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Performance Targets in Production Processes (PT-PRO)

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Foreword

The Environmental Technologies Action Plan (ETAP) has the aim of stimulating the developments and diffusion of environmental technologies. One of its main actions is the definition of performance targets:

"*Setting ambitious targets to improve the environmental performance of technologies within a given timeframe. This should encourage technological development while preparing the markets to accept and prepare for these high standard environmental technologies*".

This report is based on the outcome of the project about Performance Targets for Industry Processes (PT-PRO project) launched by the DG JRC (IPTS) on request of DG Environment, with the objective to study the needs and conditions to implement the concept of Performance Targets for Industry. The project was carried out by ITA, ÖAW, GMV/IVL, FEA and TNO.

The project was carried out through a combination of desk-research work and limited discussions with some experts and stakeholders. It has designed a general method and provided examples for four industry cases in order to illustrate how Performance Targets could be defined for a specific sector taking into account of its situation (technologies, market, environmental problems and existing legislation).

1 EXECUTIVE SUMMARY

1.1 Background and objectives

One of the main actions of the European Environmental Technologies Action Plan (ETAP) is: "*Setting ambitious targets to improve the environmental performance of technologies within a given timeframe. This should encourage technological development while preparing the markets to accept and prepare for these high standard environmental technologies*"[1]

"*Setting targets that are both long term and visionary as well as perceived as being viable and realistic by many different stakeholders (e.g. consumers, producers and policymakers) is one way to encourage industry to develop and take up environmental technologies. These targets need to be based on best environmental performance, while being realistic from an economic and social efficiency view point, as well as different regional conditions. This means focusing on concrete quantifiable values.*"

On request of DG Environment, the JRC-IPTS launched a project on Performance Targets for Industry Processes (PT-PRO project), with the objective to further define concepts and to identify the conditions necessary to implement the concept of Performance Targets. The project was carried out with the help of ITA/ ÖAW, GMV/IVL, FEA and TNO.

The project carried out a desk research and organised limited discussions with some experts and stakeholders. This report provides:

- a definition of the main elements of PT and an overview of the general principles for the implementation of PT,
- an illustration of these different elements for PT formulation in relation with a range of industry situations with their most typical environmental challenges, existing regulations, technical potentials, market situations and their organisational structure. To this end, **four case study sectors** were selected for further analysis from ten sectors. These are: the iron & steel, cement, pulp & paper and the textile industries.

These case studies and resulting conclusions should not be considered as recommendations for setting PT for these specific cases, but, instead as some preliminary exercises aimed at drawing relevant indications with respect to different key questions like:

- Could PT represent an additional incentive for the industry towards higher environmental performances?
- What could be the best conditions for PT?
- What could be the limitations?

1.2 Principles and key issues for the implementation of PT

Performance targets (PT) can be defined as quantified long-term objectives for the environmental performance of a product, a group of products, a service or a production process. In ETAP, PT are envisaged to be **voluntary** and to be developed in a dialogue with stakeholders concerned by the PT scheme envisaged.

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[1] http://europa.eu.int/comm/environment/etap/implementing.htm

For industrial processes, PT should cover key parameters of the processes concerned and give companies flexibility about areas for improvement and not prescribe technological choices.

Performance targets (PT) may address different stages of the process of technological change. This report focuses on the diffusion of options for reducing environmental impacts.

Introducing PT for one industry sector should be based on a prior evaluation of its added value to the regulatory system in place, in encouraging the sector to achieve higher environmental performance by fully utilising eco-technologies.

PT can be established at different geographical levels but they would be more efficient at EU level.

The decision about, and the approach for, PT implementation must be taken in the light of an assessment of the environmental background, regulation background, technological background, market background and environmental management capacities. The parameters characterising these issues are given in Table 1 which can be seen as a non exhaustive checklist for target setting.

Area	Parameter
Environmental background	Dominating environmental parameters
	Significance of sector emissions
Regulation background	Relevant regulations
Technological background	Available and emerging technologies addressing the dominating environmental problems of the sector/plant
	Process chain complexity (multi-products, multi steps)
	National differences
Market background	Market structure (business to business versus end consumer market)
	SME and large companies
	Investment intensity of the sector
	Willingness of customers
Environmental management capacities	Implemented environmental management systems

Table 1: Background information required for setting PT

The analysis of this background information should aim to address the main questions:

- Would PT represent an added value to the existing environmental policy framework?
- Which functional unit should be considered (process, plant, sector,…)? Where should the boundaries of the systems be set (only direct impacts or also upstream impacts)?
- Which environmental problems and parameters should be considered? Should the different parameters be aggregated in a single target (single emissions or a total of emissions)?
- Which timescale and update frequency should be considered in order to reflect technological possibilities, the typical investment cycles, the investment situation of the sector/plant, etc?
- What implementation and monitoring schemes should be used?

The industry is not a homogeneous block and there is obviously no unique set of answers to the above questions. The sector case studies carried out in the PT Project illustrate how the specific situations could influence the conclusion and choices.

Achieving robust conclusions at a sector level regarding the necessity, nature and shape of PT would actually require an in-depth assessment of improvement potentials for the long term, the extent to which existing policies support the innovation and the diffusion of new technologies and the optimal conditions and format of the target(s). This report provides a first overview to the results from the four case studies.

1.2.1 Regulatory framework and performance targets

There is evidence that **many environmental aspects are already regulated,** especially those that are associated with industry installations (e.g. the Integrated Pollution Prevention and Control Directive (IPPC), the National Emission Ceilings Directive (NEDC), the Emission Trading System (ETS) Directive and, the Large Combustion Plants Directive (LCP).

So far, only new installations have been subjected to the obligations of the **IPPC Directive,** which means that the consequences can not be fully assessed. The requirements of the Directive will only be fully implemented in all Member states by October 2007 when all eligible industrial installations (including the existing ones) must have an IPPC permit.

The **ETS Directive** has introduced a cap-and-trade system for CO2 emissions first for the period 2005-2007 and then for the period 2008-2012.

The **NECD (National Emission Ceilings Directive)** and its Annex I establishes national air emission ceilings by the year 2010. The Member States are responsible for implementing appropriate measures to comply with the national emission ceilings. The Directive is expected to be reviewed this year (2007) in the light of the EU's Thematic Strategy on Air Pollution and targets for a longer term horizon (2020) will be proposed.

A detailed analysis of the fraction of environmental impacts associated with the European industry covered by the existing legislation would be needed before establishing PT. However, one can consider that many of them are covered in sectors such as iron and steel, cement and pulp and paper. As the textile industry is dominated by SME's, a lower fraction of its environmental impacts is likely to be concerned. But a quantification is not possible due to the weak environmental information about SMEs.

This report provides an overview about the emerging technologies which could be encouraged by PT in the four case studies considered. This exercise suggests that potential for improvement exists in all four cases studied. It should, however, be extended in order to assess the technical potential achievable beyond the time schedule and the requirements of these existing regulations.

In addition, although the project identified particularly promising technological developments, this does not automatically suggest that PT would systematically contribute to their development and market diffusion: Autonomous research efforts are currently being made by the industry in order to achieve drastic performance improvements. This is, for instance, the case of the iron and steel industry ULCOS project, which may, to a substantial extent, be driven by the perceived need to anticipate very ambitious CO2 emission targets in the future.

This could be seen as evidence that under the existing policy framework and with a possible anticipation of its future development, at least some industry sectors already find incentives for eco-innovation.

The project indeed found evidence from both the US and the EU that the environmental policy instruments stimulate **eco-innovation**. It is also suggested, by both the economic theory and by the empirical literature, that market-based instruments have a stronger impact on the rate and the direction of technological changes than non-market instruments.

The ability of current policies to drive eco-innovation depends on the policy and on what it is targeting. There are successful policies and failing ones.

The **IPPC Directive** will no doubt accelerate the diffusion of eco-technologies. The exact impact on innovation is however not as clear: first it is based on emission levels achievable through BAT and second, it does not provide enough opportunity for updating nor does it define long term targets for improvement.

It has also been shown that the **EU emissions trading** scheme (ETS), which is the other major policy instrument affecting many of the industry sectors, has an effect on long-term decisions made in the sector and on innovation: For 50% of the companies, the EU ETS plays a key role in long-term decisions and for 48% it is only one of many other issues that need to be considered.

This finding is of particular relevance for innovation in energy technologies, on CO2 emissions reduction and, indirectly, on other energy-related impacts (air pollution).

It can also be expected that the new **Water Framework Directive** will trigger innovations.

Together, these findings support the idea that if performance targets are envisaged for industrial processes, they should only be seen as **complementary tools** to the existing policy tools.

Therefore, the time horizon for, and the dynamic character of, PT have to be defined bearing in mind the existing policy framework, the typical investment cycles and the possible incremental improvements in the sector.

In general, the time horizon in the **existing legislation** does not go beyond 2015. This time horizon will probably be extended further, at least with the future NEC targets and as a result of the new climate change targets beyond 2012 (see the recent Communication on limiting global climate change to 2 degrees Celsius).

It is also important to have in mind that many **investments** for improved processes are capital intensive and would thus need a long time. In addition, radical improvements need time to be achieved because they would rely on more research and developments.

All this supports long term ambitious targets. These could be **regularly updated** with a view to, as much as possible, stimulate changes that are achievable with more modest investments. It will indeed be crucial for all sectors that the stakeholders are fully aware of tougher demands in the future, in order to send out the right signals to those who develop and implement the technological solutions of tomorrow. This would also better reward proactive companies that are likely to be in a position to comply with e.g. a 3-year target, or those who will be able to in the near future. Thre is no problem if these companies could take advantage of their pioneering efforts.

Shorter targets could be justified for the industrial companies that are not so well covered by the existing legislation and those that are characterised by shorter investment cycles (basically **SME**s).

If necessary, new parameters could be included which could take new scientific knowledge about environmental impact into account whereas other parameters could be excluded, because of their declining importance. This again should fully **consider the evolving policy framework**.

In addition, as suggested by successful examples of voluntary agreements, linking a PT system to some regulatory instruments may increase its efficiency. For instance, this could consist of tax exemption or subsidies.

1.2.2 Definition of PT

Experience with voluntary instruments, and more specifically with energy efficient convenants in several countries provide evidence that a system where **targets simultaneously involve the whole** sector (as represented by the sector federation) **and the individual plants/companies** would enable the reduction of monitoring and make verification feasible. It would also offer sufficient flexibility within sectors if the necessary efforts (investments) are going to be distributed.

The level of disaggregation in terms of industrial activity and outputs has to be made based on three criteria:

- the need to specify a unit for which environmental flows can be simply **allocated and measured**, which should be based on the degree of complexity of the process chain (multi-products, energy and material recovery, by-products,…). Setting targets for complex sectors like textiles would be more difficult than for sectors with a lower degree of complexity like the cement industry
- the need to make the **monitoring** and verification feasible
- the need to allow a sufficient degree of **flexibility** within a sector when distributing the necessary efforts and investments.

Whatever level of definition is ultimately chosen (sector/company), a decision has also to be taken regarding the level of **integration of the impacts** considered:

- Integration regarding the process/product chain (sector versus upstream processes), with a view to avoid sub-optimisation of the instrument while also seeking system easy which is implement and monitor. A life cycle approach seems attractive as it is more comprehensive, but it would also make the system complex to monitor and verify. The sectoral approach is likely to be the most appropriate for the basic industry sectors (those mainly relying on raw materials), whereas a life cycle perspective could be envisaged for sectors producing final products in order to encourage them reducing their direct and also indirect impacts.
- Integration of the different environmental flows: all four case studies suggest that several environmental flows should be considered. The project could not however address the question of how to integrate these different environmental flows within a common target system.

1.2.3 Monitoring

A **self-monitoring system** built upon existing monitoring schemes would give flexibility to the companies. Guidelines could be given regarding the reporting format and the perimeters for reporting. This system would however be the least reliable.

Monitoring could be carried out by **external parties** (authorised verification bodies). However, this would be a duplication of effort, since companies are already monitoring some of their inputs (energy for instance) and their emissions. These monitoring activities result, in many cases, from a regulation requirement.

A compromise would be a system where the results are measured by the company and checked by an external party.

1.2.4 Example of possible PT schemes

Many environmental flows generated by industrial processes are already regulated. Natural resources can be seen as the main exception. Therefore, this environmental area could be relevant for a voluntary approach, especially when considering PT (also in connection with waste and recycling). If such an outcome were to be included in performance targets, there would be an added incentive for the integrated improvement of the environmental process performance. This would also be in line with the Strategy proposed by the Commission on the the sustainable use of resource (COM(2005) 670 final).

Resource efficiency-type voluntary targets are likely to offer incentive to participating companies because of higher profits resulting from reduced manufacturing costs. The scale of such a benefit should, however, be prior assessed and would vary from one sector to another.

If such an approach is envisaged, a series of questions should be *ex ante* assessed:

- the actual added value of having such a target would depend very much on the sector, notably because the energy component of the resource is actually targeted in existing policy instruments, especially as far as energy intensive sectors are concerned
- resource efficiency is already being improved to some extent. The reasons why resource efficiency is not increasing more rapidly should be analysed in order to know how PT could best support further improvements
- the implications of having resource efficiency targets set on non-energy components like raw materials, water, soils, etc. should be analysed. For instance, raw material processing is, together with energy transformation, the source of emissions to air, water and soils, which are somehow already targeted in existing legislation. Therefore, we would need to analyse the added value of setting targets for input parameters compared to existing targets for output parameters.

Two illustrative PT cases have been developed in order to exemplify the PT concept. One of them focuses on one environmental issue – resource efficiency, and the second focuses on implementation. The selection of the two examples was guided by the following considerations: PT should be technology neutral, regurlarly updated and attractive to industry.

The first proposal is a ***general target for resource efficiency improvement*** (improve resource efficiency by *x*% in *y* years). The target could be set at company/plant level or at a higher level.

Companies willing to be involved in this scheme could be asked to elaborate improvement programmes to be discussed with the environmental authorities.

Resource efficiency could include issues like (non-renewable) energy use, water consumption and raw material use[2]. Improvement does not have to be uniform in all three areas. If, for instance, a 25% improvement is targeted, under a weighting system, companies could opt for a 20% or 30% reduction in energy use, a 20% or 30% reduction in water consumption and a 25% or 15% reduction in the use of raw materials. The percentages and weights could be differentiated for sectors.

The advantages of such a PT system are the followings:

- it targets something that is not completely covered by policy (resource efficiency)
- it is a simple model which allows for different choices (which makes is efficient);
- it involves a tool for achieving this (an improvement programme designed by companies);
- it can be applicable to all companies, including SMEs;
- it is dynamic, thus allowing adaptation.

Such a PT system does not preclude the use of energy taxes or taxes/charges for waste disposal and water use, and does not interfere with IPPC and current regulations. The improvement plan fits with ISO 14000

[2] Waste volumes could also be used as a measure but as there are so many types of waste, some of which are very hazardous, a PT would be difficult to formulate. To a lesser extent, the same is true for resources.

and EMAS in which there is already an obligation for achieving continuous improvement. It could be linked with eco-label schemes as the requirement of resource efficiency could be a criterion.

The second proposal is one of *a **dynamic classification scheme*** for products based on the environmental performance of their production (similar to the Top Runner programme in Japan). The parameters considered could be the resource efficiency or a set of key environmental parameters. This could be designed as a classification scheme of products in class, e.g. B, A, and A+, based on a weighted average of the chosen parameters or on the absolute values of each individual parameter.

The dynamic nature of the system would be announced to the stakeholders from the beginning. The targets could be formulated as ratios of sold products in different classes at a certain year. Depending on the performance levels assigned to the classes, the goal could be the outphasing the worst products, the increase of the market penetration of the "good", or even the stimulation of innovation. Targets could be formulated both for individual companies and for the whole sector in a similar manner.

The time horizon depends on which case is chosen. However, the frequency of changes between steps in the classification should be high enough (2-3years). The tentative long term evolution of the levels in the classification schemes must be clearly announced, in order to send out the right signals to both producers and customers, and to facilitate the investment plans for the producers.

Like in successful examples of voluntary agreements, the scheme could be linked with other policy actions and measures. This could be the withdrawal of plans for future more stringent legislation, tax reimbursements, subsidies, "eco-labels" for the firms that could fulfil the agreements, a more lenient treatment from the permit authorities, and so forth.

Some naming and shaming, awards for the most resource efficient companies, certificates for the companies that fulfil the targets could represent efficient incentives. The incentive structure should be adapted to the number of SMEs concerned. Market activities like product labelling and green public procurement could also represent incentive instruments by the fact that they provide possibilities of increasing market shares.

The great advantage is that the power of the different customers could come into play if they base their purchase decisions on environmental performance.

This scheme is somewhat more complex in terms of monitoring because the resource efficiency or environmental performance must be established per product. This could, e.g. yield allocation problems if the manufacturing process is complicated with parallel production lines and so forth. The monitoring could be undertaken by the companies themselves, or by an independent body, like in the ISO14001/EMAS systems.

These proposals were discussed with a limited number of stakeholders, who suggested the followings:

- the first model would be more applicable for ***textiles*** as this sector has severe allocation problems due to the very complex and diverse process structure. This makes it unsuitable for the second model. The customers in the ***steel*** sector are more unlikely to take green purchasing decisions. This, together with the fact that there are numerous types of steel qualities, the applicability of the second model for the steel sector.

- the second model is applicable to the ***cement*** and to the ***pulp and paper*** sector. The reasons are that it seems possible to assign environmental impacts to products. Another important criterion is that for these two sectors there might be proactive consumers that could make green purchasing decisions.

2 INTRODUCTION

The EU´s Lisbon Strategy was adopted in March 2000 and aims to make the EU the most dynamic and competitive economy by 2010. The strategy identifies economic, social and environmental aspects as key to growth. Eco-innovations and environmental technologies can make an important contribution towards this goal. The main policy to stimulate the developments and diffusion of environmental technologies is the European Environmental Technologies Action Plan (ETAP). One of its main actions is "*Setting ambitious targets to improve the environmental performance of technologies within a given timeframe. This should encourage technological development while preparing the markets to accept and prepare for these high standard environmental technologies*"[3]

"Setting targets that are both long term and visionary as well as perceived as being viable and realistic by many different stakeholders (e.g. consumers, producers and policymakers) is one way to encourage industry to develop and take up environmental technologies. These targets need to be based on best environmental performance, while being realistic from an economic and social efficiency view point, as well as different regional conditions. This means focusing on concrete quantifiable values."

PT for production processes should be a clear signal to developers and processes users and even to other stakeholders on the market. To deal with the complexity of industrial sectors, the targets should be formulated in a way that makes it possible for different stakeholders to join the system.

The PT-PRO project on which this report is based has studied the conditions necessary to implement the concept of Performance Targets for **Industry Processes** that meant to help an entire branch of industry achieve a considerably lower level of environmental impact by fully utilising the options offered by new technologies.

It designs a general method and provides examples for four industrial cases in order to illustrate how PT could be defined for a specific sector, taking into account of its situation (technologies, market, environmental problems and existing legislation).

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[3] http://europa.eu.int/comm/environment/etap/implementing.htm

3 METHODOLOGY

The project was carried out a desk research work and limited discussions with some experts and stakeholders. The desk research was first to define different concepts for PT and develop a scheme where the different elements for PT formulation, implementation and monitoring were analysed in general, considering their advantages and disadvantages. This made used of lessons learnt from some existing experiences in voluntary approaches and performance targets (see Chapter 4)[4].

Then, the project considered four case study sectors with a view to appraising these different elements for PT formulation in relation with a range of industry situations with their most typical environmental challenges and existing regulations, their technical potential, their market situation and also their organisational structure. Sectors selected were the iron & steel, cement, pulp & paper and the textile industries (see Chapter 0 and Appendix II).

These case studies and resulting conclusions should not be considered as recommendations for setting PT for these specific cases, but, instead as some preliminary exercises aimed at drawing relevant indications with respect to different key questions like:

- Could PT represent an additional incentive for the industry towards higher environmental performances?
- What could be the best conditions for PT?
- What could be the limitations?

[4] Top runner, ACEA agreement, Branch agreements about energy in some countries

4 OBJECTIVES OF PERFORMANCE TARGETS AND PRINCIPLES FOR IMPLEMENTATION

Performance targets (PT) can be defined as quantified long-term objectives for the environmental performance of a product, a group of products, a service or a production process.

In ETAP, PT are envisaged to be **voluntary**, at least to begin with. They are intended to contribute to improve the market conditions for environmental technologies.

