.9%	6	0.0%	0.0%	0.0%	0	0.0%	0.0%	0.0%	3	0.0%	0.1%	0.1%	6
Opportunity costs of free allowances	%**	3.9%	5.1%	10.8%	6	0.0%	0.0%	0.0%	0	0.0%	0.2%	0.5%	3	0.0%	3.1%	3.9%	6
Administrative costs	%**	0.1%	0.1%	0.1%	6	0.0%	0.1%	0.0%	0	0.0%	0.1%	0.1%	3	0.0%	0.2%	0.3%	6
DIRECT EFFECT	**%****	**4.3%**	**5.5%**	**11.0%**	**6**	**0.0%**	**0.1%**	**0.0%**	**0**	**0.0%**	**0.4%**	**0.6%**	**3**	**0.0%**	**3.3%**	**4.2%**	**6**
2. INDIRECT EFFECT																	
Cost increase fibrous raw materials	%**	32.8%	40.0%	76.6%	6	0.0%	33.5%	0.0%	0	29.3%	30.5%	35.7%	2	20.0%	30.8%	47.8%	6
Cost increase chemical raw materials	%**	0.1%	0.3%	0.5%	6	0.0%	0.0%	0.0%	0	0.2%	0.2%	0.3%	2	0.0%	0.2%	0.3%	5
Total cost increase raw materials	**%****	**33.3%**	**40.3%**	**77.1%**	**6**	**0.0%**	**33.5%**	**0.0%**	**0**	**29.6%**	**30.7%**	**35.9%**	**2**	**24.0%**	**30.9%**	**47.8%**	**5**
Cost increase fuels	%**	0.0%	0.9%	2.4%	6	0.0%	0.0%	0.0%	0	0.0%	0.2%	0.5%	3	0.0%	0.2%	0.8%	6
Cost increase electricity	%**	1.5%	2.9%	5.3%	6	0.0%	37.5%	0.0%	0	24.7%	31.8%	35.5%	3	1.8%	3.8%	4.5%	6
Total cost increase energy	**%****	**1.8%**	**3.7%**	**5.9%**	**6**	**0.0%**	**37.5%**	**0.0%**	**0**	**24.8%**	**32.0%**	**35.5%**	**3**	**2.0%**	**4.1%**	**4.5%**	**6**
INDIRECT EFFECT	**%****	**35.1%**	**44.0%**	**81.1%**	**6**	**0.0%**	**71.0%**	**0.0%**	**0**	**58.8%**	**62.7%**	**60.7%**	**2**	**28.5%**	**35.0%**	**49.8%**	**5**
3. GROSS EFFECT	**%****	**40.1%**	**49.5%**	**92.0%**	**6**	**0.0%**	**71.1%**	**0.0%**	**0**	**59.1%**	**63.1%**	**61.4%**	**2**	**30.6%**	**38.3%**	**51.2%**	**5**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**3.9%**	**5.1%**	**10.8%**	**6**	**0.0%**	**0.0%**	**0.0%**	**0**	**0.0%**	**0.2%**	**0.5%**	**3**	**0.0%**	**3.1%**	**3.9%**	**6**
5. OUT-OF-POCKET EFFECT	**%****	**36.1%**	**44.4%**	**81.2%**	**6**	**0.0%**	**71.1%**	**0.0%**	**0**	**58.9%**	**62.9%**	**60.9%**	**2**	**28.7%**	**35.3%**	**50.1%**	**5**
6. RECOVERY FROM PRICE INCREASE																	
10% recovery from price increase	%**	3.6%	4.4%	8.1%	6	0.0%	7.1%	0.0%	0	5.9%	6.3%	6.1%	2	2.9%	3.5%	5.0%	5
50% recovery from price increase	%**	18.1%	22.2%	40.6%	6	0.0%	35.6%	0.0%	0	29.5%	31.4%	30.4%	2	14.4%	17.6%	25.1%	5
7. NET EFFECT																	
Net effect at 10% recovery from price increase	%**	32.5%	39.9%	73.1%	6	0.0%	64.0%	0.0%	0	53.0%	56.6%	54.8%	2	25.8%	31.7%	45.1%	5
Net effect at 50% recovery from price increase	%**	18.1%	22.2%	40.6%	6	0.0%	35.6%	0.0%	0	29.5%	31.4%	30.4%	2	14.4%	17.6%	25.1%	5

* Investigated lines
** Percent of manufacturing costs

Scenario: "Worst case"

Appendix 6: Financial effect of emission trading on paper manufacturing processes

Scenario: BEST CASE Administrative: DEFAULT Pulp: PRIMARY/SECONDARY		Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
Pass on pulp cost increase: 0	Unit	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	EUR/t	-0.41	-0.20	-0.02	2	0.00	-0.20	0.00	1	-2.55	-0.30	0.00	5	-0.19	-0.35	0.00	3	0.00	-0.40	0.00	4	-2.10	-0.35	-0.22	4	-0.25	-0.15	0.00	2	-2.55	-0.30	0.00	21
Opportunity costs of free allowances	EUR/t	0.40	1.50	1.83	2	0.30	1.50	0.30	1	0.00	1.75	3.61	5	0.88	2.25	3.56	3	2.27	3.00	3.81	4	1.58	2.25	3.32	4	0.39	1.00	0.87	2	0.00	2.00	3.81	21
Administrative costs	EUR/t	0.25	0.25	0.25	3	0.25	0.25	0.25	1	0.00	0.25	0.25	5	0.25	0.25	0.25	3	0.25	0.25	0.25	4	0.25	0.25	0.25	4	0.25	0.25	0.25	2	0.00	0.25	0.25	22
DIRECT EFFECT	**EUR/t**	**0.63**	**1.55**	**1.68**	**2**	**0.55**	**1.55**	**0.55**	**1**	**0.00**	**1.70**	**2.20**	**5**	**0.94**	**2.15**	**3.81**	**3**	**2.52**	**2.85**	**4.06**	**4**	**0.81**	**2.15**	**3.34**	**4**	**0.39**	**1.10**	**1.12**	**2**	**0.00**	**1.95**	**4.06**	**21**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	EUR/t	0.00	0.00	0.00	1	N.a.	0.00	N.a.	0	0.00	0.00	0.00	5	0.00	0.00	0.00	1	0.00	0.00	0.00	1	0.00	0.00	0.00	4	0.00	0.00	0.00	2	0.00	0.00	0.00	14
Cost increase chemical raw materials	EUR/t	0.00	0.00	0.00	1	N.a.	0.00	N.a.	0	0.00	0.00	0.00	5	0.00	0.00	0.00	1	0.00	0.00	0.00	1	0.00	0.00	0.00	4	0.00	0.00	0.00	2	0.00	0.00	0.00	14
Total cost increase raw materials	**EUR/t**	**0.00**	**0.00**	**0.00**	**1**	**N.a.**	**0.00**	**N.a.**	**0**	**0.00**	**0.00**	**0.00**	**5**	**0.00**	**0.00**	**0.00**	**1**	**0.00**	**0.00**	**0.00**	**1**	**0.00**	**0.00**	**0.00**	**4**	**0.00**	**0.00**	**0.00**	**2**	**0.00**	**0.00**	**0.00**	**14**
Cost increase fuels	EUR/t	0.00	0.00	0.00	1	0.00	0.00	0.00	1	0.00	0.00	0.00	5	0.00	0.00	0.00	3	0.00	0.00	0.00	4	0.00	0.00	0.00	4	0.00	0.00	0.00	2	0.00	0.00	0.00	20
Cost increase electricity	EUR/t	0.17	0.30	0.47	2	0.74	0.50	0.74	1	0.13	0.40	0.51	5	0.26	0.50	0.61	3	0.66	0.70	0.66	1	0.12	0.30	0.41	4	0.45	0.50	0.54	2	0.12	0.50	0.74	18
Total cost increase energy	**EUR/t**	**0.17**	**0.30**	**0.17**	**1**	**0.74**	**0.50**	**0.74**	**1**	**0.13**	**0.40**	**0.51**	**5**	**0.26**	**0.50**	**0.61**	**3**	**0.66**	**0.70**	**0.66**	**1**	**0.12**	**0.30**	**0.41**	**4**	**0.45**	**0.50**	**0.54**	**2**	**0.12**	**0.50**	**0.74**	**17**
INDIRECT EFFECT	**EUR/t**	**0.17**	**0.30**	**0.17**	**1**	**N.a.**	**0.50**	**N.a.**	**0**	**0.13**	**0.40**	**0.51**	**5**	**0.41**	**0.50**	**0.41**	**1**	**0.66**	**0.70**	**0.66**	**1**	**0.12**	**0.30**	**0.41**	**4**	**0.45**	**0.50**	**0.54**	**2**	**0.12**	**0.50**	**0.66**	**14**
3. GROSS EFFECT	**EUR/t**	**1.84**	**1.85**	**1.84**	**1**	**N.a.**	**2.05**	**N.a.**	**0**	**0.51**	**2.10**	**2.49**	**5**	**4.21**	**2.65**	**4.21**	**1**	**3.96**	**3.55**	**3.96**	**1**	**1.11**	**2.45**	**3.46**	**4**	**0.92**	**1.60**	**1.57**	**2**	**0.51**	**2.45**	**4.21**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**0.40**	**1.50**	**1.83**	**2**	**0.30**	**1.50**	**0.30**	**1**	**0.00**	**1.75**	**3.61**	**5**	**0.88**	**2.25**	**3.56**	**3**	**2.27**	**3.00**	**3.81**	**4**	**1.58**	**2.25**	**3.32**	**4**	**0.39**	**1.00**	**0.87**	**2**	**0.00**	**2.00**	**3.81**	**21**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**0.01**	**0.35**	**0.01**	**1**	**N.a.**	**0.55**	**N.a.**	**0**	**-1.93**	**0.35**	**0.51**	**5**	**0.66**	**0.40**	**0.66**	**1**	**0.91**	**0.55**	**0.91**	**1**	**-1.55**	**0.20**	**0.31**	**4**	**0.53**	**0.60**	**0.70**	**2**	**-1.93**	**0.45**	**0.91**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	EUR/t	0.00	0.04	0.00	1	N.a.	0.06	N.a.	0	-0.19	0.04	0.05	5	0.07	0.04	0.07	1	0.09	0.06	0.09	1	-0.16	0.02	0.03	4	0.05	0.06	0.07	2	-0.19	0.05	0.09	14
50% Recovery from price increase	EUR/t	0.00	0.18	0.00	1	N.a.	0.28	N.a.	0	-0.97	0.18	0.25	5	0.33	0.20	0.33	1	0.46	0.28	0.46	1	-0.78	0.10	0.16	4	0.27	0.30	0.35	2	-0.97	0.23	0.46	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	EUR/t	0.01	0.32	0.01	1	N.a.	0.50	N.a.	0	-1.74	0.32	0.46	5	0.59	0.36	0.59	1	0.82	0.50	0.82	1	-1.40	0.18	0.28	4	0.48	0.54	0.63	2	-1.74	0.41	0.82	14
Net effect at 50% recovery from price increase	EUR/t	0.00	0.18	0.00	1	N.a.	0.28	N.a.	0	-0.97	0.18	0.25	5	0.33	0.20	0.33	1	0.46	0.28	0.46	1	-0.78	0.10	0.16	4	0.27	0.30	0.35	2	-0.97	0.23	0.46	14

Scenario: BEST CASE Administrative: DEFAULT Pulp: PRIMARY/SECONDARY		Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
Pass on pulp cost increase: 0	Unit	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	%**	-0.1%	0.0%	-0.1%	1	0.0%	0.0%	0.0%	1	-0.4%	0.0%	0.0%	5	0.0%	-0.1%	0.0%	1	0.0%	-0.1%	0.0%	1	-0.7%	-0.1%	-0.1%	4	0.0%	0.0%	0.0%	2	-0.7%	-0.1%	0.0%	15
Opportunity costs of free allowances	%**	0.4%	0.3%	0.4%	1	0.1%	0.3%	0.1%	1	0.0%	0.3%	0.6%	5	0.6%	0.4%	0.6%	1	0.4%	0.4%	0.4%	1	0.3%	0.8%	1.3%	4	0.1%	0.2%	0.2%	2	0.0%	0.4%	1.3%	15
Administrative costs	%**	0.1%	0.1%	0.1%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.1%	0.1%	0.1%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.1%	15
DIRECT EFFECT	**%****	**0.4%**	**0.4%**	**0.4%**	**1**	**0.1%**	**0.3%**	**0.1%**	**1**	**0.0%**	**0.3%**	**0.3%**	**5**	**0.6%**	**0.3%**	**0.6%**	**1**	**0.5%**	**0.4%**	**0.5%**	**1**	**0.3%**	**0.7%**	**1.3%**	**4**	**0.1%**	**0.2%**	**0.2%**	**2**	**0.0%**	**0.4%**	**1.3%**	**15**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	%**	0.0%	0.0%	0.0%	1	N.a.	0.0%	N.a.	0	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.0%	14
Cost increase chemical raw materials	%**	0.0%	0.0%	0.0%	1	N.a.	0.0%	N.a.	0	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.0%	14
Total cost increase raw materials	**%****	**0.0%**	**0.0%**	**0.0%**	**1**	**N.a.**	**0.0%**	**N.a.**	**0**	**0.0%**	**0.0%**	**0.0%**	**5**	**0.0%**	**0.0%**	**0.0%**	**1**	**0.0%**	**0.0%**	**0.0%**	**1**	**0.0%**	**0.0%**	**0.0%**	**4**	**0.0%**	**0.0%**	**0.0%**	**2**	**0.0%**	**0.0%**	**0.0%**	**14**
Cost increase fuels	%**	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.0%	15
Cost increase electricity	%**	0.0%	0.1%	0.0%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.1%	5	0.1%	0.1%	0.1%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.1%	4	0.1%	0.1%	0.1%	2	0.0%	0.1%	0.1%	15
Total cost increase energy	**%****	**0.0%**	**0.1%**	**0.0%**	**1**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.0%**	**0.1%**	**0.1%**	**5**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.0%**	**0.1%**	**0.1%**	**4**	**0.1%**	**0.1%**	**0.1%**	**2**	**0.0%**	**0.1%**	**0.1%**	**15**
INDIRECT EFFECT	**%****	**0.0%**	**0.1%**	**0.0%**	**1**	**N.a.**	**0.1%**	**N.a.**	**0**	**0.0%**	**0.1%**	**0.1%**	**5**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.0%**	**0.1%**	**0.1%**	**4**	**0.1%**	**0.1%**	**0.1%**	**2**	**0.0%**	**0.1%**	**0.1%**	**14**
3. GROSS EFFECT	**%****	**0.4%**	**0.4%**	**0.4%**	**1**	**N.a.**	**0.4%**	**N.a.**	**0**	**0.1%**	**0.3%**	**0.3%**	**5**	**0.7%**	**0.4%**	**0.7%**	**1**	**0.5%**	**0.5%**	**0.5%**	**1**	**0.4%**	**0.8%**	**1.4%**	**4**	**0.2%**	**0.3%**	**0.3%**	**2**	**0.1%**	**0.5%**	**1.4%**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**0.4%**	**0.3%**	**0.4%**	**1**	**0.1%**	**0.3%**	**0.1%**	**1**	**0.0%**	**0.3%**	**0.6%**	**5**	**0.6%**	**0.4%**	**0.6%**	**1**	**0.4%**	**0.4%**	**0.4%**	**1**	**0.3%**	**0.8%**	**1.3%**	**4**	**0.1%**	**0.2%**	**0.2%**	**2**	**0.0%**	**0.4%**	**1.3%**	**15**
5. OUT-OF-POCKET EFFECT	**%****	**0.0%**	**0.1%**	**0.0%**	**1**	**N.a.**	**0.1%**	**N.a.**	**0**	**-0.3%**	**0.1%**	**0.1%**	**5**	**0.1%**	**0.1%**	**0.1%**	**1**	**0.1%**	**0.1%**	**0.1%**	**1**	**-0.6%**	**0.1%**	**0.1%**	**4**	**0.1%**	**0.1%**	**0.1%**	**2**	**-0.6%**	**0.1%**	**0.1%**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	%**	0.0%	0.0%	0.0%	1	N.a.	0.0%	N.a.	0	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	-0.1%	0.0%	0.0%	4	0.0%	0.0%	0.0%	2	-0.1%	0.0%	0.0%	14
50% Recovery from price increase	%**	0.0%	0.0%	0.0%	1	N.a.	0.0%	N.a.	0	-0.1%	0.0%	0.0%	5	0.1%	0.0%	0.1%	1	0.1%	0.0%	0.1%	1	-0.3%	0.0%	0.0%	4	0.0%	0.1%	0.1%	2	-0.3%	0.0%	0.1%	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	%**	0.0%	0.1%	0.0%	1	N.a.	0.1%	N.a.	0	-0.3%	0.0%	0.1%	5	0.1%	0.1%	0.1%	1	0.1%	0.1%	0.1%	1	-0.5%	0.1%	0.1%	4	0.1%	0.1%	0.1%	2	-0.5%	0.1%	0.1%	14
Net effect at 50% recovery from price increase	%**	0.0%	0.0%	0.0%	1	N.a.	0.0%	N.a.	0	-0.1%	0.0%	0.0%	5	0.1%	0.0%	0.1%	1	0.1%	0.0%	0.1%	1	-0.3%	0.0%	0.0%	4	0.0%	0.1%	0.1%	2	-0.3%	0.0%	0.1%	14