Performance targets (PT) may be used for three purposes:

- to stimulate the development of innovations.
  PT examples could be R&D goals, pilot, collaborative innovation projects on a specific topic (e.g. water pollution, substance)
- to stimulate the market diffusion of options for reducing environmental impact (which may be technological, organisational or managerial)
  PT examples could be the time by which existing facilities must meet standards for new processes.
- to phase out low performance and/or hazardous processes.
  An example could be to set the time by which a "dirty" process or certain substance must be abandoned.

This report focuses on the diffusion of options to reduce environmental impacts.

Targets should give direction to decision-making by telling companies what is required or expected (signalling function). Targets not only specify a goal but may also help companies to achieve it.

PT should only be considered if:

- there is a *real benefit* in having a PT that exceeds any disbenefits (possibly in terms of competitive disadvantages, administrative burden). It shouldn't entail *problem shifting* due to favoured solutions.
- the problem addressed by the PT cannot be addressed more efficiently in some other ways.
-

Ideally performance targets should

- be representative
- be simple and easy to interpret and communicate
- give a clear signal to producers and customers
- be quantifiable and attached to specific measurable parameters of key products, services or processes
- be capable of triggering innovation and/or of improving market conditions for the environmentally-friendly technologies
- be capable of being upgraded at regular intervals
- be scientifically valid, based on data adequately documented and of a known quality
- show changes and trends over time
- be formulated in a dialogue between many different stakeholders
- be used to set long term goals for resource efficiency; and
- be non-legislative, building on the economic interest of customers and producers to phase out unsustainable technologies.

They should also cover key parameters and should give companies flexibility on areas for improvement and not prescribe technological choices.

Differentiation between companies, sectors and possibly nations may be needed or warranted to allow for flexible implementation as some companies will be harder hit by a target than others; also, local environmental circumstances may call for a different approach.

5 VOLUNTARY AGREEMENTS

5.1 Experiences from existing voluntary agreements

Performance targets can be regarded as an agreement to fulfil a certain environmental objective. Sometimes it is set by one company[5]. But most often the targets are set in discussions between a public authority and the sector or companies.

There is a reasonable number of examples of such agreements[6]. Some of the examples have been voluntary, so-called voluntary agreement, like the ACEA Agreement.[7]

Other examples were introduced and were legally supported, like the Top Runner programme introduced in Japan in 1999 as part of the revision of the Law concerning the rational use of energy (Energy Conservation Law). Both mandatory and voluntary information tools are employed to disseminate information on the energy efficiency achieved by the products under the programme. The standards set in the Programme are utilized in a couple of policy legislation, such as the Green Purchasing Law and the green automobile tax scheme. There has also been an annual award provision for energy efficient products and systems since 1990 .

An other example is the Californian Low Emission Vehicle (LEV) programme.

Voluntary agreements (VA) fall in to two main categories:

- the first category in which the **environmental performance is related to the products** (mainly to the actual environmental performance of the products). The ACEA Agreement, the Top Runner programme and the California LEV-programme fall under this first category

- the second one where the **performance of the sector/companies/plants** are considered. Expamples are the energy efficiency programmes in the Netherlands and Denmark (Krarup and Ramesohl 2000; Delmas and Terlaak 2002).

An other example of the second category is the Stora Enso initiative that has defined Group level environmental performance targets for emissions, energy, and fibre acceptability to maintain and achieve industry-leading performance on sustainability and environmental issues. Environmental performance is monitored and reported by each production unit. Progress towards achieving the targets is monitored at Group level as weighted averages. The progress is reported annually in the sustainability seport. The targets were established in autumn 2004. They were formulated by identifying the most critical environmental issues, evaluating various monitoring methods, and incorporating stakeholder priorities. At an earlier phase, Stora Enso's environmental targets were unit-specific.[8].

[5] An example of a sector which has set its own performance target is the UK meat industry. http://www.foodanddrinkeurope.com/news/ng.asp?id=15309-performance-targets-high

[6] UNEP 2000 mentions more than 300 voluntary agreements only in EU 15 alone.

[7] The ACEA (**A**ssociation des **C**onstructeurs **E**uropéens d'**A**utomobiles) Agreement is a voluntary agreement by the European automobile manufacturers association and the European Commission to reduce carbon dioxide (CO_2) emissions rates of vehicles sold in the European Union to a new fleet average of 140 grams of CO2 per kilometre by 2008. If the industry fails to meet the target, the Commission is expected to adopt formal regulations to reduce CO_2 emissions from new passenger vehicles.

[8] http://www.storaenso.com/CDAvgn/main/0,,1_-6174-13560-,00.html

Benefits	Limits
Key advantages of successful voluntary agreements are: Long-term cultural changes in business management. Shift from reactive, end-of-pipe, and financial-cost attitudes to proactive, cleaner production, economic savings behaviour Improved dialogue and trust between industry and government and industry and the public, leading to more co-operative relationships. Greater flexibility than regulations, particularly in complex or rapidly changing contexts, offering more ambitious goals, lowering administrative and enforcement costs, and faster implementation than with legislation.	Voluntary agreements can not, on their own: Be applied in areas where there is no business self-interest. The voluntary approach is limited to areas where there is a business interest (e.g. cost-effectiveness, public recognition, avoidance of future regulations, etc) in voluntarily changing behaviour Deal with free riders. Voluntary measures are unable to incite all companies to invest in environmental protection and can not, on their own, deal with negligent or consistently poor performers. Set or enforce emission limits or discharge requirements for individual facilities. Ensure global application. Voluntary measures will need to be developed and applied differently in different cultural and socio-economic contexts. This makes it difficult to ensure that voluntary environmental commitments are equally met globally.
Source: UNEP (2000)	

Table 2: Benefits and limits of voluntary agreements

No comprehensive review study of successes and failures of all types of voluntary agreements could be found. However, some results and conclusions are presented here:

- VA should address individual companies to avoid the potential **free rider problem** or "no-one bothers problem". Also the sector approaches of the Dutch and Danish programmes demonstrated the importance of communication with individual companies, even though the overall target was formulated for a whole sector. The approach of the second phase of the Dutch example was more individually oriented than the first. In the rather successful Top Runner and California LEV programmes, the individual companies were addressed from a legislative point of view. In ACEA Agreement, only the branch organisations took part in the agreement. Despite improvements regarding energy efficiency of new cars, data show that these are not sufficient and that the target will not be met in 2008

- They efficiency is often higher when they are used in **combination with other incentives** (used as enforcement). The voluntary agreements in a whole sector, e.g. in the Netherlands and in Denmark, that also were quite successful, were backed up by tax reimbursements, exemption from compliance to other instruments, reduced surveillance by authorities, long national traditions of co-operation between public bodies and companies (Price 2005)

- When it is difficult to **allocate the correct environmental impact to each single process/product** entity, the sector/company approach could be the best.

With regard to additional requirements for dealing with voluntary agreements (as even given in *Table 2*) UNEP 2000 draws attention to the limited time and resources of partners during the planning and monitoring phases.

Voluntary approaches have recently be reviewed by Arthur D. Little[9]: *"The research on VAs reaches relatively lukewarm conclusions regarding their impact on* ***environmental performance****. However, there is a lack of empirical evidence, and all the studies reviewed use a case study approach. More encouraging is the anecdotal evidence on the success of VAs negotiated with a single firm, although this will need to be explored more thoroughly before firm conclusions can be drawn. However, it can be concluded that the bargaining power of regulators is crucial for setting appropriately stringent VA targets."*

Labelling systems, for instance, have proven to be very efficient under certain circumstances, but certainly not in all cases. Labelling systems are most likely to be efficient for consumer products.

Experience has shown that sectors which have signed covenants have made more environmental progress than sectors in which environmental policy was limited to mandatory regulations and abiding by the law. It suggests that the convenant system contributed to the result. In addition, it seems that when the target is simpler (or the problem simplified) targets work better. For example, sectors where energy consumption is the major issue are often more manageable than sectors with undesired complex by-products.

5.2 Stakeholders involvement and acceptance

A crucial point for a PT system to be successfull will be the **acceptance** by both customers and by the industry. This acceptance will highly depend on the advantage taken from participating in the system compared to competitors. Cost savings, lower fees or taxes would be helpful in implementing the system. Other possible advantages could be added value for customers or easier environmental control and reporting.

In order for VA to be effective and efficient, **dialogue** between stakeholders is vital. A wide range of stakeholders has become involved in the development, implementation and monitoring of VA, including, for example:

- national, regional and local governments
- industry associations and companies
- environmental, consumer and other civic society groups
- research organisations and academic institutions
- trade unions
- professional associations
- independent standard organisations
- other (e.g. national cleaner production centres)

PT should be understood and ideally **agreed by both consumers and producers**, even if producers may, in most cases, be the main stakeholder in implementing performance targets.

One of the key issues to achieve the required performance is the common understanding of the needs. The formulation of performance targets can be regarded as an intermediate to translate these needs of the different stakeholders - technology suppliers, customers of different kinds and producers.

[9] Arthur D. Little and the University of Birmingham, 2006, Improving the environmental performance of businesses: Corporate Incentives and Drivers in Decision Making (Study for DEFRA)

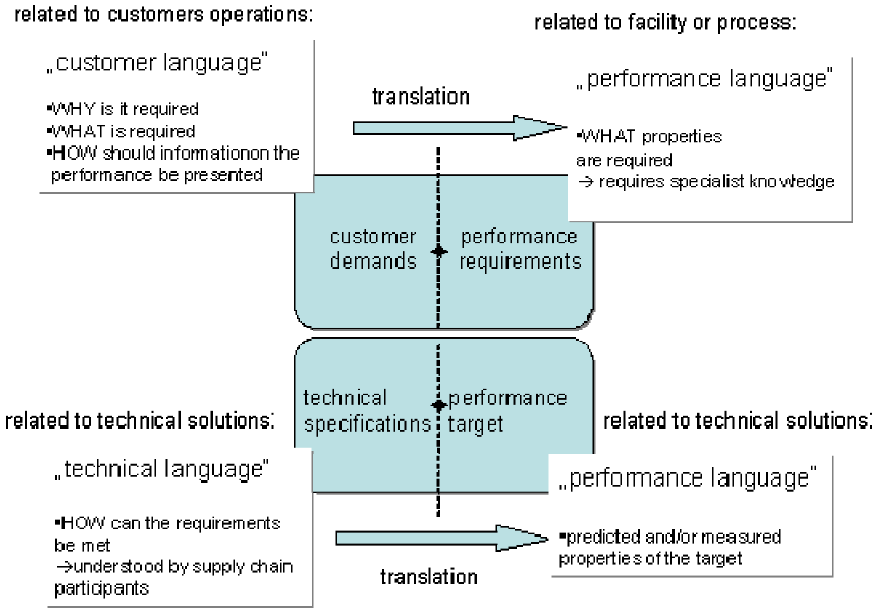

Figure 1: Performance targets as an intermediate between different stakeholders
(modified from Foliente et al. 2005, p. 23)

An important incentive for the companies to make efforts to fulfil the PT could then involve the customers, and thereby improve the market conditions for the more environmentally friendly technology solutions.

In the Top Runner programme in Japan, this was performed by having a labelling and an information system. Another important tool to improve market conditions for environmentally friendly products is Green Public Procurement. Although of lower efficiency, an other option would be to give companies which meet the targets, a certificate, parallel, with the ISO14001/EMAS systems. The certificate could render a somewhat better market position. Yearly awards to the best companies and similar incentives, including name and shame lists could also be applied.

6 IMPLEMENTATION OF PERFORMANCE TARGETS

The definition of PT for a specific sector must be carried out in the light of a comprehensive background analysis providing a clear understanding of the main factors influencing the feasibility and efficiency of such a system. The areas to be considered are:

- environmental background
- regulation background
- technological background
- market background
- environmental management capacities

The parameters characterising these issues are given in the table below.

Area	Parameter	Remarks
Environmental background	Dominating environmental parameters	PT should only be formulated for environmental relevant sectors/plants.
	Significance of sector emissions	
Regulation background	Relevant regulations	Environmental targets if any
Technological background	Available and emerging technologies which address the dominating environmental problems of the sector/plant.	
	Process chain complexity (multi-products, multi steps)	This level of complexity will influence the possibilities for allocating environmental impacts and targets to some intermediate products or process steps
	National differences	
Market background	Market structure (business to business versus end consumer market)	
	SME and large companies	
	Investment intensity of the sector	
	Willingness of customers	To put forward environmental demands, and to pay for it
Environmental management capacities	Implemented environmental management systems	

Table 3: Background information required for setting PT

Based on this background analysis, the main questions to be addressed when envisaging PT for the industrial sector considered are:

- Would PT represent an added value towards better environmental performances, to the existing policy framework?
- Which unit should be considered (process, plant, sector,…)? Where should the boundaries of the systems be set (only direct impacts or also upstream impacts)?

- Which environmental parameters should be considered? Should the different parameters be aggregated in a single target (single emissions or a sum of emissions, or certain raw materials or resource efficiency)
- Dynamic/timescale: These two issues are closely connected and should be chosen to the reflect technological possibilities, the typical investment cycles, the investment situation of the sector/plant
- Monitoring measures: These two issues are connected with management capacities.

There is no unique set of answers to the above question as each sector has its own characteristics. The sector case studies illustrate how the specific situations could influence the conclusion and choices.

The following subsections discuss and formulate proposals regarding the different characteristics of PT.

6.1 The level of PT definition

Many companies are global players. The EU is the smallest possible economic area for bulk products and the EU level provides greater room for manoeuvre than the national level.Therefore a PT system should be at least European.

PT can be defined at different levels of aggregation, from a single process within a plant to the whole sector. The allocations issues (including from a technical point of view), the market structure and the ratio between SMEs and large companies have to be considered. In principle, the main choice to be made is between the sector or company/plant/process levels.

The level of disaggregation to be considered in the PT formulation, in terms of industry activity and outputs, has to be made based on three criteria:

- the need to specify a unit for which environmental flows can simply be allocated and measured. This will depend on the complexity of the process chain (multi-products, energy and material recovery, by-products,…) and on the environmental parameter measured.
- the need to make the monitoring and verification feasible
- the need to allow a sufficient degree of flexibility within a sector when distributing the efforts – and investments required.

The advantages of choosing a sector approach (see for instance the Stora Enso intitiave referred to in 5.1), is to address the impact of the whole sector. Another advantage is that hitherto environmentally uninterested companies might be challenged or forced to participate.

The main disadvantages of the whole sector approach are the possible “free-rider” and “no-one feels responsible” problems.

There are some successful national examples (Dutch, Danish, …) where targets have been formulated for the whole sector (Krarup, S. and Ramesohl, S., 2000). However, in these cases it is important that individual companies are addressed either individually or sectorially. The importance of the at least partly individual approach is one of the lessons learned from the successful Dutch voluntary agreement programme on energy efficiency, where the second phase was even more company-oriented.

The sector level approach has often been backed-up with other incentives, like tax reimbursement, softer legislation, a long tradition of co-operation between public bodies and the branch, and so forth (Price 2005). The efficiency of these measures EU level can't be appraised due to the lack of experience.

On the other hand, under the individual company/plant approach[10], the "free riders" or "no-one feels responsible" effects would be lower. However, higher administrative burden to sign targets with each company would be entailed. In addition, it would be important to establish some incentives for the companies to join.

A hybrid of the two approaches (sector versus company/plant) might be the best solution. It would consist of a target system that simultaneously involves the whole sector (as represented by the sector federation) and the individual plants/companies. This is the approach followed by some energy efficiency voluntary agreements.

With such an approach an independent organisation may be involved both for the target negotiation and for the monitoring. This third party should be trusted by all parties.

	Advantages	**Disadvantages**
Plant or site level	Clear what is expected of the company for a particular plant, being the level at which results are to be delivered	High amount of administration
Company level	Gives more flexibility than PT specified at plant or site level	High amount of administration
Sector level	Allows for a sectoral specific approach (but this is also true for lower levels of aggregation)	It is less direct than a PT for companies; companies may feel not addressed

Table 4: Advantages and disadvantages of different levels of definition

6.2 Level of integration

6.2.1 System boundaries

Once the unit to be considered (company, sector) is specified, the second question is how to define the system and set the system boundaries.

One has to decide between considering only the direct impacts (sectoral) or also the indirect impacts (life cycle approach). The decision may influence the impact of the PT may differ.

For example, the usage of surplus heat, e.g. from hot water or fluegas for district heating, can lead to allocation problems because energy efficiency will not reduce the process emissions at the production sites, but will be able to reduce the emissions in the region due to the reduced need for heat generation plants.

Even the transport of products can significantly contribute to the total environmental impacts. This leads to the question of how environmental impacts outside the facility could be handled. Another similar aspect is the fact that changes in the chain can make measures at the individual plant or company level less meaningful. For example, when a company starts to generate part of its required electricity itself, through cogeneration for example, its emissions increase whereas those for the nation may decrease.

[10] Besides the the whole company approach, one could also consider a process approach. This however entails many difficulties like reducing the flexibility for the companies making the investments where they are the most cost-effective and there are also more problems in terms of allocaltion which might even be impossible with very complex and interconnected processes.

It is also important to avoid sub-optimisation, i.e. reduced emissions from production processes that would imply a worse situation during product use. For instance, a steel quality, with higher environmental impact at the manufacturing phase, could contribute to higher environment performance further down the manufacturing chain (car driving for instance).

Considering all life cycle impacts seems a solution to address such risks as it is more comprehensive. A disadvantage is the difficulty to monitor and verify the system.

Broadly speeking, the sectoral approach might be the most appropriate for the basic industry sectors (mainly relying on raw materials), whereas sectors producing final products should be encouraged reducing their direct and indirect impacts. In this case, a product-oriented approach (implementing the life cycle thinking) could be envisaged.

6.2.2 Integration of the different environmental parameters

The question is whether one particular category of impacts is considered or all of them.

If more than one environmental parameter is considered, there is the question of how to handle this when setting targets. The most obvious way is to have target levels for each parameter that must be met individually.

Another option would be to consider a weighted sum of the parameters. In this case, some flexibility could be given to each company to define the weights assigned to the different parameters. Certain minimum performances should however be met for each parameter.

The system should in any case be consistent with the requirements that already exist in the legislation. One should remember that the IPPC Directive was driven by the need to achieve an integrated control of all pollutions. This should also be the guiding principle for PT.

One should not overlook the issue of setting weighting factors for which there is no scientifically accepted method[11].

6.3 Timescale and frequency of update

Performance targets should be updated with a certain frequency in order to reflect changes in technology as well as new knowledge about environmentally important parameters. This can be accomplished by regularly updating the targets (every 2-5 years for instance). It will indeed be crucial for all sectors that the stakeholders are fully aware of tougher demands in the future, in order to send the right signals to those who develop and implement technology solutions of tomorrow.

In the case of an eco-labelling system, this means that the categories and levels would need updating[12], either by adding new categories, or to have a planned increase in demand for each level. It should be possible to include new parameters in the different categories, or parameters might also be dropped[13]. Ideas for making the PT dynamic could be borrowed from the Top Runner programme. "*The average of the best performing 10% of today should be the average of all sold products within three years*".

[11] If one category is considered like climate change or acidification, one can make use of existing factors that characterise the potential contribution of the different substances concerned (global warming potentials, acidification potentials).

[12] If labelling is to be adopted it must come into place already after 2-3 years. Then, considering the long investment cycles, the system will reward those companies that made the "good" investments already some years ago.

[13] The interval could then be every 3 years for updating the labelling schemes (see chapter 8.3 second proposal for a description of how the labelling and the PT could interact).

The suitable timeframes are to some extent dependent on the sector. One key parameter to be considered when setting the timeframe is the typical investment cycle in the sector. The investment cycle can be very long and, in some cases, even more than 30 years, like in the iron and steel industry.

Therefore, an indication of the targets in 10-20 years from now would help the companies to make the right investment decisions. Sometimes the industry advocates a whole lifetime of a large investment as a suitable timeframe for targets, but shorter time intervals may also be reasonable in view of the time span between the decision for an investment to production. This is also supported by the fact that companies often run several plants characterised by different investment cycles. Furthermore, a lot of improvements could often be performed by incremental or partial investments. If market activities (labelling, green public procurement …) are planned, timeframes that are too long will be troublesome, especially for the first time period and they might delay the improvement process.

For the sake of initial learning, the time span for the first target to be fulfilled would preferably not be too long. The most important thing is that there is a clear and distinct message that after the first target have been set, there will be more and more demanding targets. One should also keep in mind that there are proactive companies that could already today comply with, e.g. the 3-year target, or will be able to in the near future. There is no problem if these companies could take advantage of their pioneering efforts.

Following this, a systematic review will be necessary. Also new future targets should be decided upon.

The dynamic and ambition level of the targets should also be set in consideration of the companies that are already proactive.

Process investments are undertaken with a long time perspective, especially for larger investments. Therefore an instrument for performance targets needs to give a long-time perspective, i.e. companies need to be sure about the valid framework for a longer time perspective.

6.4 Monitoring

The efficiency of PT implemention will highly depend on how the achievement of targets are encouraged and monitored. Monitoring can be caried out by the company and/or by an external party.

Advantages of **self-monitoring** are that the monitoring system can build upon existing monitoring systems and that it gives the company flexibility. There could be some reporting format, to lay down the perimeters for reporting, complemented by examples. The main disadvantage is that it offers less guarantee that the information reported is reliable.

Monitoring could be done by **external parties** (authorised verification bodies) doing their own measurements. However, since companies are monitoring their own emissions and resource input, this would be a duplication of effort and not really an attractive option.

A **mixed form** is when the results of the company are checked by an external party. It introduces more administrative burden but has the clear benefit that the results are checked by an independent party.

Advantages and disadvantages of different models of monitoring are summarised in next table.

	Advantages	**Disadvantages**
Self monitoring	Efficient from an administrative point of view; company-friendly because it can build on existing monitoring systems	No verification of data
Monitoring by an external party	Verification by independent body, which increases the trustworthiness of the information	More cumbersome administratively and more expensive
Self monitoring with check by external party	Efficient and credible	The involvement of an external party makes it more expensive

Table 5: Advantages and disadvantages of different models of monitoring and encouragement of voluntary PT

7 CASE STUDIES

7.1 Introduction

Four industry sectors were selected from 10 industry sectors and subjected to a review which contained:

The identification of the sector's relevant environmental issues

a short review of **market trends and emerging technologies** relevant to the sector.

The review of **performance objectives in the existing regulation**. These objectives, together with the indicators and parameters used can create the basis for developing performance targets. Furthermore, they can be utilised as instruments to measure (monitor) the fulfilment and achievement of targets.[14]

The analysis outlines the main properties of PT that could best fit with the characteristics of these sectors.

To exemplify the PT concept, two illustrative schemes are then described, with an indication regarding the sectors where they could be most appropriate.

The chapter ends with a proposed list of environmental, economic and social criteria which is based on the criteria considered when implementing the impact assessment of new proposed EU policies.

The application of such a matrix for analysis could help to highlight goal conflicts and necessary trade-offs. These issues also refer to sustainable development, which is also an important goal in the context of ETAP.

The first step was the selection of ten sectors for a first brief review. The sectors selected were:

- iron and steel production (excl. mining),
- surface treatment of metals (inorganic surface treatment, as for instance phosphating, etc),
- greenhouse farming,
- large volume organic chemicals EDC/VMC
- production of rigid foam based on polystyrene,
- pulp and paper manufacturing,
- cement and lime production,
- textile processing, and
- food industry, e.g. meat processing.

For these examples the relevant environmental problems, available technological solutions and existing environmental performance objectives were surveyed.

[14] Environmental performance indicators (described as operational performance indicators and management performance indicators) and environmental condition indicators represent instruments for the evaluation of environmental performance as described in ISO 14031 (JASCH 2000).

Sector	Structure of the sector, stakeholder situation	Environmental issues	European regulation
Food processing	SMEs and large companies	Air pollution, water consumption and pollution, energy consumption	IPPC, ETS
Iron and Steel	Few large companies, business to business, through international competition, other relevant stakeholders are the car industry, construction industry	Air pollution (heavy metals, PCDD/F), dust, by-products, (waste), water pollution (metals and organics), energy consumption	IPPC, LCP, ETS, NEC
Surface treatment of metals (inorganic surface treatment)	Both large companies and SMEs, but mostly SMEs, A large number of small companies, mainly business to business, many customers, although often not many for each company	Several types of water emissions	IPPC, VOC, ETS
Production of rigid foam based on polystyrene	Large companies, although production often takes place in smaller plants. A few large producers on the market. Producers manufacture in every country due to significant transportation costs. Mainly B2B, customers are mainly in the construction sector both infrastructure and buildings.	HCFC and alternative blowing agents	F-Gas Directive
Greenhouse farming	SME's in most countries, producing for end-consumers. The SME's may also have well-organised cooperations. The market is more or less international, but with a European base market	Energy use, CO2 use, pesticides, herbicides, fertiliser use, water use and water pollution,	REACH, dangerous materials
Large volume organic chemicals Lower olefines	Large, both producers and customers. 50 crackers in EU15, 61 in Europe, The market is very "international". Large export from Europe, one third of the global market. Price more or less decisive. Not much difference in products, regarding quality and design.From 20 to 30 manufacturers in Europe.	Energy consumption Several types of Air Pollution	IPPC, VOC, LCP, ET, NEC
Large volume organic chemicals EDC/VMC	Large, both producers and customers, 31 sites in WE. The market is very "international". One fifth of the global market. The price is more or less decisive. Not much differences in products, regarding quality and design.	Energy consumption Several types of Air Pollution Maybe also water emissions	IPPC/BREF, VOC, LCP, ET, NEC
Pulp and Paper manufacture	SMEs (over 40% of paper mills) and large companies (chemical pulp production) Complicated. Rather international in its character. Mostly business to business, but also end-consumer perspective	Energy consumption Several types of air emissions including odour Water emissions of different types	IPPC, LCP, ET, NEC
Cement and Lime production	Large companies which exist in every country as transport is expensive Relatively local, due to transport costs. Some large production companies. The construction sector is the customer, both large companies and SMEs, and also end-consumers	Energy consumption, Several types of air emissions	IPPC, WI, LCP, ET, NEC
Textile processing	Fragmented and heterogeneous sector dominated by SMEs. Complex. Dominated by five countries.	Energy consumption Several types of air emissions including odour Water emissions	IPPC, VOC, ET, REACH

Abbreviations in directives and international protocols:

CHP	Directive on Combined Heat and Power (2004/8/EC)
IPPC	IPPC Directive
ETS	Emission Trading Scheme Directive (2003/87/EC)
LCP	Large Combustion Plants Directive (2001/80/EC)
NEC	National Emission Ceilings Directive (2001/81/EC)
REACH	Registration, Evaluation and Authorisation of Chemicals
VOC	Volatile Organic Compounds Directive (1999/13/EC) and amendment (2004/42/EC)
WI	Waste Incineration Directive (2000/76/EC)

Table 6: Results of the ten sectors surveyed

After this initial scanning of the ten sectors, a more thorough analysis was performed for the **Iron and Steel, Textile, Pulp and Paper and Cement Sectors**. The aim was to cope with a variety of prerequisites for setting PT and the selection of a range of situations regarding the following aspects:

The examples should be different with regard to **stakeholders**, or **market conditions** and **organisation of the sector** (SME or large companies).

Another important criterion was the sector's **substantial environmental impact**. Also the **environmental impact trends** are important to the discussion.

These considerations are summarised in the next table:

	Iron and steel	**Pulp & paper**	**Textile**	**Cement**
Market situation	Large companies High exposure to the international competition	Mostly large companies Medium exposure to the international competition	Mostly SME's High international competition	Large companies Low international competition
Complexity of the branch	Medium	Medium	High	Low
Environmental situation	Energy intensive and CO2 emitter High contribution to air pollutants Waste	Energy and water intensive Several types of air and water emissions	Main impacts on water	Energy intensive and CO2 emitter High contribution to air pollutants

Table 7 : Summary of the main characteristics of the four sectors

In the following sections, the main findings from the review of the four industrial sectors are summarised.

The review aimed to provide an overview of the situation in the four sectors considered with regard the issues identified in the previous chapter as these are important to consider when formulating performance targets. The detailed information gathered is given in Annex II.

7.2 Sector background

7.2.1 Market background

The ***pulp and paper industry*** is dominated by large companies with an international dimension. Customer demand can represent an important driving force for higher environmental performance paper products. An example of customer demands as a driving force is the establishment of chlorine-free bleached paper for magazines.

Whether customers today would have the willingness to pay for improved environmental performance during production of the products purchased, needs a study of its own. Labelling has a large market penetration, at least in some parts of Europe.

The ***textile industry*** is a branch with serious international competition. It is a fragmented and heterogeneous sector dominated by small and medium enterprises (SMEs), with a demand mainly driven by three main end-uses: clothing, home furnishing and industrial use. International competition is important. The situation may differ between products for end-consumers like clothing, and the industrial textile products for, e.g. the car industry (airbags, safety belts, and so forth), with the latter having less economic problems with international competition.

The sector addresses business to business as well as end consumer markets.

Textiles have been the most popular items for eco-labelling activities and there are some indications that customers are willing to pay more for eco-labelled products. However, these indications need to be verified on a wider scale.

The ***iron and steel industry*** consists mainly of large international and capital intensive companies, of which a considerable and growing number are mainly active outside Europe. There is tough international competition. The price is a main factor, but so is the production of special steel qualities and high quality products specifically designed for certain customers and for the improvement of other product.

Customers are mainly companies, e.g. the car industry and the construction industry. The customers generally have an environmental management system in place and have an interest in buying products that have been produced with less environmental impact.

The **Cement industry** also consists mainly of large international and capital intensive companies. The sector is characterised by relatively high transport costs. Cement is often sold on a “split” market, consisting of a regional market and an international “spot" market (Aahmann 2004). This may require special attention when considering PT.

No study on the willingness of consumers to pay for environmentally friendly products has been found for the cement industry. Since the cost of cement is only a small part of the production costs for new buildings, reasonable increases of costs for an environmentally better product might be possible to handle from an economic point of view. However, if all building materials are more costly, the total increase of costs for building materials could be troublesome for the proactive customer. Yet it has to be kept in mind that some of the environmental measures give lower costs to the producers, regarding e.g. energy production and waste handling. Also costs for raw materials could be lowered. Such possible cost savings could help the proactive companies to keep the prices for the environmentally better cement as low as possible, in order to win more customers.

7.2.2 Environmental background and regulation background

Using existing environmental data available for the EU25 (or at least for the EU15) - especially data from EUROSTAT (energy) and the EPER database containing data for the industry in 2002 -, the relevant BREF documents, sectoral studies for the EU and for some specific countries, we draw the following conclusions regarding the most typical environmental impacts associated with these four sectors:

Dominant impacts / substances	Iron and steel	Pulp & paper	Textile	Cement
Energy use and intensity	Important	Important High contribution of renewable energy		Important
Major air pollutants	CO2, NOx, SOx, AOX, heavy metals, phosphorus, phenols, nitrogen, fluorides, dichloromethane, dichloroethane, cyanides, chlorides and brominated diphenyl ethers	NOx, NH3, CO2, SO2, VOC, PM10, As, Cl	VOC	CO2, NOx, CO, heavy metals, particulates, dioxins, PAH
Water use and intensity		High	High	
Major water pollution	HAP, particulate matters, total carbon, and heavy metals	HAP, nitrogen , phosphorus, total carbon, heavy metals	HAP, total carbon, Heavy metals	
Waste issue	Important	Significant		

Table 8 : Main environmental problems associated with the four sectors

Pulp and paper production is highly energy (including renewable energy) and water intensive. The key emissions to air are mainly related to energy production (often a substantial proportion of the mill's needs are generated on-site), while the main emissions to water are related to organic wastes and to some process chemicals (such as chlorine) (Berkhout et al. 2001). Also, a considerable amount of solid waste is generated from different process steps.

The **textiles industry** has always been regarded as a water-intensive sector. The main environmental concern is about the amount of water discharged and the chemical load it carries. (European Commission 2003b). A recent research report provides an in depth survey on the different processing steps and compiles useful information on the function, processes and on the application of about 2500 chemicals substances in products used in textile finishing. "Other important issues are energy consumption, air emissions and solid wastes and odours, which can be a significant nuisance in certain treatments." (European Commission 2003b). The air emissions are mostly well defined, stemming from the evaporation from heated process steps, and of course from the production of the energy used.

Iron and steel production is one of the basic industries, supplying other industries with pre-products. Large amounts of raw materials are handled and processed. The industry is an energy intensive sector. There are significant emissions from the production processes of several different categories. Air emissions are the dominating issues (CO_2, NO_x, SO_2 and particulates including heavy metals).

Cement is one of the most consumed substances on earth. The cement industry is very energy intensive. The four main types of emissions are CO_2, NO_x, SO_2 and dust. The increasing co-incineration of waste may generate higher emissions of heavy metals and possibly also dioxin, in the future.

The four sectors are already subject to different regulations.

The **IPPC Directive** and the **Emission Trading System Directive** (ETS) are relevant to all installations in these four sectors as long as their activity levels are higher than certain thresholds.

So far, only new installations have been subjected to the obligations from the IPPC Directive so the consequences can't be fully assessed. The Directive will only be fully implemented in all Member states by October 2007 when all industrial installations covered must have an IPPC permit. The IPPC Directive does not specify any sectoral and mid- or long-term objectives in terms of emission reductions.

The ETS was launched in January 2005, thus initiating the first environmental market in the EU, involving thousands of operators having the obligation of limiting the carbon dioxide emissions from their plants. The second phase of the ETS covers the period 2008 to 2012. The system covers 45% of the EU's CO2 emissions.

Regarding air pollution, the **NEC (National Emission Ceilings) Directive** states that, by 2010, Member States shall not exceed national emissions ceilings as laid down in its Annex I. The Member States are responsible for implementing appropriate measures to comply with the national emission ceilings. This can include measures in the industry sectors.

The EU's Thematic Strategy on Air Pollution, which was adopted by the Commission in September 2005 proposes interim environmental objectives for 2020. This will be of importance for the NECD, which is currently subject to review (a proposal for a revision of the NEC Directive is expected by summer 2007).

Besides these policies, each of the sectors is also affected by other regulations, especially:

- **pulp and paper**: The LCP Directive (2001/80/EC) contains emission limits for combustion sources. The Water Framework Directive (2000/60/EC) may entail additional requirements for waste water treatment

- **textile**: the sector may also be concerned by the Water Framework Directive (2000/60/EC). The REACH[15] addresses different chemicals and may have further requirements for the textile industry. The Directive on dangerous substances (76/464/EC) states that the use of some substances is forbidden.
- **iron and steel:** LCP Directive (2001/80/EC) contains emission limits for combustion sources. The NEC directive (2001/81/EC) addresses emissions namely SO_2 and NO_x.
- **cement**: the LCP Directive (2001/80/EC) contains emission limits for combustion sources. The Waste Incineration directive (200/76/EC) contains emission limits for co-combustion of waste in cement kilns.

7.2.3 Does the existing policy framework stimulate innovation?

The impacts of environmental policy instruments on eco-innovation has recently been analysed by Heady et al (2006)[16]. Based on a review of the empirical (economic) literature, the paper concludes that "environmental policy provides an important incentive for firms and households to develop and adopt new equipment or technologies with more environmentally favourable characteristics".

The paper also attempts to draw conclusions on whether market-based incentives have a stronger impact on rate and direction of technological change than non-market alternatives. In this respect, the review tends to confirm what economists suggest that innovators look carefully for money making opportunities which, in turn, depend on specific incentives signalled by the type of environmental policy. For instance, air emission reductions (mostly due to fossil energy use) are triggered by higher implicit emission prices due to rising energy prices.

The ability of the current policies addressing industry pollution to drive innovation depends on the type of policy and on the type of environmental problem.

Concerning the **IPCC Directive**, it is still premature to fully assess the impacts on technological changes in the industry sectors as it will be fully implemented in October 2007. Some exchanges with the industry in the course of the project suggest that its effects may be limited by the fact that the forerunners are not rewarded in the IPPC-BREF system today.

It was also suggested that environmental permits can be drivers, if authorities set higher requirements than the BREF, e.g. if the BREF document has been overrun by new and better examples. Some companies have implemented technological solutions that perform better than BAT.

On the other hand, long procedures for getting permits for the implementation of environmental technology is an obstacle.

Regarding the impact of **market-based mechanisms** in the EU, the review of the **EU emissions trading** scheme made by McKinsey and Ecofys (2005)[17] provided interesting findings regarding the effect of the system on long-term decisions in the sector and on innovation.

For 50% of the companies, the EU ETS plays a key role in long-term deicions and for 48% it is only one of many other issues. In the steel industry, the pulp and paper and the cement, respectively 86%, 66% and 46% of the companies involved in the survey consider that ETS plays a key role in their decisions.

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[15] **R**egistration, **E**valuation, **A**uthorisation of **Ch**emicals

[16] Vollebergh H., 2006, Impacts of environmental policy instruments on technological change, OECD paper (COM/ENV/EPOC/CTPA/CFA(2006)36/Final

[17] McKinsey & Company, Ecofys, 2005, Review of the EU emissions trading scheme – Survey Highlights, study for the EC Commission (DGENV)

The survey also showed that "about half of the companies claim a strong or medium impact on decisions to develop innovative technology". The proportion is even higher in the steel sector (84%), in the pulp and paper sector (78%) and slightly higher in the cement sector (54%).

This means that the ETS is likely to stimulate innovation on energy technologies with of course a direct impact on CO2 emissions. One can also expect more indirect impacts on other energy-related impacts (air pollution).

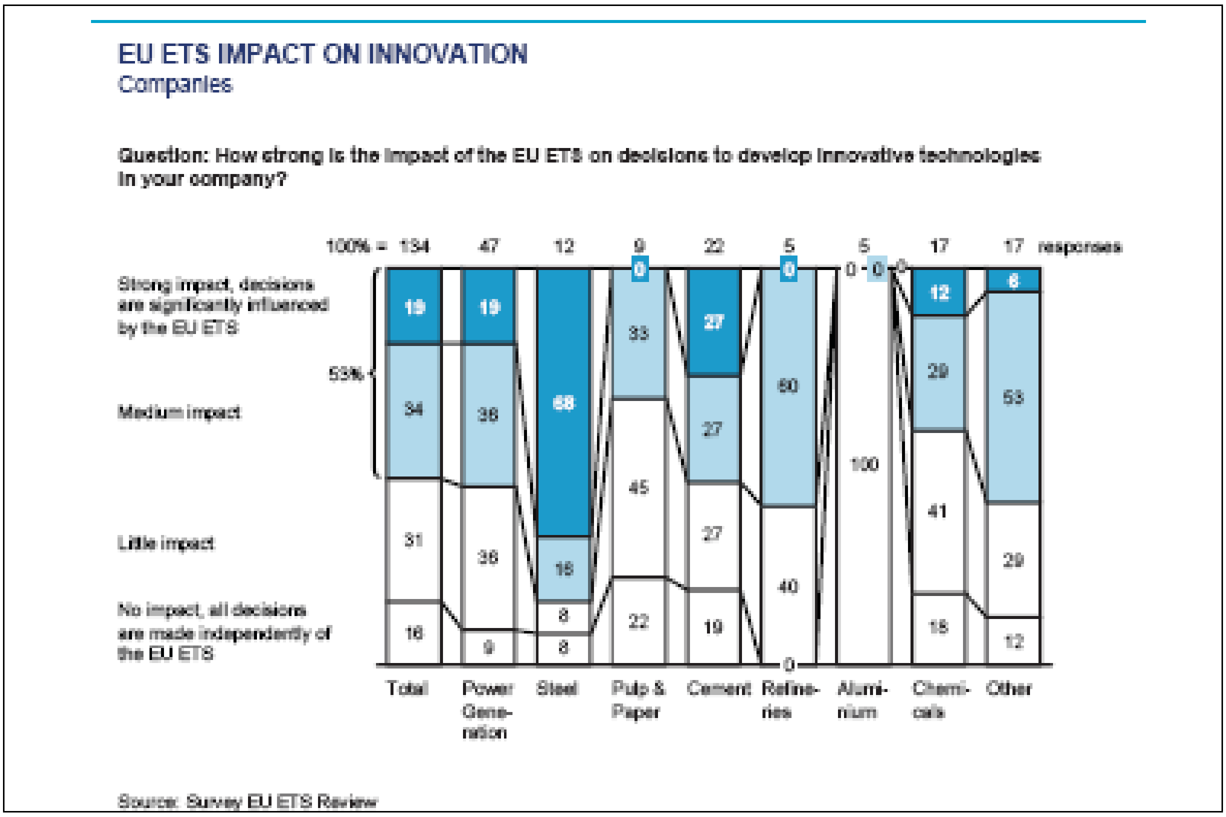

Figure 1: Impact of ETS on innovation source: McKinsey, Ecofys (2005)

The new **Water Framework Directive** could be expected to trigger innovations, since requirements for waste water are sometimes more demanding than the requirements for the production process so that the waste water might well be kept in the company to be used in a closed circuit in the production processes. Further examples are the banning of CFCs in cooling systems and filters for PM10.