* Investigated lines
** Percent of manufacturing costs

Scenario: "Best case"; Pulp: Primary/Secondary

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: PRIMARY Pass on pulp cost increase: 0.5	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	EUR/t	-1.64	-0.40	-0.09	2	0.20	-0.40	0.20	1	-10.19	-0.60	0.00	5	-0.75	-0.70	0.54	3	0.00	-0.80	0.11	4	-8.41	-0.70	-0.90	4	-1.01	-0.30	0.25	2	-10.19	-0.60	0.54	21
Opportunity costs of free allowances	EUR/t	1.61	6.00	7.34	2	0.98	6.00	0.98	1	0.00	7.00	14.42	5	3.52	9.00	13.69	3	9.08	12.00	15.24	4	6.34	9.00	13.27	4	1.55	4.00	3.23	2	0.00	8.00	15.24	21
Administrative costs	EUR/t	0.25	0.25	0.25	3	0.25	0.25	0.25	1	0.00	0.25	0.25	5	0.25	0.25	0.25	3	0.25	0.25	0.25	4	0.25	0.25	0.25	4	0.25	0.25	0.25	2	0.00	0.25	0.25	22
DIRECT EFFECT	**EUR/t**	**1.77**	**5.85**	**5.95**	**2**	**1.43**	**5.85**	**1.43**	**1**	**0.00**	**6.65**	**8.05**	**5**	**3.03**	**8.55**	**14.48**	**3**	**9.33**	**11.45**	**15.49**	**4**	**2.49**	**8.55**	**12.62**	**4**	**0.79**	**3.95**	**3.72**	**2**	**0.00**	**7.65**	**15.49**	**21**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	EUR/t	0.71	20.00	0.71	1	N.a.	15.00	N.a.	0	14.30	15.00	17.51	5	0.78	15.00	0.78	1	19.12	20.00	19.12	1	0.67	18.00	16.45	4	15.77	18.00	18.54	2	0.67	18.00	19.12	14
Cost increase chemical raw materials	EUR/t	0.17	0.20	0.17	1	N.a.	1.00	N.a.	0	1.28	1.40	2.02	5	1.39	1.50	1.39	1	0.51	0.50	0.51	1	0.18	0.80	1.06	4	1.35	1.40	1.49	2	0.17	1.00	2.02	14
Total cost increase raw materials	**EUR/t**	**0.88**	**20.20**	**0.88**	**1**	**N.a.**	**16.00**	**N.a.**	**0**	**15.76**	**16.40**	**19.54**	**5**	**2.17**	**16.50**	**2.17**	**1**	**19.62**	**20.50**	**19.62**	**1**	**1.20**	**18.80**	**17.22**	**4**	**17.25**	**19.40**	**19.90**	**2**	**0.88**	**19.00**	**19.90**	**14**
Cost increase fuels	EUR/t	0.00	0.10	0.00	1	0.00	0.10	0.00	1	0.00	0.10	0.49	5	0.00	0.10	0.33	3	0.00	0.10	0.05	4	0.00	0.10	0.52	4	0.18	0.10	1.14	2	0.00	0.10	1.14	20
Cost increase electricity	EUR/t	2.34	5.00	8.29	2	10.35	7.00	10.35	1	1.75	5.00	7.06	5	4.50	7.00	8.55	3	9.25	9.00	9.25	1	1.62	4.00	5.73	4	7.84	8.00	9.36	2	1.62	6.00	10.35	18
Total cost increase energy	**EUR/t**	**2.34**	**5.10**	**2.34**	**1**	**10.35**	**7.10**	**10.35**	**1**	**2.24**	**5.10**	**7.06**	**5**	**4.83**	**7.10**	**8.55**	**3**	**9.30**	**9.10**	**9.30**	**1**	**1.62**	**4.10**	**5.73**	**4**	**8.01**	**8.10**	**10.50**	**2**	**1.62**	**6.10**	**10.50**	**17**
INDIRECT EFFECT	**EUR/t**	**3.22**	**25.30**	**3.22**	**1**	**N.a.**	**23.10**	**N.a.**	**0**	**18.47**	**21.50**	**22.86**	**5**	**7.82**	**23.60**	**7.82**	**1**	**28.92**	**29.60**	**28.92**	**1**	**2.82**	**22.90**	**21.75**	**4**	**27.76**	**27.50**	**27.91**	**2**	**2.82**	**25.10**	**28.92**	**14**
3. GROSS EFFECT	**EUR/t**	**9.17**	**31.15**	**9.17**	**1**	**N.a.**	**28.95**	**N.a.**	**0**	**19.99**	**28.15**	**27.91**	**5**	**22.30**	**32.15**	**22.30**	**1**	**41.36**	**41.05**	**41.36**	**1**	**12.65**	**31.45**	**24.24**	**4**	**28.55**	**31.45**	**31.64**	**2**	**9.17**	**32.75**	**41.36**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE!	**EUR/t**	**1.61**	**6.00**	**7.34**	**2**	**0.98**	**6.00**	**0.98**	**1**	**0.00**	**7.00**	**14.42**	**5**	**3.52**	**9.00**	**13.69**	**3**	**9.08**	**12.00**	**15.24**	**4**	**6.34**	**9.00**	**13.27**	**4**	**1.55**	**4.00**	**3.23**	**2**	**0.00**	**8.00**	**15.24**	**21**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**1.83**	**25.15**	**1.83**	**1**	**N.a.**	**22.95**	**N.a.**	**0**	**10.91**	**21.15**	**22.86**	**5**	**8.61**	**23.15**	**8.61**	**1**	**29.28**	**29.05**	**29.28**	**1**	**2.18**	**22.45**	**13.59**	**4**	**27.00**	**27.45**	**28.41**	**2**	**1.83**	**24.75**	**29.28**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	EUR/t	0.18	2.52	0.18	1	N.a.	2.30	N.a.	0	1.09	2.12	2.29	5	0.86	2.32	0.86	1	2.93	2.91	2.93	1	0.22	2.25	1.36	4	2.70	2.75	2.84	2	0.18	2.48	2.93	14
50% Recovery from price increase	EUR/t	0.92	12.58	0.92	1	N.a.	11.48	N.a.	0	5.45	10.58	11.43	5	4.30	11.58	4.30	1	14.64	14.53	14.64	1	1.09	11.23	6.79	4	13.50	13.73	14.20	2	0.92	12.38	14.64	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	EUR/t	1.65	22.64	1.65	1	N.a.	20.66	N.a.	0	9.82	19.04	20.57	5	7.75	20.84	7.75	1	26.36	26.15	26.36	1	1.96	20.21	12.23	4	24.30	24.71	25.57	2	1.65	22.28	26.36	14
Net effect at 50% recovery from price increase	EUR/t	0.92	12.58	0.92	1	N.a.	11.48	N.a.	0	5.45	10.58	11.43	5	4.30	11.58	4.30	1	14.64	14.53	14.64	1	1.09	11.23	6.79	4	13.50	13.73	14.20	2	0.92	12.38	14.64	14

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: PRIMARY Pass on pulp cost increase: 0.5	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *	Min*	Typical	Max*	n *
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	%**	-0.4%	-0.1%	-0.4%	1	0.0%	-0.1%	0.0%	1	-1.6%	-0.1%	0.0%	5	0.1%	-0.1%	0.1%	1	0.0%	-0.1%	0.0%	1	-3.0%	-0.2%	-0.3%	4	-0.2%	-0.1%	0.0%	2	-3.0%	-0.1%	0.1%	15
Opportunity costs of free allowances	%**	1.7%	1.4%	1.7%	1	0.2%	1.0%	0.2%	1	0.0%	1.0%	2.2%	5	2.1%	1.4%	2.1%	1	1.7%	1.7%	1.7%	1	1.4%	3.0%	5.3%	4	0.3%	0.7%	0.6%	2	0.0%	1.5%	5.3%	15
Administrative costs	%**	0.1%	0.1%	0.1%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.1%	0.1%	0.1%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.1%	15
DIRECT EFFECT	**%****	**1.4%**	**1.4%**	**1.4%**	**1**	**0.2%**	**1.0%**	**0.2%**	**1**	**0.0%**	**1.0%**	**1.0%**	**5**	**2.3%**	**1.3%**	**2.3%**	**1**	**1.7%**	**1.6%**	**1.7%**	**1**	**0.9%**	**2.9%**	**5.0%**	**4**	**0.1%**	**0.7%**	**0.7%**	**2**	**0.0%**	**1.4%**	**5.0%**	**15**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	%**	0.2%	4.6%	0.2%	1	N.a.	2.6%	N.a.	0	1.9%	2.2%	2.5%	5	0.1%	2.3%	0.1%	1	2.6%	2.8%	2.6%	1	0.1%	6.0%	5.8%	4	2.6%	3.2%	3.6%	2	0.1%	3.3%	5.8%	14
Cost increase chemical raw materials	%**	0.0%	0.0%	0.0%	1	N.a.	0.2%	N.a.	0	0.2%	0.2%	0.3%	5	0.2%	0.2%	0.2%	1	0.1%	0.1%	0.1%	1	0.1%	0.3%	0.3%	4	0.2%	0.3%	0.3%	2	0.0%	0.2%	0.3%	14
Total cost increase raw materials	**%****	**0.2%**	**4.7%**	**0.2%**	**1**	**N.a.**	**2.7%**	**N.a.**	**0**	**2.0%**	**2.4%**	**2.7%**	**5**	**0.3%**	**2.6%**	**0.3%**	**1**	**2.7%**	**2.8%**	**2.7%**	**1**	**0.4%**	**6.3%**	**6.1%**	**4**	**2.9%**	**3.5%**	**3.8%**	**2**	**0.2%**	**3.5%**	**6.1%**	**14**
Cost increase fuels	%**	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.1%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.2%	4	0.0%	0.0%	0.2%	2	0.0%	0.0%	0.2%	15
Cost increase electricity	%**	0.5%	1.2%	0.5%	1	1.8%	1.2%	1.8%	1	0.3%	0.7%	1.1%	5	0.9%	1.1%	0.9%	1	1.3%	1.2%	1.3%	1	0.6%	1.3%	1.5%	4	1.5%	1.4%	1.6%	2	0.3%	1.1%	1.8%	15
Total cost increase energy	**%****	**0.5%**	**1.2%**	**0.5%**	**1**	**1.8%**	**1.2%**	**1.8%**	**1**	**0.4%**	**0.8%**	**1.1%**	**5**	**0.9%**	**1.1%**	**0.9%**	**1**	**1.3%**	**1.3%**	**1.3%**	**1**	**0.6%**	**1.4%**	**1.6%**	**4**	**1.5%**	**1.5%**	**1.8%**	**2**	**0.4%**	**1.1%**	**1.8%**	**15**
INDIRECT EFFECT	**%****	**0.7%**	**5.9%**	**0.7%**	**1**	**N.a.**	**3.9%**	**N.a.**	**0**	**2.6%**	**3.2%**	**3.7%**	**5**	**1.2%**	**3.7%**	**1.2%**	**1**	**4.0%**	**4.1%**	**4.0%**	**1**	**1.1%**	**7.6%**	**7.7%**	**4**	**4.6%**	**4.9%**	**5.4%**	**2**	**0.7%**	**4.6%**	**7.7%**	**14**
3. GROSS EFFECT	**%****	**2.1%**	**7.2%**	**2.1%**	**1**	**N.a.**	**4.9%**	**N.a.**	**0**	**3.3%**	**4.1%**	**3.9%**	**5**	**3.5%**	**5.0%**	**3.5%**	**1**	**5.7%**	**5.6%**	**5.7%**	**1**	**2.7%**	**10.5%**	**8.6%**	**4**	**4.8%**	**5.6%**	**6.1%**	**2**	**2.1%**	**6.0%**	**8.6%**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE!	**%****	**1.7%**	**1.4%**	**1.7%**	**1**	**0.2%**	**1.0%**	**0.2%**	**1**	**0.0%**	**1.0%**	**2.2%**	**5**	**2.1%**	**1.4%**	**2.1%**	**1**	**1.7%**	**1.7%**	**1.7%**	**1**	**1.4%**	**3.0%**	**5.3%**	**4**	**0.3%**	**0.7%**	**0.6%**	**2**	**0.0%**	**1.5%**	**5.3%**	**15**
5. OUT-OF-POCKET EFFECT	**%****	**0.4%**	**5.8%**	**0.4%**	**1**	**N.a.**	**3.9%**	**N.a.**	**0**	**1.7%**	**3.1%**	**3.7%**	**5**	**1.3%**	**3.6%**	**1.3%**	**1**	**4.0%**	**4.0%**	**4.0%**	**1**	**0.9%**	**7.5%**	**4.8%**	**4**	**4.5%**	**4.9%**	**5.5%**	**2**	**0.4%**	**4.6%**	**5.5%**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	%**	0.0%	0.6%	0.0%	1	N.a.	0.4%	N.a.	0	0.2%	0.3%	0.4%	5	0.1%	0.4%	0.1%	1	0.4%	0.4%	0.4%	1	0.1%	0.7%	0.5%	4	0.5%	0.5%	0.5%	2	0.0%	0.5%	0.5%	14
50% Recovery from price increase	%**	0.2%	2.9%	0.2%	1	N.a.	2.0%	N.a.	0	0.8%	1.6%	1.8%	5	0.7%	1.8%	0.7%	1	2.0%	2.0%	2.0%	1	0.4%	3.7%	2.4%	4	2.3%	2.5%	2.7%	2	0.2%	2.3%	2.7%	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	%**	0.4%	5.3%	0.4%	1	N.a.	3.5%	N.a.	0	1.5%	2.8%	3.3%	5	1.2%	3.3%	1.2%	1	3.6%	3.6%	3.6%	1	0.8%	6.7%	4.3%	4	4.1%	4.4%	4.9%	2	0.4%	4.1%	4.9%	14
Net effect at 50% recovery from price increase	%**	0.2%	2.9%	0.2%	1	N.a.	2.0%	N.a.	0	0.8%	1.6%	1.8%	5	0.7%	1.8%	0.7%	1	2.0%	2.0%	2.0%	1	0.4%	3.7%	2.4%	4	2.3%	2.5%	2.7%	2	0.2%	2.3%	2.7%	14

* Investigated lines
** Percent of manufacturing costs

Scenario: "Most likely"; Pulp: Primary

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: SECONDARY Pass on pulp cost increase: 0.5	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	EUR/t	-1.64	-0.40	-0.09	2	0.20	-0.40	0.20	1	-10.19	-0.60	0.00	5	-0.75	-0.70	0.54	3	0.00	-0.80	0.11	4	-8.41	-0.70	-0.90	4	-1.01	-0.30	0.25	2	-10.19	-0.60	0.54	21
Opportunity costs of free allowances	EUR/t	1.61	6.00	7.34	2	0.98	6.00	0.98	1	0.00	7.00	14.42	5	3.52	9.00	13.69	3	9.08	12.00	15.24	4	6.34	9.00	13.27	4	1.55	4.00	3.23	2	0.00	8.00	15.24	21
Administrative costs	EUR/t	0.25	0.25	0.25	3	0.25	0.25	0.25	1	0.00	0.25	0.25	5	0.25	0.25	0.25	3	0.25	0.25	0.25	4	0.25	0.25	0.25	4	0.25	0.25	0.25	2	0.00	0.25	0.25	22
DIRECT EFFECT	**EUR/t**	**1.77**	**5.85**	**5.95**	**2**	**1.43**	**5.85**	**1.43**	**1**	**0.00**	**6.65**	**8.05**	**5**	**3.03**	**8.55**	**14.48**	**3**	**9.33**	**11.45**	**15.49**	**4**	**2.49**	**8.55**	**12.62**	**4**	**0.79**	**3.95**	**3.72**	**2**	**0.00**	**7.65**	**15.49**	**21**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	EUR/t	0.71	0.75	0.71	1	N.a.	0.70	N.a.	0	14.30	0.70	17.51	5	0.78	0.70	0.78	1	19.12	0.80	19.12	1	0.67	0.75	16.45	4	15.77	0.75	18.54	2	0.67	0.75	19.12	14
Cost increase chemical raw materials	EUR/t	0.17	0.20	0.17	1	N.a.	1.00	N.a.	0	1.28	1.40	2.02	5	1.39	1.50	1.39	1	0.51	0.50	0.51	1	0.18	0.80	1.06	4	1.35	1.40	1.49	2	0.17	1.00	2.02	14
Total cost increase raw materials	**EUR/t**	**0.88**	**0.95**	**0.88**	**1**	**N.a.**	**1.70**	**N.a.**	**0**	**15.76**	**2.10**	**19.54**	**5**	**2.17**	**2.20**	**2.17**	**1**	**19.62**	**1.30**	**19.62**	**1**	**1.20**	**1.55**	**17.22**	**4**	**17.25**	**2.15**	**19.90**	**2**	**0.88**	**1.75**	**19.90**	**14**
Cost increase fuels	EUR/t	0.00	0.10	0.00	1	0.00	0.10	0.00	1	0.00	0.10	0.49	5	0.00	0.10	0.33	3	0.00	0.10	0.05	4	0.00	0.10	0.52	4	0.18	0.10	1.14	2	0.00	0.10	1.14	20
Cost increase electricity	EUR/t	2.34	5.00	8.29	2	10.35	7.00	10.35	1	1.75	5.00	7.06	5	4.50	7.00	8.55	3	9.25	9.00	9.25	1	1.62	4.00	5.73	4	7.84	8.00	9.36	2	1.62	6.00	10.35	18
Total cost increase energy	**EUR/t**	**2.34**	**5.10**	**2.34**	**1**	**10.35**	**7.10**	**10.35**	**1**	**2.24**	**5.10**	**7.06**	**5**	**4.83**	**7.10**	**8.55**	**3**	**9.30**	**9.10**	**9.30**	**1**	**1.62**	**4.10**	**5.73**	**4**	**8.01**	**8.10**	**10.50**	**2**	**1.62**	**6.10**	**10.50**	**17**
INDIRECT EFFECT	**EUR/t**	**3.22**	**6.05**	**3.22**	**1**	**N.a.**	**8.80**	**N.a.**	**0**	**18.47**	**7.20**	**22.86**	**5**	**7.82**	**9.30**	**7.82**	**1**	**28.92**	**10.40**	**28.92**	**1**	**2.82**	**5.65**	**21.75**	**4**	**27.76**	**10.25**	**27.91**	**2**	**2.82**	**7.85**	**28.92**	**14**
3. GROSS EFFECT	**EUR/t**	**9.17**	**11.90**	**9.17**	**1**	**N.a.**	**14.65**	**N.a.**	**0**	**19.99**	**13.85**	**27.91**	**5**	**22.30**	**17.85**	**22.30**	**1**	**41.36**	**21.85**	**41.36**	**1**	**12.65**	**14.20**	**24.24**	**4**	**28.55**	**14.20**	**31.64**	**2**	**9.17**	**15.50**	**41.36**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**1.61**	**6.00**	**7.34**	**2**	**0.98**	**6.00**	**0.98**	**1**	**0.00**	**7.00**	**14.42**	**5**	**3.52**	**9.00**	**13.69**	**3**	**9.08**	**12.00**	**15.24**	**4**	**6.34**	**9.00**	**13.27**	**4**	**1.55**	**4.00**	**3.23**	**2**	**0.00**	**8.00**	**15.24**	**21**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**1.83**	**5.90**	**1.83**	**1**	**N.a.**	**8.65**	**N.a.**	**0**	**10.91**	**6.85**	**22.86**	**5**	**8.61**	**8.85**	**8.61**	**1**	**29.28**	**9.85**	**29.28**	**1**	**2.18**	**5.20**	**13.59**	**4**	**27.00**	**10.20**	**28.41**	**2**	**1.83**	**7.50**	**29.28**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	EUR/t	0.18	0.59	0.18	1	N.a.	0.87	N.a.	0	1.09	0.69	2.29	5	0.86	0.89	0.86	1	2.93	0.99	2.93	1	0.22	0.52	1.36	4	2.70	1.02	2.84	2	0.18	0.75	2.93	14
50% Recovery from price increase	EUR/t	0.92	2.95	0.92	1	N.a.	4.33	N.a.	0	5.45	3.43	11.43	5	4.30	4.43	4.30	1	14.64	4.93	14.64	1	1.09	2.60	6.79	4	13.50	5.10	14.20	2	0.92	3.75	14.64	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	EUR/t	1.65	5.31	1.65	1	N.a.	7.79	N.a.	0	9.82	6.17	20.57	5	7.75	7.97	7.75	1	26.36	8.87	26.36	1	1.96	4.68	12.23	4	24.30	9.18	25.57	2	1.65	6.75	26.36	14
Net effect at 50% recovery from price increase	EUR/t	0.92	2.95	0.92	1	N.a.	4.33	N.a.	0	5.45	3.43	11.43	5	4.30	4.43	4.30	1	14.64	4.93	14.64	1	1.09	2.60	6.79	4	13.50	5.10	14.20	2	0.92	3.75	14.64	14