7.2.4 Technological background

The aim of the review of the technological background was to assess the degree of complexity of the production chain in each sector's case study in order to derive indications regarding the level of aggregation to be considered in the formulation of PT in each case. It was also a first attempt at assessing the existing improvement capacities. It obviously does not represent an exhaustive compilation of available and emerging technologies[18].

[18] Examples for available/emerging technologies are given in ANNEX II.

A brief summary of the main findings is given in the following paragraphs along with some considerations of the issue of allocating environmental flows to some processes that would need to be taken into account when PTs are set for the sector.

The products and applications of the ***pulp and paper industry*** are manifold. They vary from graphic fine paper to tissue and packaging.

Available technologies allow for the use of recycled fibres, energy savings and increased system closures. This is reflected in the general trends observed: the closing of systems without losing product quality and creating problems with incrusts in the system on the one hand, and effective waste water treatment, more environmentally friendly bleaching and even better use of the energy and raw materials.

The energy use reduction potential is important. In 2004, the Netherlands for instance, the paper industry committed itself to a 50% reduction in energy use per unit of final product to be achieved by 2020.[19]

The ***textile industry*** is one of the longest and most complicated industrial chains in the manufacturing industry. The technological situation is different in each company.

Technologies which provide water savings, energy savings or decrease the chemical load of water effluents are available. Textile finishing is a much diversified sector due to the processed raw materials, manufacturing techniques and finalised products.

Trends in fashion cause a continuous change in colouring and functional finishing.

The ***iron and steel industry*** claims to be close to what is theoretically possible, at least for blast furnaces with current technology[20]. Only completely new technologies could bring about substantial future reductions in carbon dioxide and energy consumption. The ongoing research made by the industry is promising in that sense. The sector project ULCOS is very ambitious as it aims to develop steelmaking production technologies which should be able to reduce CO_2 emissions by at least 50%. These new technologies are expected to be commercially available in 10-20 years. Also the potentials of new combinations of existing technologies should be investigated. The product range varies, as there are many different applications for the Iron and steel industry.

The ***cement industry*** produces final products that differ mostly in terms of clinker content, and type of additional material. The EU has its own standardisation and, although cement is produced in several different qualities and varieties, the differences between products are rather small when it comes to the actual production step.

There are three main types of production facilities, which are the so-called dry, semi-dry and wet methods, with the dry types being more energy efficient. Solutions exist for improved monitoring and control, slag and dust reduction or re-use, acid recovery, and energy efficiency.

7.2.5 Complexity of the processes involved

The level of complexity in processes and integration has been characterized for all four sectors with a view to anticipate some specific aspects to be considered when defining PTs.

In the **pulp and paper sector**, the allocation of environmental parameters is an important issue in the context of defining optimal aggregation levels for PT. Some difficulties could arise in comparing effects from usage of new resources and recycled paper.

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[19] http://www.senternovem.nl/energietransitie/ketenefficiency/experimenten_bij_hoofdrouten/50_energiebesparing_in_de_papierketen.asp

[20] See for instance the presentation by Anders Ullberg, SSAB at IVL conference, March 2004

For the more general environmental parameters of **textile production** like COD, acids, energy, there may be some allocation problems, due to the fact that the plants may have different mixes of production. Water emissions are, for instance, often mixed together and it is not obvious how to allocate the emissions to the right source.

Allocation of environmental parameters from the **iron and steel production** is possible in most cases. A difficulty would be to compare effects from the usage of new resources and recycled steel (as mining is not included).

In the **cement industry**, the main allocation problem is how to count **waste fuels** and whether the company would be allowed to discount some part of the emissions of CO_2, if spent tyres are fired. Besides this specific problem, the production process is relatively straightforward and the system borders are naturally the whole plant.

7.2.6 Environmental management capacities

In all four sectors, available environmental data show that the span from the best to the worst performing company is currently considerable.

Some large **pulp and paper** companies in Europe have developed a **voluntary scheme**, the Paper Profile, to supply environmental product information to interested business-to-business customers. This is often used alongside EMAS and ISO as some 60% of the pulp and paper produced in Europe comes from mills certified in this way.[21]

Textiles have been the most popular items for eco-labelling activities and there are some indications that customers are willing to pay more for eco-labelled products. However, these indications need to be verified on a more wider scale. It is also worth noting that the Öko-Tex system concerns more than 6000 companies.

Important certification systems for the **steel industry** are the international ISO standards according to the ISO 9000 and 14000 groups for quality and environmental management. Many steel companies are certified according to ISO 14001 for environmental management. The Steel Recycling Institute (SRI), a unit of the American Iron and Steel Institute, gives information about a steel certificate, the LEED, which is a trademark for Leadership in Energy and Environmental Design. It is a specific certification for the recycled content of steel building products. Steel certificates also exist in order to assure a certain product quality. Such certificates can be requested for each shipment of products.

WBCSD - CSI is developing a certification system for reporting the emissions from **cement** plants. Many individual cement manufacturers have implemented Environmental Management Systems, like ISO14001 and EMAS.

[21] http://europa.eu.int/comm/environment/ipp/comments/cepi_comments.pdf, (CEPI is the Confederation of European Paper Industries)

	Iron&steel	P&P	Textile	Cement
Environmental background	Raw material consumption Energy consumption and CO2 emissions air pollution (heavy metals, PCDD/F), dust, by-products, Waste, water pollution (metals and organics),	Energy consumption Water consumption Several types of air emissions (including odour) Water emissions of different types, Waste (organic waste)	Water consumption Several types of air emissions (VOC) Water emissions of different types (pocess chemicals)	Raw material consumption Energy consumption and CO2 emissions Several types of air emissions
Main existing policy instruments	IPPC, LCP, ET, NEC	IPPC, LCP, ET, NEC	IPPC, VOC, ET, REACH	IPPC, WI, LCP, ET, NEC
Technological background: main areas for developments expected for the future	CO2 reduction together with energy savings	Use of recycled fibres Energy savings Increased system closure Waste water treatment Environmental friendly bleaching	Water savings Energy savings Decreasing chemical loads of water effluents	Energy savings and CO2 emission reduction Slag/dust reduction and reuse Acid recovery
Process chain degree of complexity	*Allocation of environmental parameters is possible in most cases. A difficulty would be to compare effects from usage of new resources and recycled steel (as mining is not included)*	Allocation of environmental parameters is an important issue in the context of defining optimal aggregation levels for PT. Some difficulties could arise in comparing effects from the usage of new resources and recycled paper	Long and complicated industrial chains which are different in each company. Textile finishing is a much diversified sector due to the processed raw materials, manufacturing techniques and finished products	The main allocation problem is how the change to waste fuels should be counted.
Market background	Capital intensive Large international companies, mainly outside europe Business to business Willingness of customers in connection with environmental management	Capital intensive International branch dominated by large companies Business to business & end consumer Willingness of customers partly in connection with labelling system	Hard international competition Heterogenous sector, dominated by SMEs Business to business & end consumer Willingness of customers questionable	Capital intensive- international competitioon limited by the transport costs (although this competition is increasing)
Existing Environmental management	LEED ISO 9000	Paper profile EMAS ISO 9000	Eco-labelling activities	CSI-certification on emissions
Possible Improvement strategies for PT and connection with existing legislation	Energy efficiency and climate change (ET, national climate change programmes) Toxic effects (e.g. LCP) Resource efficiency (besides energy)	Energy efficiency and climate change(e.g. ET for IPPC installations) Toxic effects (e.g. LCC) Eutrophication (e.g. NEC) Resource efficiency (besides energy)	Energy efficiency and climate change (e.g. ET for IPPC installations) Resource efficiency (water) Polluting materials (e.g. VOC, chemicals)	Energy efficiency and climate change (e.g. ET for IPPC installations) Resource efficiency (besides energy) Toxic effects (e.g. WI)

Table 9:Summary of the sector review

7.3 PT proposals

7.3.1 General considerations

Based on the above-described background information for the four case studies (see ***Table 9***), general indications have been derived regarding PT.

The four sectors differ in terms of the complexity degree of their process chain. It is the highest for the textile industry. Some specific problems characterise the other three sectors (paper recycling and types of raw materials used in the P&P sector, steel recycling, co-incineration in the case of cement sector) which would need to be taken into account when formulating a target.

The degree of complexity in the textile industry together with the high heterogeneity and the large number of SMEs makes a sector-approach probably the most appropriate. For the ***other examples,*** higher disaggregation levels would be possible. However, international competition and also international integration make the **sector approach** most appropriate for these sectors too. Nevertheless P&P and textile sectors producing final products are most likely driven by final consumers. Eco-labelling like PT systems might be appropriate.

All four cases seem to be characterised by a situation where **more than one environmental parameter** seems to be appropriate. A more flexible system based on a bundle of parameters (e.g. resource efficiency) could be discussed for each sector (see below).

P&P and textile sectors producing final products are most likely driven by final consumers. Eco-labelling like PT systems might be more appropriate, including life cycle approach. The Iron and steel and cement sectors could be subject to a more sectoral approach.

The suitable timeframes depend on the technological situation and the investment cycles. An indication of the targets 10-20 years from now would help the companies make the right investment decisions. PT will have to be dynamic in order to reflect changes in technology as well as new knowledge about environmentally important parameters. This can be accomplished by updating the targets every 2 or 3 years. ***Three of the sectors*** have very large long term investment cycles. The ***textile*** sector is the exception, since there are many incremental steps to be taken. A suitable time table for the increasing demand of the targets must be designed in a joint effort with all stakeholders involved.

7.3.2 Resource efficiency targets

A review of the existing legislation applicable to the sectors considered shows that many environmental substances and flows are concerned by one or more policy instruments.

Natural resources can be seen as an exception. Therefore, this environmental area could be relevant for a voluntary approach, especially when considering PT (also in connection with waste and recycling). If such an outcome were to be included in performance targets, there would be an added incentive for the integrated improvement of the environmental process performance. This would also be in line with the Strategy proposed by the Commission on the the sustainable use of resource (COM(2005) 670 final).

Resource efficiency-type voluntary targets are likely to offer incentive to participating companies because of higher profits resulting from reduced manufacturing costs. The scale of such a benefit should, however, be assessed beforehand it would vary from one sector to another.

If such an approach is envisaged, a series of questions should also *ex ante* assessed:

- the actual added value of having such a target would depend very much on the sector, notably because the energy component of the resource is actually targeted in existing policy instruments, especially as far as energy intensive sectors are concerned
- resource efficiency is already being improved to some extent. The reasons why resource efficiency is not increasing more rapidly should be analysed in order to know how PT could best support further improvements[22]
- the implications of having resource efficiency targets set on non-energy components like raw materials, water, soils, etc. should be analysed. For instance, raw material processing is, together with energy transformation, the source of emissions to air, water and soils, which are somehow already targeted in existing legislation. Therefore, we would need to analyse the added value of setting targets for input parameters compared to existing targets for output parameters.

The above questions could be addressed in connection with the work scheduled in the Commission Communication in order to achieve "*a better understanding of the environmental impacts of resources used throughout life cycles*" with a view to "*allowing policy makers to better prioritise and concentrate on areas where they can really make a difference*".

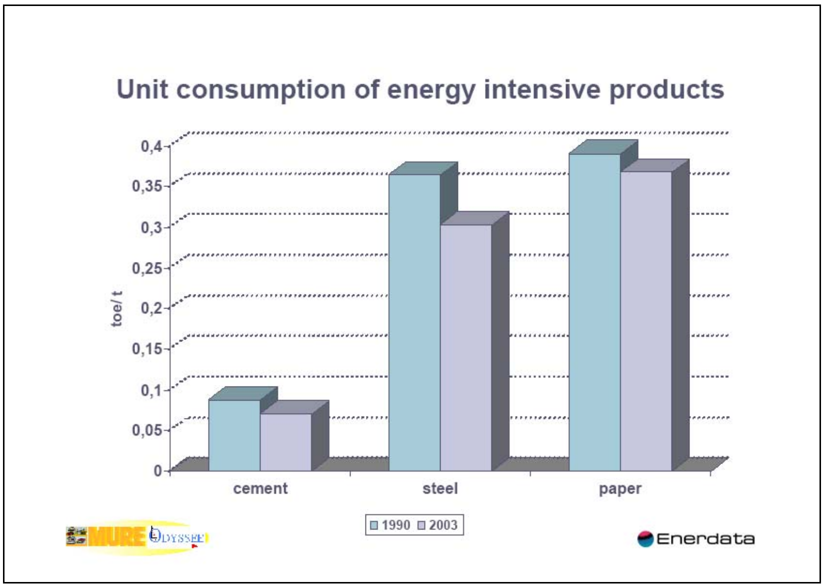

Figure 2: Evolution of energy intensity in the cement, steel and paper sectors (EU15)

Source: ENERDATA (Odyssee)

[22] For example i*n the case of textile, cement and pulp & paper,* contacts with the industry in the course of this project indicated that the search for resource efficiency is taken for granted and said to be well embedded in the routines of the firms: "resource efficiency is a decisive means to lower overall costs". In many companies of these sectors, resource efficiency is part of the already implemented environmental management systems. It is claimed that state-of-the-art technology is applied to achieve this end. In terms of resource efficiency in energy, water and material inputs, reduction or substitution in all fronts is common practice as this is important not only for environmental purposes but also for cost efficiency. Similarly to the comments given by representatives from the paper and cement sectors it is perceived in the textile sector that companies cannot do more in resource efficiency gains as they already work on the technological limits.

Situation in the four sectors reviewed

In 1993, the Dutch pulp & paper industry signed a sector wide voluntary agreement on the reduction of energy. Since 1996 a more general voluntary environmental agreement has been in place. It is generally understood that if the sector does not meet the standards from the voluntary agreement, more strict legislation will follow. Though companies act with different speeds in improving their environmental performance there does not seem to be much 'free rider' behavior. Of course there are front runners and companies who are slower, but this is usually connected to the financial situation of the company. In the sector, 17 of the 27 companies have already installed combined heat and power installations.

The sector as a whole has now launched an initiative on energy, called the energy transition. All companies in the sector are all members of the organisation and they have to meet targets set for the sector within 4 years. All companies are required to publish an annual company environmental plan. In this plan they have to present a yearly survey of their environmental performance, and an information on how they are going to meet standards for, e.g. energy use, discharges of heavy metals.. In principle this agreement is voluntary, but the result of the sector as a whole is evaluated every year. The target of this initiative is to achieve a 50% reduction of energy use by the year 2020.

In the project new concepts for paper and pulp production are investigated, such as closed cycles, thermodynamic optimum, and maximal use of ICT. This represents an interesting model involving a push and pull mechanism. It shows that PT can also be used for stimulating radical innovation through research and innovation support.

Concerning gains in resource efficiency the sector as a whole has achieved approximately a 40% reduction of primary energy use per kilotonnes of paper produced from 1980 to 2000. In addition emissions of copper and zinc have considerably decreased, too. Since there is a continuous effort to increase efficiency, it is considered that making a bigger jump in resource efficiency would be rather difficult. This would require radical innovations since a lot of incremental innovations have already been put in place. Typically companies use very large and costly installations, which will not be easily replaced before their end of life.

A paper company adds a lot of water with added chemicals to fibres and later has to extract all the water again from the substance mostly by heating. The more chemicals the company adds to the process the more toxic substances they will release (for which there are clear discharge targets). This is an incentive to be very efficient with chemicals. The representative of the paper industry stated that in the case of the Netherlands most of the targets set by the environmental policy have been reached[23].

Similarly in the ***Cement Sector***, it can be assumed that in general costly resources are used efficiently. For resource-intensive industries such as the cement industry the search for efficiency is imperative.[24] For a high capital-intensive industry sector with lowpriced products the optimisation of raw materials and energy are of crucial importance and pursued on a regular basis. This implies the existence of efficiency programmes and control systems to improve system weaknesses (no clear targets were mentioned). In the Netherlands, the usage of secondary fuels (such as end-of-use tyres) accounts for 49% of total energy. The usage of secondary grinding substances is claimed to be nearly 30%. According to the industry representatives contacted, the sector are already making great efforts to achieve improvement in resource efficiency and that they find it extremely difficult to do more on that front.

In the case of textile industry as well as in the two sectors discussed above, the search for resource efficiency is taken for granted and said to be well embedded in the routines of the firms: "resource efficiency is a decisive means to lower overall costs". In many companies of this sector resource efficiency is part of the already implemented

[23] The conclusion of the OECD report about Voluntary Approaches to Environmental Protection is however that the environmental effectiveness of voluntary approaches is often questionable, and that their economic efficiency is generally low (OECD, 2003)

[24] Electricity costs equal 10% of the turnover and the overall amount of resource costs is up to 33%.

environmental management systems. It is claimed that state-of-the-art technology is applied to achieve this end. In terms of resource efficiency in energy, water and material inputs, reduction or substitution in all fronts is common practice as this is important not only for environmental purposes but also for cost efficiency.

The ***iron and steel*** industry[25] is working actively to improve production efficiency and reduce environmental impact. Several possible low CO2 emission technologies are investigated in the EU financed ULCOS project with participants from many main steel producers in Europe. The project might lead to significant efficiency improvements in the long term, i.e. by about 10-20 years.

The Swedish steel industry and its branch organisation are performing a project aiming to increase the iron efficiency by the recycling of scrap metal and to increase the efficiency of the alloys. This would result in effectively economising the use of steel in applications and products.

7.3.3 Two proposals

Two illustrative PT cases have been developed in order to exemplify the PT concept.

In principle performance targets can apply to the following environmental parameters: different kinds of emissions, resource efficiency, substances to be phased out, the use of raw materials and secondary resources. The review on the four selected sectors has shown that in each sector there are many environmental aspects, among which many are already regulated through various policy instruments.

The aspects to be taken into account in the choice of PT have been discussed: time-scale, aggregation, national and regional differences, how to make PT dynamic, outreach to consumers. All these aspects would influence the formulation of the performance target model.

It is also widely agreed that the PT should not be technology-specific but should instead leave companies a choice for what to do. It has also been said that they should be dynamic (adaptive).

We should also consider that:

- the targets should be in areas where existing policy is absent or weak and a clear stimulus is needed
- taking into account of the fact that the industry is already subject to many environmental regulations and other administrative requirements, PT should be attractive to industry

Having these two considerations in mind and considering the four selected sectors two potential PT schemes are proposed:

- the first proposal focuses on **a general target for resource efficiency improvement** (which could be something like +*x*% in *y* years time). The target could be set at company/plant level or at a higher level (sector level for instance)
- the second proposal is one of **a dynamic classification scheme** for products based on the environmental performance of production (similar to the Top Runner programme in Japan). This proposal focuses on the aspects of implementation.

[25] http://www.stalkretsloppet.se/projekt/pdf_dokument/utdrag_igec_swedish_steel_industry.pdf, 25.5.06

7.3.3.1 A long-term target for resource efficiency

The target

One model that appears to meet the requirements is a **long-term target for resource efficiency** in which industry commits itself to achieve improvements.

An example is a target for achieving **an *x*% improvement in resource efficiency in *y* years time**[26]. The target could be set at EU, national, sector, company, plant or site level. Companies who accept being involved in this scheme could be asked to develop improvement programmes to be discussed with the environmental authorities. Monitoring could be done by the companies themselves or by an outside agency. A uniform reporting format will allow for benchmarking.

Resource efficiency could include issues like (non-renewable) energy use, water consumption and raw material use[27]. Improvement does not have to be uniform on all three fronts. If, for instance, a 25% improvement is targeted, under a weighting system, companies could opt for 20% or 30% reduction in energy use, a 20% or 30% reduction in water consumption and a 25% or 15% reduction in the use of raw materials, i.e. they can choose any kind of totals they want as long as it brings the company close to the overall target of a 25% improvement in resource efficiency. The percentages and weights could be different for different sectors and regions. For regions where water consumption is no problem and for sectors and companies who use very little water, the requirement of achieving a reduction in the use of water could be dropped.

The proposed PT model for resource efficiency is flexible in terms of how it is achieved. No competitive disadvantages are expected.

Time horizon

The advantage of a long period (more than 8-10 years) is that it helps companies to factor energy conservation into fundamental process change. The longer the time period, the more ambitious the target can be on a yealry basis.

Improvements and incentives

In principle, the format for the improvement programme could be left open (or quasi-open), leaving it to the companies to come up with simple or sophisticated plans. On the other hand, uniform reporting allows for benchmarking, which allows companies to compare their improvements with others.

The incentive structure must take into account the situation for the SMEs (especially as the sector is dominated by SMEs), since it is important that small companies are involved and they are often the ones in which resource efficiency is lowest, and the gains the highest, relatively speaking.

Benefits from a resource efficiency target

The advantages of such a PT system are:

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[26] It could also be a 35% improvement in 10 years time or 15% in 6 years time. The actual goal and time period could differ per sector. Perhaps a good formula is simply to aim for a 1% higher improvement in resource efficiency than the historical trend. The percentage does not have to be achieved every year.

[27] Waste volumes could also be used as a measure but as there are so many types of waste, some of which are very hazardous, so a PT would be difficult to formulate. To a lesser extent, the same is true for resources.

- it targets something that is not really targeted by policy (resource efficiency)[28]
- it is a simple model which allows for different choices (which makes it efficient)
- it involves a tool for achieving this (the improvement programme designed by the companies themselves)
- it is suited to all companies, including SMEs
- it is dynamic, allowing for adaptation.

It seems to be **a workable system attractive from an industry point of view** because it is simple, easy to understand, very flexible (in terms of outcomes and timing and type of actions), involving lower transaction costs, and is oriented to an issue (greater resource efficiency) which may not have received enough attention in some sectors or companies. It is believed to be suitable for large and small companies. Large companies (in which resource productivity is most likely already institutionalised) are encouraged to do more, and small companies (where attention to resource efficiency may be lacking) are encouraged to make a start. The improvement goals could be different for small and large companies.

The operational advantages of lower resource costs and waste costs may help to create a positive image for environmental measures within companies. This could make companies **more proactive,** stimulating improvement programmes for resource consumption, pollution and other environmental matters. This means that there will be spillovers into other environment-relevant areas.

The PT system may be too weak to stimulate innovation (this would, amongst other things, depend on the target ambition) but for the diffusion of resource efficient technologies it seems a good system.

It should be noted that the PT system for resource efficiency does not preclude the use of energy taxes, taxes/charges for waste disposal and water use, and does not interfere with IPPC and current regulations. The improvement plan fits with ISO 14000 and EMAS in which there is already an obligation for achieving continuous improvement.

It could be linked with eco-label schemes because the requirement of resource efficiency is a criterion.

Setting resource efficiency targets should, however, take into account the fact that in some cases, more resource demands in the production phase can lead to less environmental burden further down the production line.

7.3.3.2 A dynamic classification scheme for products

The target

The environmental performance of the company or the plant could be associated with the **products** it manufactures.

The parameters taken into consideration with this approach may be resource efficiency or a set of key environmental parameters. We are imagining a classification scheme of products in class, e.g. B, A, and A+. The classification is made due a weighted average of the chosen parameters or according to the absolute values of each parameter. The levels for the classification are understood to become more strict with time. The target could be formulated as ratios of sold products in different classes at a certain time. Another possibility would be to formulate the target as an average of a certain environmental parameter

[28] Here we should say that energy saving is considered in BREFs and a point of attention for permit writers in some countries such as the Netherlands. It is promoted in an indirect way by CO2 emission trading. Overall, however, the encouragement of greater resource efficiency by policy is considered to be weak.

for all sold products, e.g. the average NOx emission per product unit sold. Depending on the levels of the classes, outphasing of the "worst", increased market penetration of the “good”, or stimulation of innovation is possible. Targets could be formulated both for individual companies and for the whole sector in a similar manner.

Time horizon

The time horizon depends on which case is chosen. However, if the full potential of the market activities (labelling, GPP, ..) should be used, the steps between the changes of the classification schemes should not be too long. The first labels should be in place after a couple of years, and then the time interval between the increasing of the level could be 2-3 years. However, the approximate long term development of the levels in the classification schemes must be clearly announced, so that the right signals are sent to both producers and customers, and facilitate the investment plans for the producers. The short first time interval, compared to most investment cycles periods, implies that in the beginning of the system, the companies that have been proactive before the start of the programme will be rewarded. This is not a severe problem, if it is a problem at all.

Improvement & incentive

The successful examples of voluntary agreements most often have the agreement embedded in other policy instruments. It could be the withdrawal of plans for future more stringent legislation, tax reimbursements, subsidies, “eco-labels”, green public procurement, and so forth. It is important to find the appropriate incentives. However, some of the incentives could be easier to implement at national level, e.g. the tax reimbursements.

Some naming and shaming, awards for the most resource efficient companies, a certificate for the companies that fulfil the targets are related incentives that may be efficient. Because of the large number of SMEs, it is important that the incentive structure also allows for the involvement of small companies.

Strengths and weaknesses

This scheme is somewhat more complex in terms of monitoring because the resource efficiency or environmental performance, from relevant parts of the life cycle, must be established per product. This could, e.g. yield allocation problems if the manufacturing process is complicated with parallel production lines and so forth. The monitoring could be undertaken by the companies themselves, or by an independent body, like in the ISO14001/EMAS systems.

The great advantage is that the power of the different customers could come into play if they their purchase decisions are guided by environmental considerations.

This proposal for a PT system does not preclude the use of taxes, and does not interfere with IPPC and current legislation.

Also in this case, the interaction with each individual company may need significant public funding.

7.3.3.3 Possible application for the four case studies

These proposals were discussed with a limited number of stakeholders who suggested the following:

Cement is perhaps the most suited to the second model, which may also be applicable to the **pulp and *paper*** sector. The reasons are that it seems possible to assign environmental impacts to products. Another important criterion is that for these two sectors there might be proactive consumers that could make green purchasing decisions.

The ***textile*** sector has severe allocation problems due to the very complex and diverse process structure. This makes it unsuitable for the second model. The customers in the ***steel*** sector are more unlikely to take green purchasing decisions. This, together with the fact that there are numerous types of steel qualities, the second model is not applicable for the steel sector.

7.3.4 Possible criteria for an ex ante assessment of performance targets

General political issues
contribution to the general objectives of ETAP
General environmental issues
energy conservation
control / abatement of greenhouse gas emissions
control / abatement of air pollution
control / abatement of water pollution
abatement of raw material depletion
sustainable waste management
sustainable management of water resources
biodiversity and soil protection
General economic issues
potential for European lead market
market potential
cost effectiveness
dissemination potential
participation of SMEs
General technical issues
leading edge technology
shaping the technological future
technical feasibility of technologies or components
traditional position of European vendors
General social issues
creation of jobs
improvement of employment conditions
health protection
consumer protection
consumer needs
availability / accessibility for different societal groups (aspects of social exclusion)
contribution to rural development
General geographical issues
majority of the new member states
majority of the EU-15 countries

Table 10: Suggestion for possible evaluation criteria

8 CONCLUSIONS

The PT-PRO project has studied the conditions necessary to implement the concept of Performance Targets for **Industry Processes**. It has defined the main constituents of a method to design PT and has provided examples for four case studies used to illustrate what PT could look like and how they could be applied. These examples could be used in a second phase to launch discussions with stakeholders, notably industry sectors, about the actual need, feasibility and best conditions regarding PT.

Performance targets (PT) can be defined as quantified long-term objectives for the environmental performance of a product, a group of products, a service or a production process. PT within the framework of ETAP are envisaged to be **voluntary**, at least to begin with. PT should be developed **"in a dialogue between many different stakeholders"**.

Introducing PT for one industry sector should be based on a prior evaluation of its likely benefits in really helping the sector to achieve lower level of environmental impact by fully utilising the options offered by new technologies, including its value added to the regulatory system in place. The evidence that the existing environmental legislation already addresses many environmental aspects related to industrial activities makes a highly relevant question. Several studies and reports considered in the project show that this existing legislation has a stimulating effect on eco-innovation. Market-based mechanisms (such as ETS) seem to have a strong impact too.

This suggests that PT should not be envisaged to compete and certainly not subsitute the existing tools but rather complement them with a view to stimulating eco-innovation and further reduce environmental impacts from the industrial sectors.

PT can be established at different geographical levels but they would be more efficient at EU level as many companies are global players.

Whereas general guiding principles can be and have been identified for all sectors, some criteria and their different options need to be assessed against the different industrial sector's contexts, i.e. considering the environmental background, regulation background, technological background, market background and environmental management capacities.

Achieving firm conclusions for one sector would require an in-depth assessment of improvement potentials for the long term, the extent to which existing policies support the innovation and diffusion of new technologies, and the optimal conditions and format of the targets. This was obviously not within the scope of the PT PRO project. Nevertherless, this project provides some orientations regarding the different issues concerned:

The **time horizon** for PT and the dynamic character of PT have to be envisaged bearing in mind all the existing policies (for the sake of complentarity), the typical investment cycles and the possible incremental improvements in the sector. Long term ambitious targets would need to be embedded in PT that could consider horizons similar to or longer than what the existing legislation covers (2010-2015). This is in line with the fact that many investments for improved processes are capital intensive and thus need long time. In addition, radical improvements need time to be achieved because they would rely on more research and developments.

Long term ambitious targets could be envisaged in a same PT system. These could be **regularly updated** (every 2-5 years for instance) in order to stimulate changes that are achievable with more modest investments. It will indeed be crucial for all sectors that the stakeholders are fully aware of tougher demands in the future, in order to send out the right signals to those who develop and implement the technological solutions of tomorrow. This would also better reward proactive companies that are likely to be in a position to comply with e.g. the 3-year target, or those who will be able to in the near future.

Shorter targets could be justified for the industrial companies that are not so well covered by the existing legislation and those that are characterised by shorter investment cycles (basically **SME**s).

If necessary, new parameters could be included which could take new scientific knowledge about environmental impact into account whereas other parameters could be excluded, because of their declining importance. This again should fully **consider the evolving policy framework**.

A system where **targets simultaneously involve the whole sector (as represented by the sector federation) and the individual plants/companies** would enable to reduce the reduction of a monitoring and make verification feasible. It would also offer sufficient flexibility within sectors when distributing efforts and investments required.

Whatever level of definition is ultimately chosen (sector/company), a decision has also to be taken regarding the level of **integration of the impacts** considered:

Integration regarding the process/product chain (sector versus upstream processes), with a view to avoid sub-optimisation of the instrument while also seeking system easy which is implement and monitor. A life cycle approach seems attractive as it is more comprehensive, but it would also make the system complex to monitor and verify. The sectoral approach is likely to be the most appropriate for the basic industry sectors (those mainly relying on raw materials), whereas a life cycle perspective could be envisaged for sectors producing final products in order to encourage them reducing their direct and also indirect impacts.

Integration of the different environmental flows: all four case studies suggest that several environmental flows should be considered. The project could not however address the question of how to integrate these different environmental flows within a common target system.

Resource efficiency could be one environmental area to consider in relation with PT as it is only partly covered by current legislation. However, before concluding on the advantage and added-value of such a new approach, it will be necessary to closely assess what it means, what possible trade-offs need to be addressed, what it could imply and what sort of target would be relevant for each sector.

More generally, whatever environmental parameters are considered, the PTs should be formulated in a way that best fits with the integrated approach of the IPPC Directive. This is one of the different aspects to consider when seeking a PT scheme which would constructively interact with the existing policies.

Two PT schemes have been suggested:

- the first proposal focuses on a **general target for resource efficiency improvement**. The target could be set at company/plant level or at a higher level
- the second proposal is one of *a* ***dynamic classification scheme*** for products based on the environmental performance of production (similar to the Top Runner programme in Japan).

These proposals were discussed with a limited number of stakeholders who suggested the following:

- the second model is likely to be the most suited to the cement and to the paper and pulp sectors where it seems possible to assign environmental impacts to products. In addition, these two sectors have proactive consumers that could make green purchasing decisions
- the second model seems less appropriate for the textile sector which has severe allocation problems as a result of the very complex and diverse process structure. The second model is also less appropriate for the steel sector which is has customers that are less likely to take green purchasing decisions. Also, the qualities of steels are numerous.

9 ANNEX I - EXISTING POLICY INSTRUMENTS

9.1 IPPC Directive (96/61/EC)

This Directive concerning the Integrated Pollution Prevention and Control is applicable to all industry sectors listed in its Annex 1. Most important is the timeframe given: all existing plants have to meet the same criteria as those imposed for new plants by 31 October 2007 (except those in Cyprus, Malta and Slovenia).

The Directive lists a lot of qualitative objectives: cause no significant pollution, avoid waste, use energy efficiently, prevent accidents.

"The European IPPC Bureau produces BAT reference documents (BREFs) which Member States are required to take into account when determining best available techniques generally or in specific cases. The Bureau carries out its work through Technical Working Groups (TWGs) comprising nominated experts from EU Member States, EFTA countries, Accession countries, industry and environmental NGOs. These experts provide information and data and then review the draft documents that the Bureau produces".

The Commission is currently carrying out a review of the Directive, and related legislation on industrial emissions. The review will not affect the requirements given by the IPPC Directive that Member States and industry will need to fulfil before 30 October 2007.

9.2 Emission Trading Directive (2003/87/EC)

The Emission Trading Directive (ET) was launched in January 2005, thus initiating the first environmental market in the EU, involving thousands of operators having the obligation for limiting the carbon dioxide emissions from their plants. The second phase of the ETS covers the period 2008 until 2012.

The emission trading system covers 45% of the EU's CO2 emissions.

The Annex III of the ET Directive states that Member States may base their distribution of allowances on average emissions of greenhouse gases by product in each activity and achievable progress in each activity and that the quantities of allowances to be allocated shall be consistent with the potential, including the technological potential.

Therefore, the National Allocation Plans should include developments according to BAT via benchmarking mechanisms.

9.3 NEC Directive (2001/81/EC) and CAFE (COM 2005/446)

The aim of the National Emission Ceiling (NEC) Directive is the setting of national emission ceilings for the pollutants NH_3, VOC, SO_2 and NO_x. The Member States are responsible for meeting the ceilings. The targets are set for the year 2010.

The EU's Thematic Strategy on Air Pollution, which was adopted by the Commission in September 2005 proposes interim environmental objectives for 2020. In this proposed strategy, the Commission sets targets for the level of air quality in the EU until that year.

One of the actions that may directly concern industry concerns the possible extension of the IPPC directive to combustion plants up to 50 MW_{th}.

The Thematic Strategy is of importance to the NEC Directive, which is currently subject to review (a proposal for a revision of the NEC Directive is expected by summer 2007).

9.4 The EIA Directive (97/11/EC)

This Directive requires an assessment to be carried out by the competent national authorities for certain projects which have a physical (direct and indirect) effect, including on the environment (fauna, flora, soil, water, air, climate, landscape) and the interaction between these various elements.

An assessment is obligatory for certain projects, including some industry installations, including dangerous industrial facilities such as oil refineries, nuclear fuel or nuclear waste treatment facilities, integrated chemical installations, power installations, waste and water treatment facilities and a large mining facilities (large quarries, large gas or oil rigs).

Other projects are not automatically assessed: Member States can decide to subject them to assessment on a case-by-case basis or according to thresholds, certain criteria (for example size), location (sensitive ecological areas in particular) and potential impact (surface affected, duration). This notably includes all industry projects that concern all four sectors reviewed.

9.5 VOC Directive (1999/13/EC) and amendment (2004/42/EC)

This Directive requires existing plants to meet the requirements for new plants by 31 October 2007 (thus same deadline as in the IPPC Directive). The Directive deals with all activities in which solvents are used. Emission limits are given for each activity separately; they are given as a percentage of the solvent used or the amount of solvent per mass/unit/surface of product or media used. An interesting feat of the Directive is the emission reduction plan described in its Annex II B.

The amendment (2004/42/EC) provides a maximum value of VOC in products (Annex II B).

9.6 LCP Directive (2001/80/EC)

The LCP Directive sets limits for SO_2 and NO_x emissions from large combustion plants. For each fuel type, emissions limits are given in concentrations (mg/m3) with respect to the installed power (MWth) for the pollutants SO_2, NOx and dust.

New member states have extended transition periods for the emission ceilings and reduction targets (in percent) given in the Annexes for the pollutants SO_2 and NO_x. Separately There are several exceptions for special cases.

9.7 Waste Incineration Directive (2000/76/EC)

An objective of the fifth Environment Action Programme states that critical loads and levels of certain pollutants such as nitrogen oxides (NOx), sulphur dioxide (SO2), heavy metals and dioxins should not be exceeded. In terms of air quality the objective is that all people should be effectively protected against recognised health risks from air pollution. This programme further sets as an objective a 90% reduction of dioxin emissions from identified sources by 2005 (from the level achieved in 1985) and at least a 70% reduction from all pathways of cadmium (Cd), mercury (Hg) and lead (Pb) emissions by 1995.

Apart from the emission limit values (ELV, in mg/m3) in Article 6, the slag and bottom ashes Total Organic Carbon (TOC) content must be less than 3% or their loss on ignition must be less than 5% of the dry weight of the material.

As qualitative objectives, temperature requirements are given.

The provisions of this Directive applied to existing plants as from 28 December 2005.

9.8 Combined Heat and Power (CHP) Directive (2004/8/EC)

This Directive defines highly efficient CHP as plants with energy savings of >10%. The power to heat ratio is a technical characteristic that needs to be defined in order to calculate the amount of electricity from cogeneration.

The Directive had to be converted into national law by February 2006. However, there is no quantitative target for increasing the share of CHP.

9.9 Packaging and packaging waste Directive (2004/12/EC)

Article 6 of the Directive states recovery and recycling rates for waste which were valid from 2001, and from the year 2009 on, respectively.

9.10 Water Framework Directive (2000/60/EC)

The influence of this Directive on production processes is not clear yet. It will probably affect energy production but it is not known to what extent. The timeframe of the Directive is 10 to 15 years (2010 to 2015).

9.11 Dangerous substances (76/464/EC)

Article 5 states that emission standards shall determine the maximum concentration of a substance permissible in a discharge; and in the case of dilution, the limit value shall be divided by the dilution factor, but it gives no quantification of limit values.

It furthermore states that the maximum quantity of a substance permissible in a discharge may, if necessary, also be expressed as a unit of weight of the pollutant per unit of the characteristic element of the polluting activity (e.g. unit of weight per unit of raw material or per product unit).

Malta, Poland and Slovakia have extended transition periods for the implementation of this Directive.

ANNEX II – Sector case studies

When considering the environmental and technological background of the sectors considered, the best available technique reference documents (BREFs) elaborated in the context of the IPPC Directive obviously represent an important source of information for the design of PT, although the “emerging technology” parts are often rather limited.

Beyond this, the process used for preparing these reference documents (Sevilla process), with the exchange of information on technologies and performances along with consensus building amongst all stakeholders, could represent a good example when designing the formal process for setting PT.

10 PULP AND PAPER INDUSTRY

10.1 Characterisation of the pulp and paper sector

10.1.1 Branch structure

The pulp and paper industry is an international branch, with companies in many countries. Customers and production can be located in different countries.

The European production of paper and board has a share of about 27% of the world market, as shown in the table below.

Germany	19 310
Finland	13 057
France	9.938
Great Britain	6.225
Italy	9.372
Netherlands	3.341
Austria	4.564
Poland	2.362
Sweden	11.062
Spain	5.438
Other EU	7.128
EU25	**91.797**
China	41.660
Japan	30.925
Canada	20.060
USA	80.220
Other countries	74.724
World total	**338.756**

Table 11: Production paper and board in 1000 t, 2003

Source: CEPI

10.1.2 Product classes

Typical product classes are:

- pulp
- newsprint
- woodfree printing and writing papers
- printing and writing papers containing wood
- tissue
- wrapping papers
- kraft papers
- folding box boards
- kraft liners

Of the total world production of 339 Mt in 2003, about 141 Mt was graphical paper (printing, etc.) and about 164 Mt was packaging paper.

10.1.3 Important stakeholders for the implementation of PT

The diversity of the stakeholder groups for this sector and the heterogeneous priorities in different countries are presented by Mikkilä et al. (2003). The authors differentiate between "internal" from "external" stakeholders as follows:

- **internal stakeholders** include e.g. headquarters and departments of forest operations and factory staffing (top and middle management, personnel)
- **external stakeholders** are described in three main groups: financial stakeholders (customers, suppliers); stakeholders dealing with environmental, social and human rights aspects (local population, farmers, education, media, etc.); polity makers.

NGOs play an important role in the sector especially because of the forestry activities and water pollution. “Criticism of production techniques in Finland and other countries of Central and Northern Europe and also in the USA, on account of their pollution effects started in the 1970s (Hellstrom,2001). Public interest turned to sustainability and biological diversity in the production of round wood in the early 1990”(Mikkilä et al. 2003).

As pulp and paper products are processed into different end-user products, the **customer** situation varies for different companies. Direct customers are often companies that produce final products like newspapers and magazines, packaging, etc.