Scenario: MOST LIKELY Administrative: DEFAULT Pulp: SECONDARY Pass on pulp cost increase: 0.5	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	%**	-0.4%	-0.1%	-0.4%	1	0.0%	-0.1%	0.0%	1	-1.6%	-0.1%	0.0%	5	0.1%	-0.1%	0.1%	1	0.0%	-0.1%	0.0%	1	-3.0%	-0.2%	-0.3%	4	-0.2%	-0.1%	0.0%	2	-3.0%	-0.1%	0.1%	15
Opportunity costs of free allowances	%**	1.7%	1.4%	1.7%	1	0.2%	1.0%	0.2%	1	0.0%	1.0%	2.2%	5	2.1%	1.4%	2.1%	1	1.7%	1.7%	1.7%	1	1.4%	3.0%	5.3%	4	0.3%	0.7%	0.6%	2	0.0%	1.5%	5.3%	15
Administrative costs	%**	0.1%	0.1%	0.1%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.1%	0.1%	0.1%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.1%	15
DIRECT EFFECT	**%****	**1.4%**	**1.4%**	**1.4%**	**1**	**0.2%**	**1.0%**	**0.2%**	**1**	**0.0%**	**1.0%**	**1.0%**	**5**	**2.3%**	**1.3%**	**2.3%**	**1**	**1.7%**	**1.6%**	**1.7%**	**1**	**0.9%**	**2.9%**	**5.0%**	**4**	**0.1%**	**0.7%**	**0.7%**	**2**	**0.0%**	**1.4%**	**5.0%**	**15**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	%**	0.2%	0.2%	0.2%	1	N.a.	0.1%	N.a.	0	1.9%	0.1%	2.5%	5	0.1%	0.1%	0.1%	1	2.6%	0.1%	2.6%	1	0.1%	0.3%	5.8%	4	2.6%	0.1%	3.6%	2	0.1%	0.1%	5.8%	14
Cost increase chemical raw materials	%**	0.0%	0.0%	0.0%	1	N.a.	0.2%	N.a.	0	0.2%	0.2%	0.3%	5	0.2%	0.2%	0.2%	1	0.1%	0.1%	0.1%	1	0.1%	0.3%	0.3%	4	0.2%	0.3%	0.3%	2	0.0%	0.2%	0.3%	14
Total cost increase raw materials	**%****	**0.2%**	**0.2%**	**0.2%**	**1**	**N.a.**	**0.3%**	**N.a.**	**0**	**2.0%**	**0.3%**	**2.7%**	**5**	**0.3%**	**0.3%**	**0.3%**	**1**	**2.7%**	**0.2%**	**2.7%**	**1**	**0.4%**	**0.5%**	**6.1%**	**4**	**2.9%**	**0.4%**	**3.8%**	**2**	**0.2%**	**0.3%**	**6.1%**	**14**
Cost increase fuels	%**	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.1%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.2%	4	0.0%	0.0%	0.2%	2	0.0%	0.0%	0.2%	15
Cost increase electricity	%**	0.5%	1.2%	0.5%	1	1.8%	1.2%	1.8%	1	0.3%	0.7%	1.1%	5	0.9%	1.1%	0.9%	1	1.3%	1.2%	1.3%	1	0.6%	1.3%	1.5%	4	1.5%	1.4%	1.6%	2	0.3%	1.1%	1.8%	15
Total cost increase energy	**%****	**0.5%**	**1.2%**	**0.5%**	**1**	**1.8%**	**1.2%**	**1.8%**	**1**	**0.4%**	**0.8%**	**1.1%**	**5**	**0.9%**	**1.1%**	**0.9%**	**1**	**1.3%**	**1.3%**	**1.3%**	**1**	**0.6%**	**1.4%**	**1.6%**	**4**	**1.5%**	**1.5%**	**1.8%**	**2**	**0.4%**	**1.1%**	**1.8%**	**15**
INDIRECT EFFECT	**%****	**0.7%**	**1.4%**	**0.7%**	**1**	**N.a.**	**1.5%**	**N.a.**	**0**	**2.6%**	**1.1%**	**3.7%**	**5**	**1.2%**	**1.5%**	**1.2%**	**1**	**4.0%**	**1.4%**	**4.0%**	**1**	**1.1%**	**1.9%**	**7.7%**	**4**	**4.6%**	**1.8%**	**5.4%**	**2**	**0.7%**	**1.4%**	**7.7%**	**14**
3. GROSS EFFECT	**%****	**2.1%**	**2.8%**	**2.1%**	**1**	**N.a.**	**2.5%**	**N.a.**	**0**	**3.3%**	**2.0%**	**3.9%**	**5**	**3.5%**	**2.8%**	**3.5%**	**1**	**5.7%**	**3.0%**	**5.7%**	**1**	**2.7%**	**4.7%**	**8.6%**	**4**	**4.8%**	**2.5%**	**6.1%**	**2**	**2.1%**	**2.9%**	**8.6%**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**1.7%**	**1.4%**	**1.7%**	**1**	**0.2%**	**1.0%**	**0.2%**	**1**	**0.0%**	**1.0%**	**2.2%**	**5**	**2.1%**	**1.4%**	**2.1%**	**1**	**1.7%**	**1.7%**	**1.7%**	**1**	**1.4%**	**3.0%**	**5.3%**	**4**	**0.3%**	**0.7%**	**0.6%**	**2**	**0.0%**	**1.5%**	**5.3%**	**15**
5. OUT-OF-POCKET EFFECT	**%****	**0.4%**	**1.4%**	**0.4%**	**1**	**N.a.**	**1.5%**	**N.a.**	**0**	**1.7%**	**1.0%**	**3.7%**	**5**	**1.3%**	**1.4%**	**1.3%**	**1**	**4.0%**	**1.4%**	**4.0%**	**1**	**0.9%**	**1.7%**	**4.8%**	**4**	**4.5%**	**1.8%**	**5.5%**	**2**	**0.4%**	**1.4%**	**5.5%**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	%**	0.0%	0.1%	0.0%	1	N.a.	0.1%	N.a.	0	0.2%	0.1%	0.4%	5	0.1%	0.1%	0.1%	1	0.4%	0.1%	0.4%	1	0.1%	0.2%	0.5%	4	0.5%	0.2%	0.5%	2	0.0%	0.1%	0.5%	14
50% Recovery from price increase	%**	0.2%	0.7%	0.2%	1	N.a.	0.7%	N.a.	0	0.8%	0.5%	1.8%	5	0.7%	0.7%	0.7%	1	2.0%	0.7%	2.0%	1	0.4%	0.9%	2.4%	4	2.3%	0.9%	2.7%	2	0.2%	0.7%	2.7%	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	%**	0.4%	1.2%	0.4%	1	N.a.	1.3%	N.a.	0	1.5%	0.9%	3.3%	5	1.2%	1.2%	1.2%	1	3.6%	1.2%	3.6%	1	0.8%	1.6%	4.3%	4	4.1%	1.6%	4.9%	2	0.4%	1.2%	4.9%	14
Net effect at 50% recovery from price increase	%**	0.2%	0.7%	0.2%	1	N.a.	0.7%	N.a.	0	0.8%	0.5%	1.8%	5	0.7%	0.7%	0.7%	1	2.0%	0.7%	2.0%	1	0.4%	0.9%	2.4%	4	2.3%	0.9%	2.7%	2	0.2%	0.7%	2.7%	14

* Investigated lines
** Percent of manufacturing costs

Scenario: "Most likely"; Pulp: Secondary

Scenario: WORST CASE Administrative: DEFAULT Pulp: PRIMARY Pass on pulp cost increase: 1	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	EUR/t	0.00	0.40	0.36	2	0.40	0.40	0.40	1	0.00	1.00	3.15	5	0.31	1.00	1.22	3	0.45	0.60	0.76	4	0.00	0.30	0.66	4	0.00	0.30	0.49	2	0.00	0.60	3.15	21
Opportunity costs of free allowances	EUR/t	3.21	11.40	14.31	2	1.96	11.40	1.96	1	0.00	13.30	28.84	5	5.82	17.10	27.38	3	17.71	22.80	29.73	4	12.36	17.10	25.87	4	3.10	7.60	6.46	2	0.00	15.20	29.73	21
Administrative costs	EUR/t	0.25	0.25	0.25	3	0.25	0.25	0.25	1	0.00	0.25	0.25	5	0.25	0.25	0.25	3	0.25	0.25	0.25	4	0.25	0.25	0.25	4	0.25	0.25	0.25	2	0.00	0.25	0.25	22
DIRECT EFFECT	**EUR/t**	**3.46**	**12.05**	**14.92**	**2**	**2.61**	**12.05**	**2.61**	**1**	**0.00**	**14.55**	**29.09**	**5**	**7.29**	**18.35**	**28.71**	**3**	**18.41**	**23.65**	**30.74**	**4**	**12.93**	**17.65**	**26.78**	**4**	**3.35**	**8.15**	**7.20**	**2**	**0.00**	**16.05**	**30.74**	**21**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	EUR/t	45.24	140.00	45.24	1	N.a.	125.00	N.a.	0	123.81	125.00	143.37	5	49.39	125.00	49.39	1	156.59	150.00	156.59	1	42.89	140.00	149.99	4	115.86	140.00	145.13	2	42.89	135.00	156.59	14
Cost increase chemical raw materials	EUR/t	0.45	0.60	0.45	1	N.a.	2.80	N.a.	0	3.41	4.00	5.39	5	3.72	4.50	3.72	1	1.35	1.40	1.35	1	0.47	2.20	2.82	4	3.61	4.00	3.96	2	0.45	3.00	5.39	14
Total cost increase raw materials	**EUR/t**	**45.69**	**140.60**	**45.69**	**1**	**N.a.**	**127.80**	**N.a.**	**0**	**127.69**	**129.00**	**148.76**	**5**	**53.10**	**129.50**	**53.10**	**1**	**157.94**	**151.40**	**157.94**	**1**	**45.71**	**142.20**	**152.05**	**4**	**119.83**	**144.00**	**148.74**	**2**	**45.69**	**138.00**	**157.94**	**14**
Cost increase fuels	EUR/t	0.00	0.50	0.00	1	0.00	0.50	0.00	1	0.00	0.50	3.89	5	0.00	0.50	2.65	3	0.00	0.50	0.39	4	0.00	0.50	4.13	4	1.41	0.50	9.11	2	0.00	0.50	9.11	20
Cost increase electricity	EUR/t	6.23	11.00	22.10	2	27.59	15.00	27.59	1	4.67	11.00	18.83	5	12.01	15.00	22.81	3	24.66	22.00	24.66	1	4.32	9.00	15.28	4	20.90	20.00	24.97	2	4.32	12.00	27.59	18
Total cost increase energy	**EUR/t**	**6.23**	**11.50**	**6.23**	**1**	**27.59**	**15.50**	**27.59**	**1**	**7.02**	**11.50**	**18.83**	**5**	**14.66**	**15.50**	**22.81**	**3**	**25.05**	**22.50**	**25.05**	**1**	**4.32**	**9.50**	**15.28**	**4**	**22.32**	**20.50**	**34.08**	**2**	**4.32**	**12.50**	**34.08**	**17**
INDIRECT EFFECT	**EUR/t**	**51.92**	**152.10**	**51.92**	**1**	**N.a.**	**143.30**	**N.a.**	**0**	**138.63**	**140.50**	**155.78**	**5**	**68.17**	**145.00**	**68.17**	**1**	**182.99**	**173.90**	**182.99**	**1**	**50.66**	**151.70**	**166.06**	**4**	**153.91**	**164.50**	**171.06**	**2**	**50.66**	**150.50**	**182.99**	**14**
3. GROSS EFFECT	**EUR/t**	**66.85**	**164.15**	**66.85**	**1**	**N.a.**	**155.35**	**N.a.**	**0**	**147.68**	**155.05**	**171.59**	**5**	**96.87**	**163.35**	**96.87**	**1**	**207.63**	**197.55**	**207.63**	**1**	**73.91**	**169.35**	**187.61**	**4**	**157.26**	**172.65**	**178.25**	**2**	**66.85**	**166.55**	**207.63**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE	**EUR/t**	**3.21**	**11.40**	**14.31**	**2**	**1.96**	**11.40**	**1.96**	**1**	**0.00**	**13.30**	**28.84**	**5**	**5.82**	**17.10**	**27.38**	**3**	**17.71**	**22.80**	**29.73**	**4**	**12.36**	**17.10**	**25.87**	**4**	**3.10**	**7.60**	**6.46**	**2**	**0.00**	**15.20**	**29.73**	**21**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**52.54**	**152.75**	**52.54**	**1**	**N.a.**	**143.95**	**N.a.**	**0**	**141.29**	**141.75**	**158.03**	**5**	**69.50**	**146.25**	**69.50**	**1**	**183.85**	**174.75**	**183.85**	**1**	**51.57**	**152.25**	**166.31**	**4**	**154.16**	**165.05**	**171.80**	**2**	**51.57**	**151.35**	**183.85**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	EUR/t	5.25	15.28	5.25	1	N.a.	14.40	N.a.	0	14.13	14.18	15.80	5	6.95	14.63	6.95	1	18.38	17.48	18.38	1	5.16	15.23	16.63	4	15.42	16.51	17.18	2	5.16	15.14	18.38	14
50% Recovery from price increase	EUR/t	26.27	76.38	26.27	1	N.a.	71.98	N.a.	0	70.65	70.88	79.02	5	34.75	73.13	34.75	1	91.92	87.38	91.92	1	25.78	76.13	83.15	4	77.08	82.53	85.90	2	25.78	75.68	91.92	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	EUR/t	47.28	137.48	47.28	1	N.a.	129.56	N.a.	0	127.17	127.58	142.23	5	62.55	131.63	62.55	1	165.46	157.28	165.46	1	46.41	137.03	149.68	4	138.74	148.55	154.62	2	46.41	136.22	165.46	14
Net effect at 50% recovery from price increase	EUR/t	26.27	76.38	26.27	1	N.a.	71.98	N.a.	0	70.65	70.88	79.02	5	34.75	73.13	34.75	1	91.92	87.38	91.92	1	25.78	76.13	83.15	4	77.08	82.53	85.90	2	25.78	75.68	91.92	14

Scenario: WORST CASE Administrative: DEFAULT Pulp: PRIMARY Pass on pulp cost increase: 1	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	%**	0.1%	0.1%	0.1%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.4%	5	0.2%	0.2%	0.2%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.3%	4	0.0%	0.1%	0.1%	2	0.0%	0.1%	0.4%	15
Opportunity costs of free allowances	%**	3.3%	2.6%	3.3%	1	0.3%	1.9%	0.3%	1	0.0%	2.0%	4.4%	5	4.3%	2.7%	4.3%	1	3.3%	3.1%	3.3%	1	2.6%	5.7%	10.3%	4	0.5%	1.4%	1.2%	2	0.0%	2.8%	10.3%	15
Administrative costs	%**	0.1%	0.1%	0.1%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.1%	0.1%	0.1%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.1%	15
DIRECT EFFECT	**%****	**3.5%**	**2.8%**	**3.5%**	**1**	**0.4%**	**2.1%**	**0.4%**	**1**	**0.0%**	**2.1%**	**4.5%**	**5**	**4.5%**	**2.9%**	**4.5%**	**1**	**3.4%**	**3.3%**	**3.4%**	**1**	**2.8%**	**5.9%**	**10.7%**	**4**	**0.6%**	**1.5%**	**1.4%**	**2**	**0.0%**	**3.0%**	**10.7%**	**15**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	%**	10.5%	32.5%	10.5%	1	N.a.	21.4%	N.a.	0	16.1%	18.4%	21.5%	5	7.7%	19.5%	7.7%	1	21.5%	20.6%	21.5%	1	9.1%	46.7%	53.1%	4	19.4%	25.1%	28.0%	2	7.7%	24.8%	53.1%	14
Cost increase chemical raw materials	%**	0.1%	0.1%	0.1%	1	N.a.	0.5%	N.a.	0	0.5%	0.6%	0.7%	5	0.6%	0.7%	0.6%	1	0.2%	0.2%	0.2%	1	0.2%	0.7%	0.7%	4	0.7%	0.7%	0.7%	2	0.1%	0.6%	0.7%	14
Total cost increase raw materials	**%****	**10.6%**	**32.7%**	**10.6%**	**1**	**N.a.**	**21.8%**	**N.a.**	**0**	**16.6%**	**19.0%**	**22.1%**	**5**	**8.3%**	**20.2%**	**8.3%**	**1**	**21.7%**	**20.8%**	**21.7%**	**1**	**9.7%**	**47.4%**	**53.9%**	**4**	**20.0%**	**25.8%**	**28.7%**	**2**	**8.3%**	**25.4%**	**53.9%**	**14**
Cost increase fuels	%**	0.0%	0.1%	0.0%	1	0.0%	0.1%	0.0%	1	0.0%	0.1%	0.6%	5	0.0%	0.1%	0.0%	1	0.1%	0.1%	0.1%	1	0.0%	0.2%	1.6%	4	0.3%	0.1%	1.5%	2	0.0%	0.1%	1.6%	15
Cost increase electricity	%**	1.4%	2.6%	1.4%	1	4.7%	2.6%	4.7%	1	0.8%	1.6%	3.0%	5	2.4%	2.3%	2.4%	1	3.4%	3.0%	3.4%	1	1.7%	3.0%	3.9%	4	4.0%	3.6%	4.2%	2	0.8%	2.2%	4.7%	15
Total cost increase energy	**%****	**1.4%**	**2.7%**	**1.4%**	**1**	**4.7%**	**2.6%**	**4.7%**	**1**	**0.9%**	**1.7%**	**3.0%**	**5**	**2.4%**	**2.4%**	**2.4%**	**1**	**3.4%**	**3.1%**	**3.4%**	**1**	**1.7%**	**3.2%**	**5.0%**	**4**	**4.3%**	**3.7%**	**5.7%**	**2**	**0.9%**	**2.3%**	**5.7%**	**15**
INDIRECT EFFECT	**%****	**12.1%**	**35.3%**	**12.1%**	**1**	**N.a.**	**24.5%**	**N.a.**	**0**	**18.0%**	**20.7%**	**23.6%**	**5**	**10.7%**	**22.7%**	**10.7%**	**1**	**25.2%**	**23.9%**	**25.2%**	**1**	**13.0%**	**50.6%**	**58.8%**	**4**	**25.7%**	**29.5%**	**33.0%**	**2**	**10.7%**	**27.7%**	**58.8%**	**14**
3. GROSS EFFECT	**%****	**15.5%**	**38.1%**	**15.5%**	**1**	**N.a.**	**26.5%**	**N.a.**	**0**	**20.1%**	**22.8%**	**26.4%**	**5**	**15.1%**	**25.5%**	**15.1%**	**1**	**28.6%**	**27.2%**	**28.6%**	**1**	**15.8%**	**56.5%**	**66.5%**	**4**	**26.3%**	**30.9%**	**34.4%**	**2**	**15.1%**	**30.6%**	**66.5%**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCE	**%****	**3.3%**	**2.6%**	**3.3%**	**1**	**0.3%**	**1.9%**	**0.3%**	**1**	**0.0%**	**2.0%**	**4.4%**	**5**	**4.3%**	**2.7%**	**4.3%**	**1**	**3.3%**	**3.1%**	**3.3%**	**1**	**2.6%**	**5.7%**	**10.3%**	**4**	**0.5%**	**1.4%**	**1.2%**	**2**	**0.0%**	**2.8%**	**10.3%**	**15**
5. OUT-OF-POCKET EFFECT	**%****	**12.2%**	**35.5%**	**12.2%**	**1**	**N.a.**	**24.6%**	**N.a.**	**0**	**18.4%**	**20.8%**	**23.6%**	**5**	**10.9%**	**22.9%**	**10.9%**	**1**	**25.3%**	**24.0%**	**25.3%**	**1**	**13.1%**	**50.8%**	**58.9%**	**4**	**25.8%**	**29.6%**	**33.2%**	**2**	**10.9%**	**27.8%**	**58.9%**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	%**	1.2%	3.5%	1.2%	1	N.a.	2.5%	N.a.	0	1.8%	2.1%	2.4%	5	1.1%	2.3%	1.1%	1	2.5%	2.4%	2.5%	1	1.3%	5.1%	5.9%	4	2.6%	3.0%	3.3%	2	1.1%	2.8%	5.9%	14
50% Recovery from price increase	%**	6.1%	17.7%	6.1%	1	N.a.	12.3%	N.a.	0	9.2%	10.4%	11.8%	5	5.4%	11.4%	5.4%	1	12.6%	12.0%	12.6%	1	6.6%	25.4%	29.5%	4	12.9%	14.8%	16.6%	2	5.4%	13.9%	29.5%	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	%**	11.0%	31.9%	11.0%	1	N.a.	22.1%	N.a.	0	16.6%	18.8%	21.2%	5	9.8%	20.6%	9.8%	1	22.8%	21.6%	22.8%	1	11.8%	45.7%	53.0%	4	23.2%	26.6%	29.8%	2	9.8%	25.1%	53.0%	14
Net effect at 50% recovery from price increase	%**	6.1%	17.7%	6.1%	1	N.a.	12.3%	N.a.	0	9.2%	10.4%	11.8%	5	5.4%	11.4%	5.4%	1	12.6%	12.0%	12.6%	1	6.6%	25.4%	29.5%	4	12.9%	14.8%	16.6%	2	5.4%	13.9%	29.5%	14