10.2 Components of PT:

10.2.1 Regulation background and environmental relevance

“Paper production is highly energy and water intensive. Key emissions to air are related to energy conversion (often a substantial proportion of the mill’s needs are generated on-site), while the main emissions to water are related to organic (constituents of wood) wastes and some process chemicals (such as chlorine)” (Berkhout et al. 2001). Also, a considerable amount of solid waste is generated from different process steps.

The sector is concerned by several existing regulations like the IPPC Directive, the Emission Trading System Directive and regulations on landfilling of organic waste.

10.2.1.1 Dominating environmental parameters

The EPER database[29] contains environmental data about IPPC installations in the EU15 for which emission levels were reported in 2001 (9124 installations in total). Such information has been reported for a total of 386 installations in the sector.

This information can not be considered as an inventory of pollutant emissions released by the manufacturing industry in the EU and it has to be used and interpreted cautiously. However, the size of the total emissions to air and water reported for the P&P installations covered as compared to the total emissions reported by all the industrial installations provides an indication about the most critical polluting substances emitted by the sector. This is shown in Table 12.

[29] http://www.eper.cec.eu.int/eper/Emissions_Source_category.asp?CountryCode=EU&Year=2001&ActivityId=20

Regarding **air emissions**, NOx, NH3, CO2, SOx, VOC, PM10, arsenic and chlorine are suggested to be the most significant pollutants.

Regarding **water emissions**, HAP, Nitrogen, Phosphorus, total carbon, and heavy metals (Cd, Pb, Cu, Hg, Ni, Zn) are the dominating substances.

Energy use by the P&P sector is also important. About one third of the final energy consumption is from renewable sources.

According to Berkhout et al. (2001), total **waste** is also significant in the P&P sector.

	number of industry installations covered in the EPER database		emissions reported by the pulp and paper installations as a % of the total emissions reported		
			air emissions	water emissions	
	Pulp and paper installations	all manufacturing sectors		direct	indirect
Ammonia, NH3	22	446	7.12	0.00	0.00
Arsenic and its compounds	45	1200	6.03	4.32	2.13
Cadmium and its compounds	47	1206	1.30	8.46	2.45
Carbon dioxide, CO2	84	6126	3.29	0.00	0.00
Carbon monoxide, CO	25	800	1.47	0.00	0.00
Chlorides	14	424	0.00	0.59	0.00
Chlorine and inorganic compou	18	864	3.97	0.00	0.00
Chromium and its compounds	45	1497	0.00	1.08	0.52
Copper and its compounds	60	2545	0.23	8.28	7.08
Cyanides, total CN	2	204	0.00	0.55	0.00
Dinitrogenoxide (N2O)	21	472	0.53	0.00	0.00
Dioxines and furans (PCDDs ar	1	72	0.44	0.00	0.00
Fluorides	1	188	0.00	0.02	0.00
Fluorine and inorganic compou	1	143	0.12	0.00	0.00
Halogenated Organic Compoun	71	984	0.00	85.17	39.57
Hydrofluorocarbons (HFCs)	4	182	0.10	0.00	0.00
Lead and its compounds	56	2436	0.18	3.90	3.80
Mercury and its compounds	26	1284	0.39	8.06	16.66
Methane, CH4	5	1888	0.63	0.00	0.00
Nickel and its compounds	100	5145	1.18	5.73	0.88
Nitrogen oxides, NOx	166	11102	5.62	0.00	0.00
Nitrogen, total	61	1308	0.00	9.52	0.76
Non methane volatile organic co	52	4512	5.01	0.00	0.00
Phenols	12	1035	0.00	2.70	1.68
Phosphorus, total	83	3402	0.00	17.72	0.83
PM10 (Particulate matter less th	49	780	12.57	0.00	0.00
Polycyclic Aromatic Hydrocarbo	1	141	0.00	0.04	0.00
Sulphur oxides (SOx)	112	4715	3.56	0.00	0.00
Total Organic Carbon (TOC)	292	11200	0.00	70.02	12.02
Zinc and its compounds	94	5730	0.29	11.25	4.11

Table 12: Overview of the most important substances emitted to air and water by the P&P sector as compared to the overall impacts from industry in the EU-25 (based on EPER database)

Lopes et al. (2003) describe the on-site energy production in the pulp and paper industry in Portugal as the main source of SO_2 emissions and acidification. The main source of CH_4 emissions is claimed to be land filling, and transport is the main source of NO_x.

Waste is an important by-product of the branch. A considerable part of the generated waste is recycled. In 2004, the paper industry in Europe (countries covered by CEPI) used recovered paper up to 40% of the total raw materials. A 25% was achieved in 1991.

10.2.1.2 Overview of relevant regulations

	direct impact	Comment
IPPC Directive (96/61/EC)	High	Old installations have to meet the same requirements as those imposed for new installations by 31.10.2007. Relevant to facilities with a production capacity of more than 20 t/d and combustion installations exceeding 50 MW.
EIA Directive (97/11/EC)	Low	Environmental Impact Assessments are mandatory for production installations, but there is no direct influence
NEC Directive (2001/81/EC) and CAFE programme	Varies	The Directive contains emission ceilings for NO_x, SO_2, VOC and NH_3. The influence strongly depends on the country situation. Pulp and paper plants have significant SO_2 and NOx emissions. New targets are expected to be proposed in 2007
LCP Directive (2001/80/EC)	High	The Directive contains emission limits for combustion sources
ET Directive (2003/87/EC)	High	The influence strongly depends on the country situation (based on National Allocation Plans)
Packaging and packaging waste Directive (2004/12/EG)	Medium	By 2009, a minimum of 60% of packaging waste has to be recovered or incinerated for energy recovery, and between 55 and 80% has to be recycled
Water Framework Directive (2000/60/EC)	Low	Influence on energy production by 2015. Effect cannot be quantified yet. Side effects on waste water may be possible
Dangerous substances (76/464/EC)	Low	Forbiddance of some substances.

Table 13: Overview of EU legislation and their relevance concerning performance targets for the pulp and paper industry

10.2.2 Technological situation and innovation background

In the pulping processes, fibres are separated from each other.

Mechanical pulping requires a lot of electricity, but just a limited amount of organic material and nutrients are dissolved in the process water.

In chemical pulping, inorganic chemicals are used at high temperatures to separate the fibres. More organic material is dissolved, but in many processes most of the organic material is used to generate energy for the process and the following papermaking process. The used chemicals are recirculated to a great extent.

For many paper qualities, the fibres in the pulp have to be purified to increase brightness, strength and stability. This bleaching of mechanical pulps has long been performed with hydrogen peroxide or other non-chlorine agents.

"Papermaking involves the separation of (mostly) wood fibres to produce wood pulp, their suspension in a watery 'stock' which is sprayed onto a fast-moving wire belt that allows the water to drain away leaving an interconnecting 'web' of wood fibres that is dried and pressed to form paper. This 'base paper' may be further treated by polishing or coating. Paper production processes are extremely mature and technologically rather stable, deriving from the original Foudrinier machines of the mid-nineteenth century.

The environmental profile of pulp and paper production is well understood. Historically, the environmental issues deemed to be of concern for the industry have varied through different periods.

For instance, concerns about chlorinated effluents to water during the late 1980s and early 1990s, have to a large extent, been replaced in prominence by concern about the management of forests that produce wood for paper production.

A general trend in the pulp and paper industry is the closing of systems without losing product quality and without any incrustation problem.

Other trends are effective external waste water treatment, more environmentally friendly bleaching and even better use of the energy in the raw material.

Berkhout et al. (2001) found out that "*The environmental performance at the site-level is strongly related to the sub-sector in which the site operates, and the process technology being used. For example there were consistent marked differences in the environmental performance across a range of measures of graphic fine paper, hygienic fluff and packaging production sites in the pulp and paper inudtsry*."

Important factors for the process design and quality of the effluent are of course the age of the unit and the sensitivity of the receiving waters and thus the demands from authorities.

10.2.3 Market background and performance target criteria

10.2.3.1 Sector specific issues for allocation and aggregation issues

A reasonable level of aggregation might be to set up targets where the functional unit would be the production facility. Data for significant parameters are likely to be available. It might be appropriate to envisage specific PT for different types of installations as a function of the type of raw material used and products manufactured. Performance targets should at least be developed for two different categories of raw materials used in Europe - wood and non-wood. As it regards production processes, categories similar to those in the BREF document might be used.

10.2.3.2 Are there customers willing to make environmental demands?

The study of Mikkilä et al. (2003) suggests that, in Finland, the financial, technical and environmental criteria are the most important criteria for acceptability by operators, while the political and environmental groups ranked the environmental criterion as the most important.

In Germany, only environmental stakeholders considered the environmental criterion to be the most essential one. In Portugal, all stakeholders regarded financial and technical issues as the most important main criterion. This is an example of the possible differences between willingness of customers to pay for an improvement in the environmental performance of production processes.

Customer demands are indeed an important driving force. An example for such a driving force is the establishment of chlorine-free bleached paper for magazines. After a Greenpeace campaign showing that it is possible to print magazines with such paper, customers made publishers change to chlorine-free paper.

A possible way would therefore be to implement the fulfilment of performance targets as an important environmental quality label for end-consumers. They would be able to make demands on companies using paper products.

If customers today would have the willingness to pay for improved environmental performance during production of the products they purchase, would probably need to make a study. It might also depend on how clear it is made to customers that products manufactured in line with PTs are beneficial to the environment.

10.2.3.3 Are there proactive companies?

Companies in the pulp and paper sector have made efforts in reducing their environmental impacts, but there are differences in their performance. It is also worth noting that even if a BAT is implemented, it has to be well operated in order to achieve the best performance.

The proactive companies could be identified through their environmental reports. In addition, information sources such as Eurostat, especially Eionet and the EPER could be used.

kg/dry pulp	Average	Min	Max	BAT
COD	11	4	25	5-10
BOD	4.2	0.3	8.8	0.2-0.7
TSS	2.3	0.7	4.1	0.3-1.0
Tot-N	0.20	0.059	1.89	0.1-0.2
Tot-P	0.016	0.004	0.040	0.01-0.02

Table 14: Information derived from EPER for the Swedish pulp and paper industry compared to BAT values for unbleached sulphate pulp in 2000, including external waste water treatment

Table 14 illustrates the variation between different production sites in terms of environmental performance, thus suggesting the existence of proactive companies, or, at least high performance facilities.

10.3 Target systems identified through literature

10.3.1 Labelling systems

Labelling systems exist for several products. The EU labelling system, the “EU-flower” has set up criteria for copying and graphic paper as well as for tissue paper.

The criteria are:

- the product to be manufactured using special recycled fibres
- virgin fibres come from sustainably managed forests
- air emissions of sulphur and CO_2 and water pollution have to be limited during production

Other examples for labelling systems are the German environmental label "blue angel" and the Nordic "swan" label.

The German environmental label includes criteria for paper, paper towels, copying paper, etc. The Swan Nordic has labelled many different paper products: coffee filters, paper envelopes, printed matter, tissue paper, etc.

Companies manufacturing products for an international market will only take labelling into account when there is a strong customer demand.

10.3.2 Certification systems

Certification systems exist especially for companies and production sites. Both the ISO 14000 and the EMAS schemes have been implemented**.**

10.3.3 Possible environmental improvement strategies for PT

In this section, we introduce a list of different options (Table 16) which can be used for the setting of performance targets in the pulp and paper sector.

A potential PT system should address the most important environmental impact parameters from the sector. Table 15 shows a number of parameters that have been suggested for consideration under different organisational systems in the sector.

Organisational system		**Environmental parameters**				
Management systems	**Business variables**	**Waste**	**Air emissions**	**Water emissions**	**Water consumption**	**Energy**
EMAS registration	Total sales	Total solid waste	CO_2	COD	Total water consumption	Total energy input
ISO registration	Profit	Recycled waste	SO_2	Nitrogen	Process water consumption	Non renewable energy input
Environmental investment reported	Number of employees			Phosphorus		Total energy output

Table 15: Suggested parameters to be used for the pulp and paper sector
(adapted from Berkhout et al. 2001)

Besides the mentioned values, halogenated organic coumpounds (AOX) might be added, as the pulp and paper industry is still a significant source in Europe. Also particulate matter (PM10) is an issue that might need to be addressed. At the moment, there is no well elaborated system for the reporting of the toxic effects of effluents, but such a parameter would be helpful. Another important issue is the use of renewable energy.

Based on the environmental background information presented above, a list of performance target parameters could include the parameters from the following table.

Environmental Impact category	Parameter
Climate effects	Carbon dioxide emissions
Resource efficiency	Raw materials input (biomass, energy, water, chemicals, …) Use of non renewable energy Amount of waste to landfill Water consumption
Eutrophication	Nitrogen, total
	Phosporus, total
Toxic effects	Particulate emissions (PM 10, PM 2.5)
	Halogenated Organic Compounds (AOX)
	Amount of hazardous waste
	Toxicity (to be implemented later)
Eutrophication, toxic effects	Emissions of organics to water (TOC)

Table 16: Parameters for performance targets

The unit could be chosen as a standardised unit of production from the sector or if necessary as a ton of products from the individual production processes.

Target values could be worked out for different product categories as well as for the three main raw material categories.

A performance target system could include minimum criteria for some of the above mentioned parameters and specific "front-runner" values for specific values, like AOX, TOC, etc.

In order to set target values, it will be necessary to identify the current emission levels from production facilities. The EPER could serve as a starting point, as it includes most of the facilities in Europe (provided that annual production data are available). The data could be used to calculate an average value for the whole sector. Such average values could serve as minimum criteria values, although they do not reflect the different production processes (chemical, mechanical pulp, etc).

For the identification and performances of front-runners, a more comprehensive update of the technical possibilities and their impacts on emissions would be needed for the different product categories, although such updated information do not seem to be available for the time being. However, it is possible to check emissions from each registered facility in the EPER database. Another possibility would be to use the BREF document as a starting point, although the BAT values are more than 5 years old.

In order to set realistic and achievable performance targets, it is important to be aware of realistic improvement strategies for the production processes. A first overview shows that improvement strategies could contribute to improving the environmental performance of the production processes. The list presented in Table 17 only an example of different options available to achieve performance targets. This list should be further developed together with industry experts and is one of the discussion points in the national workshops.

Improvement strategies	Examples to improve the environmental performance of processes
Use of technologies which enable the substitution of primary resources by recycling materials	Increase the amount of recycled fibres and application of BAT for recovered paper processing
Changes of processes to substitute polluting chemicals	TCF-Bleaching
Improve energy efficiency of the whole production system	Optimise energy consumption combining pulp and paper production and integration of the power station
	Heat recovery systems
Innovative processes to reduce primary fuels	Gasification of black liquor
Improve material efficiency (and use of end-of-pipe technologies)	Reduce waste water effluents and emissions to air
	Intensifying mechanical dewatering systems
	SO2- and NOx- reduction (NOx-reduction: SNCR or making changes in the combustion techniques)
	Increased system closure by the use of "kidneys"
	Minimum effluent paper mills

Table 17: Examples of improvement strategies for the paper and pulp industry (based on BREF)

A) Increase the amount of recycled fibres

"Recovered fibre has become an indispensable raw material for the paper manufacturing industry because of the favourable price of recovered fibres in comparison with the corresponding grades of virgin pulp and because of the promotion of recovered paper recycling by many European countries. The recovered paper processing systems vary according to the paper grade to be produced, e.g. packaging paper, newsprint, testliner, or tissue paper and the type of furnish used. Generally, recycled fibre (RCF) processes can be divided in two main categories:

processes with exclusively mechanical cleaning, i.e. without deinking. Products involved are testliner, corrugating board and carton board

processes with mechanical and chemical unit processes, i.e. with deinking. Products involved are newsprint, tissue, printing, copy paper, magazine papers and some grades of carton board or market DIP.

The raw materials for RCF-based paper production consist mainly of recovered paper, water, chemical additives, and energy in the form of steam and power. Large quantities of water are used as process water and cooling water. Various additives are applied during paper manufacturing, both to facilitate the processing and to improve the product properties. The environmental impact of recovered paper processing comprises basically emissions to water, solid waste (especially if wash deinking is applied as, e.g. in tissue mills) and atmospheric emissions. Emissions to the atmosphere are mainly related to energy generation by the combustion of fossil fuels in power plants (European Commission 2003a).

To avoid negative environmental impacts, it is necessary to apply BAT for recovered paper processing.

B) TCF bleaching

Totally Chlorine Free (TCF) bleaching is a bleaching process carried out without any chlorine chemicals. TCF bleaching has been developing rapidly although its application has required several modifications in the pulping process. In TCF-bleaching, hydrogen peroxide together with ozone or per-acetic acid (PA) are the most commonly used chemicals. TCF bleaching leads to the reduction of COD and AOX (water emissions). Its effect on energy and chemical consumption depends on the condition of the production process (European Commission 2003a).

C) Optimise energy consumption combining pulp and paper production and integration of the power station

Energy consumption and air emissions can be reduced by cogeneration of heat and power, the improving existing boilers and, when equipment is replaced, by the use of less energy consuming equipment.

D) Heat recovery systems

The purpose of the heat recovery system is to lower the mill's consumption of primary energy by utilising waste energy from the process in an economically profitable way. Nearly all the heat energy consumed in a paper mill is used for paper drying, making the dryer section easily the biggest energy consumer in a paper machine. Roughly 80% of the energy needed in the dryer section is brought as primary steam to the dryer cylinders, the rest comes as drying and leakage air and with the paper web. Nearly all energy leaving the dryer section is exhausted with the exhaust air. About 50% of this energy i.e. something like 620 kWh per tonne of paper can be recovered by an efficient heat recovery system (at winter conditions).

Typical applications use either air-to-air heat exchangers or air-to-water heat exchangers both of plate design (some applications use also scrubbers). The former is mainly used for heating hood supply air and machine room ventilation air. The most common application for the latter is the heating of circulation water and process water. These heat exchangers are part of heat recovery towers.

Usually only part of the heat recovered is led back to the dryer section with the hood supply air. Most is used outside the dryer section to heat process water, wire pit water and machine room ventilation air (European Commission 2003a).

E) Gasification of black liquor

Gasification is a suitable promising technique for pulp mills for the generation of a surplus of electrical energy. Production of a combustible gas from various fuels (coal, wood residues, and black liquor) is possible through different gasification techniques. The principle of the gasification of black liquor is to pyrolyse concentrated black liquor into an inorganic phase and a gas phase through reactions with oxygen (air) at high temperatures. A number of gasification processes for black liquor have been proposed. Conceptually, they fall into two categories. One is low temperature gasification, where the gasifier operates below the melting point of the inorganic salts (700 to 750 °C). Fluidised beds are suitable for a low temperature gasification process, and are used in all of the low temperature processes under development. The other category includes those processes which operate above the melting point and use a water quench to cool and dissolve the molten sodium salts (European Commission 2003a).

F) Reduce waste water effluents and emissions to air

Water management in paper mills is a complex task that has many aspects. To give an overview the main principles for internal measures to reduce fresh water consumption and discharges from recovered paper mills (system closure) are briefly summarised as follows:

- use of suitable techniques to separate less contaminated water from contaminated process water. Measures to be considered are the separation and re-use of cooling water and the re-use of less contaminated sealing and process waters used in vacuum systems.

- reduction of fresh water consumption by recycling of white water in different positions depending on the water qualities required. Positions in the process of special interest when reducing fresh water consumption are dilution of fibre raw materials and fillers, dilution of process and product aids, the shower water system, the vacuum system and sealing water for pumps and agitators

- reduction of fresh water consumption by strict separation of water loops together with counter-current flows
- generation of clarified water from white water as a substitute for fresh water, usually made in the fibre recovery unit by use of bow-screens, poly-disc filters or dissolved air flotation
- measures to handle the possible negative effects of the increased recycling of process water
- in some cases the further purification of clarified white water is applied. This purified water meets relatively high quality requirements

Separation of clean cooling waters from process effluents and their re-use for other purposes are ways of reducing fresh water consumption. For protection, a micro-screen or other strainer is recommended to remove solids. Where cooling water fractions are sewered, mixing them to contaminated process water sewers should be avoided to ensure waste water treatment efficiency and reduce treatment costs.

Air emissions in paper mills are mainly related to plants installed for the production of heat and in some cases for the co-generation of electricity. Saving of energy corresponds therefore with reduction of air emissions (European Commission 2003a).

G) Intensifying mechanical dewatering systems

Energy savings can be achieved by implementation of a system for monitoring energy usage and performance, more effective dewatering of the paper web in the press section of the paper machine by using wide nip (shoe) pressing technologies and use of other energy efficient technologies.

Rejects and sludge that is generated during pulp manufacturing and water treatment must be de-watered before final disposal or further treatment. Dewatering is carried out by means of wire presses or screw presses. Dewatering aims at removing water from the sludge as far as possible. Different types of mechanical equipment are available for this operation such as belt presses (twin wire presses), screw presses and decanter centrifuges.

Most new installations during the last 10-15 years have been belt presses, which have a reliable function and produce fairly high dry solid values, 40-50% with fibre sludge and 25-40% with mixed fibre/biological/(chemical) sludge (European Commission 2003a).

H) SO_2 and NOx reduction (SNCR)

Removing sulphur oxides from flue-gases by absorption in alkaline liquid is considered BAT. The removal efficiency for SO_2 is usually well above 90%.

Due to the low combustion temperature bark boilers give relatively low NOx emissions. Emissions are typically 70-100 mg NO_x/MJ when only bark is fired. At times when oil is used in the bark boiler an increase of NO_x to about 100 - 150 mg NO_x/MJ can be determined. Excess oxygen effects the NO_x formation and should therefore be avoided. An excess of oxygen which is too low, however, increases the risk for higher emissions of CO and VOC.

Primary NO is formed in furnaces either through reaction with nitrogen in air (thermal NO) or through oxidation of nitrogen in fuel (fuel NO). Formation of thermal NO increases with increasing temperature of the flame. A part of the NO is further oxidised to NO_2. In the SNCR process, NO is reduced by urea to nitrogen, carbon dioxide and water according to the simplified reaction:

$$2\ NO + (NH_2)_2CO + 1/2\ O_2 \rightarrow 2\ N_2 + CO_2 + 2\ H_2O.$$

The reaction occurs around 1000°C (European Commission 2003a).

I) Increased system closure by the use of "kidneys"

Currently, in most mills waste water treatment is carried out together for all mill effluents, which is a purposeful way of achieving a stable operation in the biological treatment. Recently, a few mills introduced new concepts, which focus on internal treatment of most concentrated or problematic partial waste water streams by other techniques. Thus, separatation of the contaminants closer to their place of origin has been tested to decrease the size of the water treatment equipment needed. In principle, micro-flotation, membrane filtration, chemical oxidation, evaporation and combinations of these techniques could be used to reduce the amount of contaminants. Energy consumption, investment and operating costs in the given application will have a crucial influence on the choice of treatment system.

For mechanical pulp and paper mills, multi-effect vacuum evaporation seems to be especially promising because sufficient amounts of waste heat is available to operate the treatment system (European Commission 2003a).

J) Minimum effluent paper mills

Advanced waste water treatment in the pulp and paper industry is mainly focused on additional biological membrane reactors, membrane filtration techniques such as micro-, ultra-, or nano-filtration, ozone treatment and evaporation. Due to a lack of experience, relatively high costs and an increased complexity of the water treatment, there are only a few full-scale applications of tertiary treatment of waste water mill effluent up to now. However, these techniques can potentially be applied both in-line treatment and in so-called "kidneys" to eliminate those substances that negatively affect the efficiency of paper production or paper quality. However, the choice and arrangement of the kidneys in the production process has to be determined case by case (European Commission 2003a).

11 TEXTILE INDUSTRY

11.1 Characterisation of the Textile sector

11.1.1 Branch structure

“Textile finishing is a much diversified sector due to the processed raw materials, the manufacturing techniques and the finalised products. Trends in fashion cause a continuous change in colouring and functional finishing. The textile industry is one of the longest and most complicated industrial chains in the manufacturing industry. It is a fragmented and heterogeneous sector dominated by small and medium enterprises (SMEs), with a demand mainly driven by three main end-uses: clothing, home furnishing and industrial use. A recent research report provides an in depth survey on the different processing steps and compiles useful information on function, processes and application of about 2500 chemicals substances in products used in textile finishing”.

The main characteristics of the textile sector in the EU (EURATEX, 2002) are:

- *186,400 million euros/year*
- *2,012,500 employees*
- *Textile products consumption: 14.5-17.2 kg/citizen & year (and increasing)” (Arias 2003)*

Year 2000	Textile (%)	Apparel (%)	Total (%)
Germany	14.4	13.1	13.8
France	13.1	13.0	12.9
Italy	29.7	30.8	30.1
Holand	2.0	0.8	1.5
Belgium	5.6	2.2	4.2
United Kingdom	12.5	14.2	13.4
Ireland	0.7	0.5	0.6
Denmark	1.0	1.1	1.1
Spain	8.4	11.4	9.6
Greece	2.1	2.5	2.3
Portugal	6.1	7.9	6.9
Austria	2.8	1.2	2.1
Finland	0.8	1.0	0.9
Sweden	0.8	0.2	0.6
Luxemburg	--	--	--
European Union	100	100	100

Table 18: The share in the textile production of the different EU Member statess, Source: data of Euratex (2002)

In 2000, the European textile and clothing industry represented 3.4% of the EU manufacturing industry’s turnover, 3.8% of the added value and 6.9% of the industrial employment (BREF 07/2003).

An example of changes in the textile industry in Europe (Denmark) is documented by Sondergard (2004): “*The Danish textile industry undertook major structural changes in the 1990s. The business has turned to concentrate on high value-added activities, such as design, marketing, and franchising, and on specialised product niches (e.g. technical textiles). The labour-intensive sewing processes have been out-*

sourced, primarily to Eastern Europe. Finishing processes are still, for reasons of quality management, operated in Denmark for approximately 30% of the current turnover. In textile printing, however, the production is narrowed down to short runs and special deliveries."

11.1.2 Product classes

The products could be divided into raw material (man-made fibres) to semi-processed (yarn, woven, and knitted fabrics with their finishing processes) and final products (carpets, home textiles, clothing and industrial textiles). The final products are further divided into different application areas, as shown in Table 19.

Textile	Percentage
Clothing textiles	45%
Household textiles	20%
Interior textiles	10%
Technical textiles	18%
Others	7%
Total	100%

Table 19: The share of final products of the textile sector could be described in the following way (OECD):

These categories could be further divided into numerous product types. In addition there are very fast developments of new materials and products, due to the pressure from the user side, finding new or extended usage areas. Examples of this are the demands from the car industry, for medical applications and so forth.

11.1.3 Stakeholders and important stakeholders for the implementation of PT

Some of the most important stakeholders at European level are: European Association of National Organisations of Textile Retailers, European Textile and Clothing Federation (trade union), Union of Textiles Industries, EURATEX, the European Apparel and Textile Organization, Association of European Textile Collectivities (ACTE). They are all represented in the Textile High level group, organised by DG Enterprise and Industry[30]. These organisations usually have a associated national body.

Examples of other stakeholders active in the discussion about textile issues are NGOs and other organisations involved in the Eco-labeling system. Procurers could also be important stakeholders.

Furthermore, when involving stakeholders for defining PT, manufacturing and distributing companies ought to be represented directly. Experts having a broad overview of the environmental impacts from the textile industry could also make relevant contributions.

[30] http://www.europa.eu.int/comm/enterprise/index_en.htm

11.2 Components of PT:

11.2.1 Regulation background and environmental relevance

11.2.1.1 Dominating environmental parameters

"The textiles industry has always been regarded as a water-intensive sector. The main environmental concern is therefore about the amount of water discharged and the chemical load it carries. Other important issues are energy consumption, air emissions and solid wastes and odours, which can be a significant nuisance in certain treatments." (European Commission 2003b). The air emissions are mostly well defined, stemming from the evaporation from heated process steps, and of course from the production of the energy used.

The water pollutants are complicated and hitherto not so well measured. According to the textile BREF: "The various streams coming from the different processes are mixed together to produce a final effluent whose characteristics are the result of a complex combination of factors:

- *the types of fibres involved*
- *the types of make-ups processed*
- *the techniques applied*
- *the types of chemicals and auxiliaries used in the process.*

Furthermore, since the production may vary widely not only during a year (because of seasonal changes and fashion) but even over a single day (according to the production programme), the resulting emissions are even more difficult to standardise and compare.

The ideal approach would be a systematic analysis of the specific processes, but data availability is very poor for many reasons, including the fact that legal requirements have tended to focus on the final effluent rather than on the specific processes." (European Commission 2003b).

In particular the wet processing finishing industry has water-related environmental relevance. "In the printing and finishing processes the cloth passes through a number of chemical processes to enhance the appearance, the durability, and the serviceability of the end product. These wet processes result in a high consumption of water and in waste generation and in emissions of chemicals. In addition drying furnaces and mechanical finishing entail a high consumption of energy.

The main emissions from the textile printing industry originate from pigments, acrylates and conditioners used in the printing paste. The waste water is generated during the operation of the printing machine and the cleaning of rollers when new runs are prepared. The main environmental problems of the discharged waste water from printing are related to the chemical oxygen demand (COD) of the suspended material and toxic effects of the chemicals." (Sondergard et al. 2004).

11.2.1.2 **Significance of sectoral emissions**

EU figures of total emissions from the sector are difficult to find in literature. According to estimations, about 1% of the total US industrial CO_2 emissions to the textile industry.[31] Another rather old estimate for other air emissions from the textile sector in the US, shows that the VOC emissions are more significant

[31] http://ecm.ncms.org/ERI/new/GHG.htm

with 2% of the total industrial emissions, and 0.3%–0.4% for NO_x, SO_2 and PM10 (US 1997, www.p2pays.org/ref/01/00506.pdf).

Extrapolated for Europe, these figures suggest that the CO2 emissions from the textile sector are relatively low compared to the economic importance. This is also true for the other air pollutants. If one chooses to include air pollutants in the PT, the more reasonable strategy would be to have targets for VOC. The other pollutants (mostly energy-related) could be captured by considering energy within the PT system.

Substances	Environmental load (t/yr)
Salts	200000 - 250000
Natural fibres impurities (including biocides) and associated material (e.g. lignin, sericine, wax, etc.)	50000 - 100000
Sizing agents (mainly starch, starch derivatives, but also polyacrylates, polyvinylalcohol, carboxymethylcellulose and galactomannans)	80000 - 100000
Preparation agents (mainly mineral oils, but also ester oils)	25000 - 30000
Surfactants (dispersing agents, emulsifiers, detergents and wetting agents)	20000 - 25000
Carboxylic acids (mainly acetic acid)	15000 - 20000
Thickeners	10000 - 15000
Urea	5000 - 10000
Complexing agents	<5000
Organic solvents	n.d.
Special auxiliaries with more or less ecotoxicological properties	<5000
Source: [77, EURATEX, 2000]	

Table 20: Main charging loads from the textile industry in Europe (extracted from from the BREF 7/2003)

Moreover, the following comments were made in the textile BREF 7/2003:

"From the reported figures it appears that a large percentage of the total emission load from textile industry activities is attributable to substances that are already on the raw material before it enters the finishing process sequence. Typically these are sizing agents, preparation agents and natural fibres impurities and associated material.

Sizing agents are used to assist the weaving process. They are removed from the woven fabric before the finishing process, thus producing high levels of organic load in the water.

Preparation agents and spinning oils, are applied to fibres in various steps of the process, from the manufacture of the fibre itself (for synthetic fibres only) to the formation of the yarn. These organic substances are removed during pre-treatment at the finishing mill either through wet-processing *(washing) or through dry processing (heat-setting). In the former case they contribute to the increase of the organic load of the final water effluent, in the latter case they become airborne.*

All natural fibres contain a percentage of impurities and associated material. Associated materials are an essential part of natural fibres (e.g. grease for wool, pectin and hemicellulose for cotton, lignin for flax and sericine for silk). Impurities are metals, mineral and pesticides. All these substances have to be removed from the fibre before it can undergo finishing processes. They therefore also have the potential for considerable environmental impact.

The input of chemicals and auxiliaries added at the finishing mills can be up to 1 kg per kg of processed textiles, which appears to be high. The range of these substances is very extensive: the latest issues of TEGEWA lists more than 7000 auxiliaries. However, in a typical finishing mill, 80 % of the annual consumption is covered by only 20% of the product types.

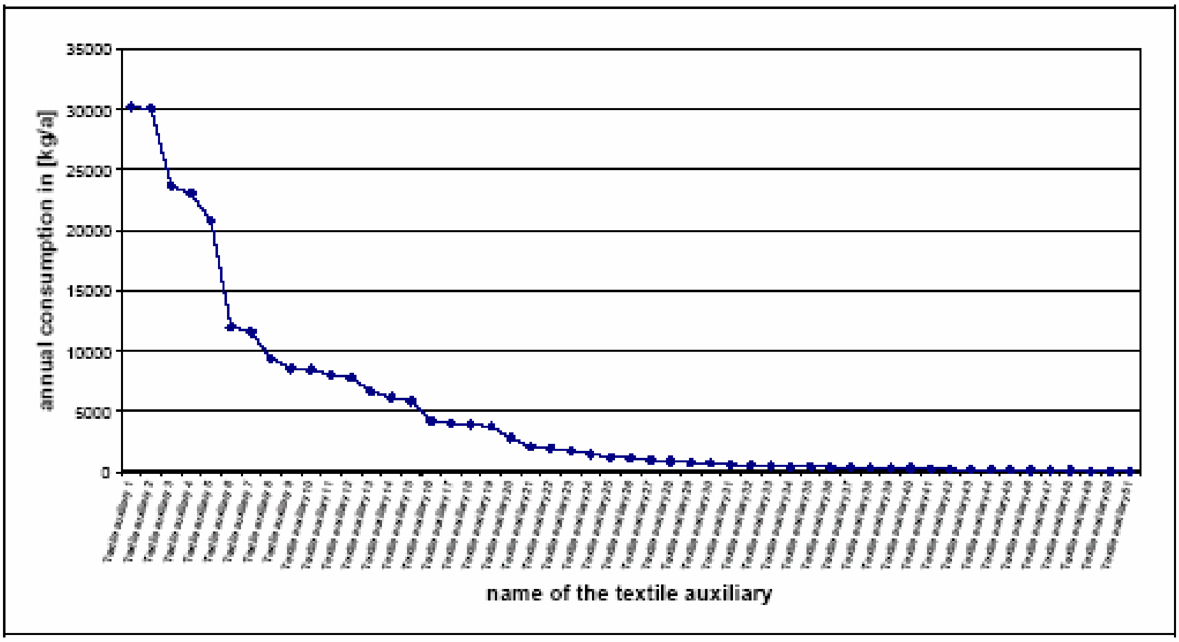

Figure 2: Auxiliaries pattern usage in a typical finishing mill (extracted from the BREF 7/2003)

- <u>alkyl phenol ethoxylates</u> (detergents, wetting agents, levelling agents, etc.): their metabolites (octyl- and nonyl phenols) are highly toxic to aquatic life and are reported to disturb the reproduction of aquatic species by disrupting the endocrine system (octyl and nonylphenol are on the list of ‘Priority Substances’ targeted for priority action under the Water Framework Directive 2000/60/EC, in particular nonylphenol is identified has ’Priority Hazardous Substance’)

- <u>polybrominated diphenyl ethers and chlorinated paraffins</u> (flame retardants), halogenated phenols and benzenes (reagents in the production of flame retardants): some members of these classes of substances (e.g. pentabromodiphenylether, C10-13 chloroparaffines) have already been identified as ‘Priority Hazardous Substances’ for their toxicity, persistency and liability to bioaccumulate or they have been evaluated under the scope of Regulation (EEC) 793/93 on the evaluation and control of the risks of existing substances. For other members of these classes the debate about their potentially negative effects on the environment is still on-going

- *mothproofing agents based on permethrin and cyfluthrin (carpet sector) and other biocides: these are highly toxic to aquatic life*
- *sequestering agents such as EDTA and DTPA and NTA: these are capable of forming very stable complexes with metals (EDTA and DTPA are also poorly bioeliminable)*
- chlorine and chlorine-releasing compounds such as sodium hypochlorite (bleaching agent) and sodium dichloroisocyanurate (wool anti-felting agent): these are capable of reacting with organic compounds to form adsorbable organic halogens (AOX)
- metal-containing compounds such as potassium dichromate
- *substances with carcinogenic potential, such as a number of aromatic amines, formed by cleavage of some azo dyes), or vinylcyclohexene and 1,3-butadiene, which can be present in polymer dispersions due to an incomplete reaction during polymerisation*
- *carriers such as trichlorobenzene, o-phenylphenol, etc. It is reported in (77, EURATEX, 2000)*
- *more than 90% of the organic chemicals and auxiliaries in pretreatment and dyeing operations does not stay on the fibre, whereas the reverse is true in the finishing treatment*
- *nearly 90% of the organic raw material load entering the textile process ends up in the waste water, the remaining amount being released to air.*

With regard to air emissions, volatile organic compounds are released from particular activities such as:

- *printing processes, in cases when organic solvents are used (e.g. they are contained in pigment printing pastes)*
- *cleaning with organic solvents*
- *heat treatments (e.g. thermofixation, drying, curing) when the textile materials contain substances that evaporate or degrade thermally (for example, oils, plasticisers, finishing agents and residues from upstream processes). Emissions of formaldehyde and uncombusted methane can be particularly significant in poorly maintained, directly heated stenters*
- *vulcanisation of the backing layers (carpet sector).*

Moreover, emissions of CO2, SOx, NOx and particulates associated with the on-site burning of fossil fuels to produce thermal energy are also to be taken into account.

Energy is consumed primarily in raising the temperature of the baths (e.g. pre-treatment, dyeing, etc.) and in drying and curing operations. To this aim steam is produced on-site. Electrical energy is required for driving the machinery."

Regarding **water emissions**, the EPER database indicates that the textile industry is the most significant in terms of HAP, total carbon, and heavy metals (Cd, Pb, Cu, Hg, Ni, Zn).

Furthermore, "The textiles industry has always been regarded as a water-intensive sector. The main environmental concern is therefore about the amount of water discharged and the chemical load it carries. (BREF).

11.2.1.3 Overview of relevant regulations

Directives	direct impact	Comment
IPPC Directive (96/61/EC)	High	Old installations have to fulfil the same requirements as those already imposed for of new installations by 31.10.2007. Via BREF determination of BAT for plants for the pretreatment or dyeing of fibres or textiles with a capacity of more than 10 t/d. In some countries, smaller installations are also included.
EIA Directive (97/11/EC)	Medium	Environmental Impact Assessments are mandatory for production installations. Costs and delays may be significant
ET Directive (2003/87/EC)	Low	Few companies are concerned
NEC Directive (2001/81/EC) and CAFE programme	Varies	The Directive contains emission ceilings for countries for NO_x, SO_2, VOC and NH_3. The influence strongly depends on the country situation. The textile industry would be more concerned by limits on NOx and NH3. New targets are expected to be proposed in 2007
Water Framework Directive (2000/60/EC)	Unclear	Effect cannot be quantified yet.
Dangerous substances Directive (76/464/EC)	Low to medium	Forbiddance of some substances. For specialised processes the replacement of substances could have significant cost implications.
REACH	High	Significant additional costs may lead to the disappearance of specialised and niche products and/or SMEs.