* Investigated lines
** Percent of manufacturing costs

Scenario: "Worst case"; Pulp: Primary

Scenario: WORST CASE Administrative: DEFAULT Pulp: SECONDARY Pass on pulp cost increase: 1	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	EUR/t	0.00	0.40	0.36	2	0.40	0.40	0.40	1	0.00	1.00	3.15	5	0.31	1.00	1.22	3	0.45	0.60	0.76	4	0.00	0.30	0.66	4	0.00	0.30	0.49	2	0.00	0.60	3.15	21
Opportunity costs of free allowances	EUR/t	3.21	11.40	14.31	2	1.96	11.40	1.96	1	0.00	13.30	28.84	5	5.82	17.10	27.38	3	17.71	22.80	29.73	4	12.36	17.10	25.87	4	3.10	7.60	6.46	2	0.00	15.20	29.73	21
Administrative costs	EUR/t	0.25	0.25	0.25	3	0.25	0.25	0.25	1	0.00	0.25	0.25	5	0.25	0.25	0.25	3	0.25	0.25	0.25	4	0.25	0.25	0.25	4	0.25	0.25	0.25	2	0.00	0.25	0.25	22
DIRECT EFFECT	**EUR/t**	**3.46**	**12.05**	**14.92**	**2**	**2.61**	**12.05**	**2.61**	**1**	**0.00**	**14.55**	**29.09**	**5**	**7.29**	**18.35**	**28.71**	**3**	**18.41**	**23.65**	**30.74**	**4**	**12.93**	**17.65**	**26.78**	**4**	**3.35**	**8.15**	**7.20**	**2**	**0.00**	**16.05**	**30.74**	**21**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	EUR/t	45.24	45.00	45.24	1	N.a.	40.00	N.a.	0	123.81	40.00	143.37	5	49.39	40.00	49.39	1	156.59	50.00	156.59	1	42.89	45.00	149.99	4	115.86	45.00	145.13	2	42.89	45.00	156.59	14
Cost increase chemical raw materials	EUR/t	0.45	0.60	0.45	1	N.a.	2.80	N.a.	0	3.41	4.00	5.39	5	3.72	4.50	3.72	1	1.35	1.40	1.35	1	0.47	2.20	2.82	4	3.61	4.00	3.96	2	0.45	3.00	5.39	14
Total cost increase raw materials	**EUR/t**	**45.69**	**45.60**	**45.69**	**1**	**N.a.**	**42.80**	**N.a.**	**0**	**127.69**	**44.00**	**148.76**	**5**	**53.10**	**44.50**	**53.10**	**1**	**157.94**	**51.40**	**157.94**	**1**	**45.71**	**47.20**	**152.05**	**4**	**119.83**	**49.00**	**148.74**	**2**	**45.69**	**48.00**	**157.94**	**14**
Cost increase fuels	EUR/t	0.00	0.50	0.00	1	0.00	0.50	0.00	1	0.00	0.50	3.89	5	0.00	0.50	2.65	3	0.00	0.50	0.39	4	0.00	0.50	4.13	4	1.41	0.50	9.11	2	0.00	0.50	9.11	20
Cost increase electricity	EUR/t	6.23	11.00	22.10	2	27.59	15.00	27.59	1	4.67	11.00	18.83	5	12.01	15.00	22.81	3	24.66	22.00	24.66	1	4.32	9.00	15.28	4	20.90	20.00	24.97	2	4.32	12.00	27.59	18
Total cost increase energy	**EUR/t**	**6.23**	**11.50**	**6.23**	**1**	**27.59**	**15.50**	**27.59**	**1**	**7.02**	**11.50**	**18.83**	**5**	**14.66**	**15.50**	**22.81**	**3**	**25.05**	**22.50**	**25.05**	**1**	**4.32**	**9.50**	**15.28**	**4**	**22.32**	**20.50**	**34.08**	**2**	**4.32**	**12.50**	**34.08**	**17**
INDIRECT EFFECT	**EUR/t**	**51.92**	**57.10**	**51.92**	**1**	**N.a.**	**58.30**	**N.a.**	**0**	**138.63**	**55.50**	**155.78**	**5**	**68.17**	**60.00**	**68.17**	**1**	**182.99**	**73.90**	**182.99**	**1**	**50.66**	**56.70**	**166.06**	**4**	**153.91**	**69.50**	**171.06**	**2**	**50.66**	**60.50**	**182.99**	**14**
3. GROSS EFFECT	**EUR/t**	**66.85**	**69.15**	**66.85**	**1**	**N.a.**	**70.35**	**N.a.**	**0**	**147.68**	**70.05**	**171.59**	**5**	**96.87**	**78.35**	**96.87**	**1**	**207.63**	**97.55**	**207.63**	**1**	**73.91**	**74.35**	**187.61**	**4**	**157.26**	**77.65**	**178.25**	**2**	**66.85**	**76.55**	**207.63**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**EUR/t**	**3.21**	**11.40**	**14.31**	**2**	**1.96**	**11.40**	**1.96**	**1**	**0.00**	**13.30**	**28.84**	**5**	**5.82**	**17.10**	**27.38**	**3**	**17.71**	**22.80**	**29.73**	**4**	**12.36**	**17.10**	**25.87**	**4**	**3.10**	**7.60**	**6.46**	**2**	**0.00**	**15.20**	**29.73**	**21**
5. OUT-OF-POCKET EFFECT	**EUR/t**	**52.54**	**57.75**	**52.54**	**1**	**N.a.**	**58.95**	**N.a.**	**0**	**141.29**	**56.75**	**158.03**	**5**	**69.50**	**61.25**	**69.50**	**1**	**183.85**	**74.75**	**183.85**	**1**	**51.57**	**57.25**	**166.31**	**4**	**154.16**	**70.05**	**171.80**	**2**	**51.57**	**61.35**	**183.85**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	EUR/t	5.25	5.78	5.25	1	N.a.	5.90	N.a.	0	14.13	5.68	15.80	5	6.95	6.13	6.95	1	18.38	7.48	18.38	1	5.16	5.73	16.63	4	15.42	7.01	17.18	2	5.16	6.14	18.38	14
50% Recovery from price increase	EUR/t	26.27	28.88	26.27	1	N.a.	29.48	N.a.	0	70.65	28.38	79.02	5	34.75	30.63	34.75	1	91.92	37.38	91.92	1	25.78	28.63	83.15	4	77.08	35.03	85.90	2	25.78	30.68	91.92	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	EUR/t	47.28	51.98	47.28	1	N.a.	53.06	N.a.	0	127.17	51.08	142.23	5	62.55	55.13	62.55	1	165.46	67.28	165.46	1	46.41	51.53	149.68	4	138.74	63.05	154.62	2	46.41	55.22	165.46	14
Net effect at 50% recovery from price increase	EUR/t	26.27	28.88	26.27	1	N.a.	29.48	N.a.	0	70.65	28.38	79.02	5	34.75	30.63	34.75	1	91.92	37.38	91.92	1	25.78	28.63	83.15	4	77.08	35.03	85.90	2	25.78	30.68	91.92	14

Scenario: WORST CASE Administrative: DEFAULT Pulp: SECONDARY Pass on pulp cost increase: 1	Unit	Newsprint				Magazine				Writing				Printing				Tissue				Case materials				Board				ALL			
		Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*	Min*	Typical	Max*	n*
1. DIRECT EFFECT																																	
Costs of scarce emission allowances	%**	0.1%	0.1%	0.1%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.4%	5	0.2%	0.2%	0.2%	1	0.1%	0.1%	0.1%	1	0.0%	0.1%	0.3%	4	0.0%	0.1%	0.1%	2	0.0%	0.1%	0.4%	15
Opportunity costs of free allowances	%**	3.3%	2.6%	3.3%	1	0.3%	1.9%	0.3%	1	0.0%	2.0%	4.4%	5	4.3%	2.7%	4.3%	1	3.3%	3.1%	3.3%	1	2.6%	5.7%	10.3%	4	0.5%	1.4%	1.2%	2	0.0%	2.8%	10.3%	15
Administrative costs	%**	0.1%	0.1%	0.1%	1	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	5	0.0%	0.0%	0.0%	1	0.0%	0.0%	0.0%	1	0.1%	0.1%	0.1%	4	0.0%	0.0%	0.0%	2	0.0%	0.0%	0.1%	15
DIRECT EFFECT	**%****	**3.5%**	**2.8%**	**3.5%**	**1**	**0.4%**	**2.1%**	**0.4%**	**1**	**0.0%**	**2.1%**	**4.5%**	**5**	**4.5%**	**2.9%**	**4.5%**	**1**	**3.4%**	**3.3%**	**3.4%**	**1**	**2.8%**	**5.9%**	**10.7%**	**4**	**0.6%**	**1.5%**	**1.4%**	**2**	**0.0%**	**3.0%**	**10.7%**	**15**
2. INDIRECT EFFECT																																	
Cost increase fibrous raw materials	%**	10.5%	10.5%	10.5%	1	N.a.	6.8%	N.a.	0	16.1%	5.9%	21.5%	5	7.7%	6.3%	7.7%	1	21.5%	6.9%	21.5%	1	9.1%	15.0%	53.1%	4	19.4%	8.1%	28.0%	2	7.7%	8.3%	53.1%	14
Cost increase chemical raw materials	%**	0.1%	0.1%	0.1%	1	N.a.	0.5%	N.a.	0	0.5%	0.6%	0.7%	5	0.6%	0.7%	0.6%	1	0.2%	0.2%	0.2%	1	0.2%	0.7%	0.7%	4	0.7%	0.7%	0.7%	2	0.1%	0.6%	0.7%	14
Total cost increase raw materials	**%****	**10.6%**	**10.6%**	**10.6%**	**1**	**N.a.**	**7.3%**	**N.a.**	**0**	**16.6%**	**6.5%**	**22.1%**	**5**	**8.3%**	**7.0%**	**8.3%**	**1**	**21.7%**	**7.1%**	**21.7%**	**1**	**9.7%**	**15.7%**	**53.9%**	**4**	**20.0%**	**8.8%**	**28.7%**	**2**	**8.3%**	**8.8%**	**53.9%**	**14**
Cost increase fuels	%**	0.0%	0.1%	0.0%	1	0.0%	0.1%	0.0%	1	0.0%	0.1%	0.6%	5	0.0%	0.1%	0.0%	1	0.1%	0.1%	0.1%	1	0.0%	0.2%	1.6%	4	0.3%	0.1%	1.5%	2	0.0%	0.1%	1.6%	15
Cost increase electricity	%**	1.4%	2.6%	1.4%	1	4.7%	2.6%	4.7%	1	0.8%	1.6%	3.0%	5	2.4%	2.3%	2.4%	1	3.4%	3.0%	3.4%	1	1.7%	3.0%	3.9%	4	4.0%	3.6%	4.2%	2	0.8%	2.2%	4.7%	15
Total cost increase energy	**%****	**1.4%**	**2.7%**	**1.4%**	**1**	**4.7%**	**2.6%**	**4.7%**	**1**	**0.9%**	**1.7%**	**3.0%**	**5**	**2.4%**	**2.4%**	**2.4%**	**1**	**3.4%**	**3.1%**	**3.4%**	**1**	**1.7%**	**3.2%**	**5.0%**	**4**	**4.3%**	**3.7%**	**5.7%**	**2**	**0.9%**	**2.3%**	**5.7%**	**15**
INDIRECT EFFECT	**%****	**12.1%**	**13.3%**	**12.1%**	**1**	**N.a.**	**10.0%**	**N.a.**	**0**	**18.0%**	**8.2%**	**23.6%**	**5**	**10.7%**	**9.4%**	**10.7%**	**1**	**25.2%**	**10.2%**	**25.2%**	**1**	**13.0%**	**18.9%**	**58.8%**	**4**	**25.7%**	**12.5%**	**33.0%**	**2**	**10.7%**	**11.1%**	**58.8%**	**14**
3. GROSS EFFECT	**%****	**15.5%**	**16.1%**	**15.5%**	**1**	**N.a.**	**12.0%**	**N.a.**	**0**	**20.1%**	**10.3%**	**26.4%**	**5**	**15.1%**	**12.2%**	**15.1%**	**1**	**28.6%**	**13.4%**	**28.6%**	**1**	**15.8%**	**24.8%**	**66.5%**	**4**	**26.3%**	**13.9%**	**34.4%**	**2**	**15.1%**	**14.1%**	**66.5%**	**14**
4. OPPORTUNITY VALUE OF FREE EMISSION ALLOWANCES	**%****	**3.3%**	**2.6%**	**3.3%**	**1**	**0.3%**	**1.9%**	**0.3%**	**1**	**0.0%**	**2.0%**	**4.4%**	**5**	**4.3%**	**2.7%**	**4.3%**	**1**	**3.3%**	**3.1%**	**3.3%**	**1**	**2.6%**	**5.7%**	**10.3%**	**4**	**0.5%**	**1.4%**	**1.2%**	**2**	**0.0%**	**2.8%**	**10.3%**	**15**
5. OUT-OF-POCKET EFFECT	**%****	**12.2%**	**13.4%**	**12.2%**	**1**	**N.a.**	**10.1%**	**N.a.**	**0**	**18.4%**	**8.3%**	**23.6%**	**5**	**10.9%**	**9.6%**	**10.9%**	**1**	**25.3%**	**10.3%**	**25.3%**	**1**	**13.1%**	**19.1%**	**58.9%**	**4**	**25.8%**	**12.6%**	**33.2%**	**2**	**10.9%**	**11.3%**	**58.9%**	**14**
6. RECOVERY FROM PRICE INCREASE																																	
10% Recovery from price increase	%**	1.2%	1.3%	1.2%	1	N.a.	1.0%	N.a.	0	1.8%	0.8%	2.4%	5	1.1%	1.0%	1.1%	1	2.5%	1.0%	2.5%	1	1.3%	1.9%	5.9%	4	2.6%	1.3%	3.3%	2	1.1%	1.1%	5.9%	14
50% Recovery from price increase	%**	6.1%	6.7%	6.1%	1	N.a.	5.0%	N.a.	0	9.2%	4.2%	11.8%	5	5.4%	4.8%	5.4%	1	12.6%	5.1%	12.6%	1	6.6%	9.5%	29.5%	4	12.9%	6.3%	16.6%	2	5.4%	5.6%	29.5%	14
7. NET EFFECT																																	
Net effect at 10% recovery from price increase	%**	11.0%	12.1%	11.0%	1	N.a.	9.1%	N.a.	0	16.6%	7.5%	21.2%	5	9.8%	8.6%	9.8%	1	22.8%	9.3%	22.8%	1	11.8%	17.2%	53.0%	4	23.2%	11.3%	29.8%	2	9.8%	10.2%	53.0%	14
Net effect at 50% recovery from price increase	%**	6.1%	6.7%	6.1%	1	N.a.	5.0%	N.a.	0	9.2%	4.2%	11.8%	5	5.4%	4.8%	5.4%	1	12.6%	5.1%	12.6%	1	6.6%	9.5%	29.5%	4	12.9%	6.3%	16.6%	2	5.4%	5.6%	29.5%	14

* Investigated lines
** Percent of manufacturing costs

Scenario: "Worst case"; Pulp: Secondary