Table 21: Overview of the existing regulation

11.2.2 Technological situation and innovation background

The technological situation is very diverse. In the textile BREF 7/2003 several hundred pages are devoted to describing the different technology solutions in relation to their environmental performance. The following figure is taken from the BREF 7/2003:

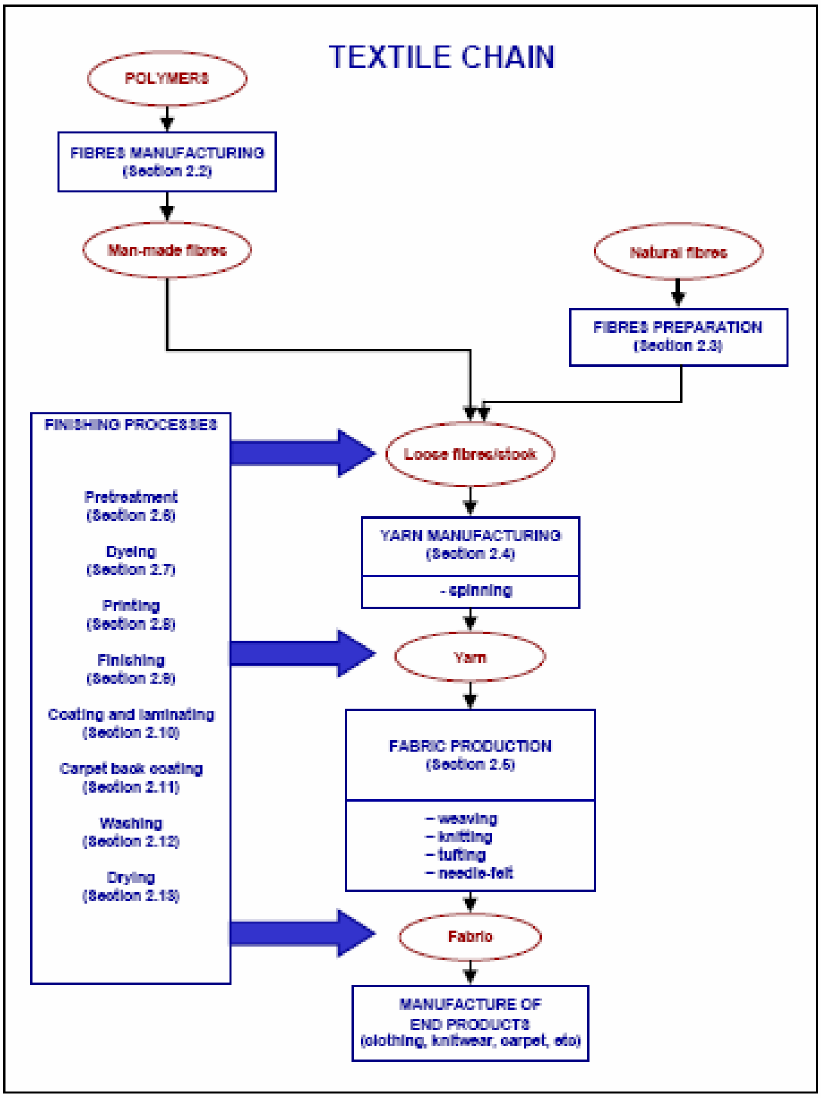

Figure 3: General diagram of processes in the textile industry (extracted from BREF 7/2003)

For all steps and boxes in this figure many options are possible, every “choice” has its own environmental impact profile. Every step could represent possible technology improvements. In addition, the energy supply and the optimal usage of energy in the chain also could be a target for improvements boosted by the formulation of PT.

The basic idea of PT is that they should not be technology specific. The producers should have the opportunity to choose the technology solutions. However, a good understanding about the possibilities that advanced technology could bring about might be important when the levels of PT should be planned. Anyhow, if effective PT should be formulated for this sector, a detailed investigation is certainly needed. The options are either to analyse the environmental impact profile for each process, or to make the same analysis for the processes leading to similar end products.

The emerging technologies applicable in the Textile sector are listed in the BREF are the follows:

Enzyme catalysed finishing processes: Enzymes are proteins that act as biocatalysts activating and accelerating chemical reactions which would otherwise normally need more energy. Their substrate selectivity allows more gentle process conditions compared to conventional processes. Enzymes are present in bacteria, yeasts and fungi.

Plasma technology: Plasma can be described as a mixture of partially ionised gases. Atoms, radicals and electrons can be found in the plasma. The electrons in low temperature plasmas are able to cleave covalent chemical bonds, thereby producing physical and chemical modifications of the surface of the treated substrate. Two types of plasma are generally used: the corona plasma and low-pressure plasma.

Electron-ray treatment: Electron-rays start free-radical initiated polymerization reactions that can then be used for coating, lamination and for graft co-polymerization reactions on textiles pre-coated with monomers or pre-polymers.

Use of supercritical CO_2 in dyeing processes: Supercritical fluids are capable of dissolving organic molecules of low to medium polarity.

CO_2 has the advantage over other gases of being non-flammable, non-explosive and non-toxic. CO_2 dyeing of PES and PP fibre is already developed on an industrial scale, however the application of this technique on wool, PA and cotton is still problematic due to the polar nature of the dyestuffs used to colour these fibres.

Ultrasonic treatments: Ultrasonic treatments improve the dispersion of dyestuffs and auxiliaries and enhance their ability to emulsify and solubilise. This allows improved liquor homogenisation, which then results in higher bath exhaustion and level dyeing properties. In addition, ultrasounds produce a de-aeration effect in the liquor and on the fabric, which is normally obtained by adding special auxiliaries (de-aerating agents).

Electrochemical dyeing: Vat and sulphur dyeing involves both a reducing and an oxidising step, which are carried out with chemical oxidants and reducing agents. An attractive alternative technique is to reduce and oxidize the dye by means of electrochemical methods. With direct electrolysis, the dye itself is reduced at the surface of the cathode. In indirect electrolysis, the reducing power of the cathode is transferred to the solution by a soluble reversible redox system (e.g. based on antraquinone chemistry or iron complexes). With this reversible redox system the reducing agent is continuously regenerated at the cathode, which thus allows full recycling of the dye bath and the reducing agent.

Alternative textile auxiliaries are:

Complexing agents: The use of polyasparginic acid as a substitute for conventional dispersing and complexing agents is under study.

Cross-linking agents: Polycarbonic acids can be used as an alternative to N-methylol-based cross-linking agents, which are responsible for formaldehyde emissions.

Biopolymers: Besides cellulose, chitin, the main structural component of crustacean shells (crabs, lobster, etc.) and insects, is the second main biopolymer. Its deacetylated derivative, chitosan, which is easier to handle due to its higher solubility, is increasing in importance.

Fuzzy logic: Significant improvements in process reliability are achievable with the use of fuzzy logic (i.e. expert systems based on self-learning software systems, which auto-enlarge their knowledge by algorithms). The application of fuzzy logic in the textile industry is the object of a number of research projects. The main advantages to be expected are the improved process control, which can subsequently result in increased productivity and enhanced quality of the final product.

On-line monitoring: Process control by on-line monitoring enhances operation liability in the direction of “right first time production”. Examples of on-going research in this area are:

dyeing: the concentration of the COD (related with the dyestuff concentration) is measured on-line during washing and rinsing operations in discontinuous dyeing processes. When the dyestuff concentration in the rinsing bath is negligible, the rinsing process is automatically stopped. This *technique allows considerable water and energy savings.*

dyeing and bleaching: by using a special amperometric sensor, the concentration of reducing or oxidising agents on fabrics can be controlled on-line. For example, the completeness of H_2O_2 removal after bleaching or the concentration of reducing agents in vat dyeing can be monitored and excess use of chemicals avoided.

dyeing with vat dyes: by monitoring the redox potential, it is possible to detect exactly the point at which the reducing agent is completely rinsed off. When this point is reached the rinsing process can be stopped and the oxidant added to the bath.

Advanced Oxidation Processes: Advanced oxidation processes are already applied in the textile industry but further research is under way to develop and test a waste water treatment based on the UV-activated photolysis of hydrogen peroxide (for the decolouration of the spent bath) combined with a bio-flotation process (for the destruction of the residual organic load). The combination of these waste water treatment processes is expected to achieve a complete decolourisation of the process waters for every type of wet process (finishing, bleaching, dyeing, etc.).

Reed bed systems for waste water treatment: For a long time researchers have pointed out the high removal capacity of natural environments (soil, wet lands, etc.) and have studied the possibility of using such environments (ecosystems) in order to purify, or at least to complete the waste water purification process. Purification techniques that use these principles in constructed plants (artificially reconstructed and confined) are commonly defined as “RBSs” or “constructed wet lands”. These techniques involve the use of plants for waste water treatment (European Commission 2003b).

11.2.3 Market background and performance target criteria

11.2.3.1 Sector specific issues for allocation and aggregation

Some allocation problems might occur. As long as specific chemicals like dyes are concerned, there are probably no problems.

For the more general parameters like COD, acids, energy and so forth, there may be some allocation problems, due to the fact that the plants may have different mixes of production, and as indicated in the textile BREF 7/2003, the water emissions are often mixed together and it is not obvious how to allocate the emissions to the right source.

However, if the emissions could be characterised at a reasonable number of representative plants for individual processes, in theory at least, general targets could be formulated for each individual process, and then a weighted summation of the “allowed” emissions could be performed at the individual plant. The same reasoning could be made for the energy consumption. Such detailed information is not available for the time being, but could in principle be gained in a future project. In practice, there might be too many parameters making all plants “unique”, which could make the formulation of targets rather complicated. If target levels are formulated for each process, this will probably also solve the aggregation issue.

11.2.3.2 Are there customers willing to make environmental demands?

Of course, this is a question that is difficult to have a firm answer to. One can argue that textiles are one of the most popular items for eco-labelling activities. These labelling activities are mostly also concerned with the environmental aspects of the production process. This is not proof, but an indication that customers are willing to prioritise environmentally better products.

A Danish investigation found that customers are willing to pay an extra 15%-17% for eco-labelled products, but otherwise there are not so many other studies that specifically address this question.

11.2.3.3 Are there proactive companies?

Over 6000 companies are involved in the Öko-Tex labelling system[32]. There are many more Ecolabelling systems that also have companies applying for the use of their symbols.

This suggests that there are many proactive companies that have already improved environmental performance of their processes, and are still successful on the market without the benefits of a PT system.

11.2.4 Control component(s) to avoid undesired impacts

The European textile industry is under a great pressure, due to imports from low-wage countries. The niche for the European textile sector is mainly high-tech products. If the PT could help to improve the market for environmentally better products, including the production process, then the competitiveness could be strengthened rather than weakened. But this is under the condition that the market is improved, because then all companies, European or non European, have to fulfil the targets to gain the benefits of the improved market. This scenario probably needs a labelling system.

It is important that SMEs will have access to support in the form of training, and perhaps technical assistance, in a similar manner as for the introduction of EMAS.

11.3 Target systems identified through literature review

The textile industry is characterised by an enormous **diversity**, both in processes and products, and, also, a lack of data. As shown before, there is however enough evidence to identify the main environmental parameters: water pollution, water consumption, waste, VOC, NH3, NOx to air, emissions to water (heavy metals, PAH,..).

There is a risk that a PT system would be very complicated, including in terms of monitoring, which could imply too much administrative and quality assurance work, compared to the environmental benefits.

Another complication is the **pressure from low-wage countries**. To make the competition fair, not only the European companies should be “forced” to comply with these PT.

A completely different way would be to have a target for the ratio of companies that fulfil other certification or labelling activities, like ISO14001/EMAS or ÖKO-TEX procedures. The number of companies having eco-labelled products in their portfolio could be seen as a form of PT. Then the targets for the emission reductions will be defined in the framework of these systems, and not in a general process. Of course, these two major ways are possible to combine.

[32] http://www.oeko-tex.com/en/main.html

11.3.1 Labelling

Compared to other products considered in this study, there are a lot of activities going on concerning the **eco-labelling** of textile products.

The **EU-Flower** offers the possibility to ecolabel textiles.

In a background report produced in 2002 for the Commission, the Danish Technological Institute[33] presents more labelling systems, e.g. the two Nordic systems:

Sweden (”Bra Miljöval”): The very detailed criteria are divided into three groups, relating to Requirements for ”Good fibres” (voluntary), for ”Good manufacturing” (compulsory), for Final products (compulsory). All products must fulfil the criteria for "Good manufacturing"which covers many different parameters, e.g. energy (< 70 MJ/kg), emissions of COD and P, waste water treatment, chemicals (classification requirements, negative list), bleaching (no perborate or chlorine containing agents).

The Nordic Eco-label, The Swan*:* The criteria are divided into seven areas: overview of production, fibre production, storage and transport of fibres, requirements of chemical products, emissions from textile processes, energy and water consumption, finished textile products.

Examples of criteria are: no chlorine-based bleaching chemicals, only solvent-free spinning, average VOC less than 1.2 g/kg; NOx less than 1 g/kg, total energy and water consumption must be documented. A plan for minimising electricity and heat consumption must exist at all plants where wet processing takes place.

An other major system is the **Blue Angel system in Germany**[34].

Outside Europe, eco-labelling systems can be found in, e.g. Zimbabwe, US, Japan, Singapore, India and New Zealand.

[33] http://europa.eu.int/comm/environment/ecolabel/pdf/textiles/background_report_april2002.pdf

[34] http://www.blauer-engel.de/willkommen/willkommen.htm

Check-list (for a first assessment only) European Commission

Life Cycle Step	Criterium	Expectations
Manufacturing (fibres)	Type of fibres	• All types of fibres can be used, with the exception of mineral fibres, glass fibres, metal fibres, carbon fibres and other inorganic fibres. • The criteria for a given-fibre type need not be met if that fibre contributes to less than 5% of the total weight of the textile fibres in the product, or if the fibres are of recycled origin.
Manufacturing (fibres)	Limitation of toxic residues in fibres	• Acrylic: Acrylonitrile < 1.5mg/kg • Cotton: residues of certain pesticides < 0.05ppm • Elastane and polyurethane: no organotin compounds • Greasy wool and other keratin fibres: limitations of certain pesticides • Man-made cellulose: AOX < 250ppm • Polyester: Antinomy < 260ppm • Polypropylene: no lead based pigments
Manufacturing (fibres)	Reduction of air pollution during fibre process	• Acrylic: acrylonitrile < 1g/kg • Elastane and polyurethane: aromatic diisocyanates < 5mg/kg • Man-made cellulose: S < 120g/kg (filament) and 30g/kg (staple) • Polyamide: N_20 < 10g/kg polyamide 6 and < 50g/kg polyamide 6.6 • Polyester: VOCs < 1.2g/kg
Manufacturing (fibres)	Reduction of water pollution during fibre process	• Flax and other bast fibres: COD/TOC from water retting reduced by at least 75% (hemp) and 95% (flax, other) • Viscose: Zn < 0.3g/kg • Cupro: Cu < 0.1ppm • Greasy wool and other keratin fibres: COD < 60 g/kg, 75% reduction of COD, off-site treatment. If on-site treatment, COD < 5 g/kg, 6 < pH < 9 and T < 40 °C
Manufacturing (processes and chemicals)	Limitation of the use of substances harmful for the environment (in particular aquatic environment) and health process	• 90% of carding and spinning oil, lubricants and finishes for primary spinning and 95% of sizing preparations, detergents, fabrics softeners and weight complexing agents shall be sufficiently biodegradable or eliminable. • Polycyclic aromatic hydrocarbons (PaH) in mineral oils < 1% • No cerium compounds, halogenated carriers • No heavy metals and formaldehyde in stripping and depigmentation • No APEOs, DTDMAC, DSDMAC, DHTDMAC, EDTA, LAS, DTPA, chrome mordant dyeing • AOX emissions from bleaching agents < 40 mg Cl/kg (100mg in certain cases) • Level of impurities in dyes (in ppm): Ag < 100 Ba < 100 Co < 500 Se < 20 Fe < 2500 As < 50 Cd < 20 Cr < 100 Cu < 250 Hg < 4 Ni < 200 Pb < 100 Sb < 50 Sn < 250 Zn < 1500 Mn < 1000 • Level of impurities in pigments (in ppm): As < 50 Cd < 50 Cr < 100 Hg < 25 Pb < 100 Sb < 250 Zn < 1000 Ba < 100 Se < 100 • No chlorophenols, PCB and organotin compounds during transportation or storage • No biocidal or biostatic products active during use phase • Discharge to the water of metal complex dyes based on Cu, Cr or Ni: max 20% (cellulose dyeing), 7% (other dyeing process). After treatment: Cu < 75 mg/kg (fibre, yarn, fabric), Cr < 50 mg/kg, Ni < 75 mg/kg • No azo dyes that cleave to a list of aromatic amines • No dyes classified as carcinogenic, mutagenic, toxic for reproduction according to Directive 67/548/EEC. • No potentially sensitising dyes if fastness to perspiration > 4 • Printing pastes < 5% VOCs. No plastisol based printing • Formaldehyde < 30ppm for products in direct contact with the skin. 300ppm for others • COD from wet-processing < 25g/kg. If on-site treatment, 6 < pH < 9 and T < 40°C • No flame retardants or finishing substances containing > 0.1% of substances classified as carcinogenic, mutagenic, toxic for reproduction and dangerous for the environment according to Directive 67/548/EEC • Shrink resistant finishes only allowed for wool slivers • Coatings, laminates and membranes: no plasticizers or solvents assigned a list of R-phases according to Directive 67/548/EEC
Use	Performance and durability	The following tests shall be carried out either on dyed yarn, final fabrics or final product: • Dimensional changes during washing and drying: 8% for knitted products, 8% for terry towelling, 6% for other woven products, 2% removable and washable curtain and furniture fabric • Colour fastness to perspiration (acid, alkaline), washing, wet rubbing, dry rubbing, light (see criteria)

Table **22**: Table from the EU-Flower website

(extracted from *http://europa.eu.int/comm/environment/ecolabel/index_en.htm*)

11.3.2 Certification systems

There are actually special certification systems specially designed for the textile sector (e.g. ÖKO-TEX 1000). Furthermore there are the usual certification systems that could also be relevant for companies in the textile sector, ISO14001[35] and EMAS[36].

"There are two philosophies how to achieve a better environmental performance of a company. On the one hand improvements can be achieved by external pressure applied, i.e. legal requirements or other regulations defining exact goals for environmental protection. On the other hand systems can be promoted, which yield a permanent improvement of the environ-mental performance of a company using the resources at hand.

A possibility to achieve such environmental improvements, to verify them and show them to the public, is the participation in environmental auditing and certification schemes like this Öko-Tex Standard 1000, the ISO-standard 14000 series or the EMAS-system of the European Union." [37]

11.3.3 Possible environmental improvement strategies for PT

In this section, we introduce a list of different options (Table 23) which can be used for setting the Performance Targets in the textile sector.

In order to set realistic and achievable performance targets it is important to be aware of realistic improvement strategies for the production processes. According to the first analysis improvement strategies are found which can contribute to the improvement of the environmental performance of production processes. The list presented in Table **22**, is only an example of the options that are available to achieve performance targets. This list should be further developed together with industry experts.

Improvement strategies	**Examples to improve environmental performance of processes**
Improve energy efficiency	Power and heat management
Improve material efficiency	Water management
	Water recycling (e.g. membrane technologies)
	Optimisation of chemical processes in the textile industry (predominantly dyeing and finishing)
	Increase the amount of spun-dyed fibres
Innovative processes to reduce polluting materials	Supercritical CO2-dyeing for PET and PP
	Development of ecological finishing systems (e.g. fibre finish, sizing, resins etc.)
Innovative processes for quality management and improve material and energy efficiency	Implementation of computer aided process control (fuzzy logic, ASPEN® plus, etc.)

Table 23: Examples of improvement strategies which are suggested for Textile industry

[35] http://www.iso.org/iso/en/ISOOnline.frontpage

[36] http://europa.eu.int/comm/environment/emas/index_en.htm

[37] http://www.oeko-tex.com/en/main.html

Water and energy management, power and heat management

Water and energy savings are often related to the textile industry because the main use of energy is to heat up the process baths. A summary of the selected BAT for water and energy saving is presented here:

- monitor water and energy consumption in the various processes
- install flow control devices and automatic stop valves on continuous machinery
- install automatic controllers for control of fill volume and liquor temperature in batch machines
- establish well-documented production procedures in order to avoid wastage of resources from inappropriate work practices
- optimise scheduling in production and adjust processes in pretreatment to quality requirements in downstream processes
- investigate the possibility of combining different treatments into one single step
- install low- and ultra-low liquor ratio machinery in batch processes
- introduce low add-on application techniques in continuous processes
- improve washing efficiency in both batch and continuous processing
- re-use cooling water as process water (also allowing heat recovery)
- investigate possibilities for water re-use and recycling by systematic characterisation of quality and volume of the various process streams in order to identify processes for which the substances contained in the various waste streams are still valuable and/or do not interfere with the quality of the product. For recycling purposes in batch processes it is convenient to install machinery with built-in features that facilitate recovery and re-use of waste streams
- fit hoods and covers ensuring full closure of machinery that could give rise to vapour losses
- insulate pipes, valves, tanks and machines to minimise heat losses
- optimise boiler houses by applying re-use of condensed water, preheating of air supply, heat recovery from combustion gases
- segregate hot and cold waste water streams prior to heat recovery and recover heat from the hot stream
- install heat recovery systems for off-gases
- install frequency-controlled electric motors

Implementation of quality management standards (ISO 9000-series, EN 14000-series etc.)

The main environmental advantages achievable by systematic performance of optimised housekeeping and management measures are savings in the consumption of chemicals, auxiliaries, fresh water and energy and the minimisation of solid waste and pollution loads in waste water and off-gas.

Tools such as EN ISO 9000, EN ISO 14001 and EMAS will support this approach. Information and communication are required at company level and within the whole supply chain.

Water recycling (e.g. membrane technologies)

Batch processes do not easily allow for water recycling. When trying to re-use waste water in batch operations, storage facilities for re-usable waste water must be provided. Other problems associated with the re-use of waste water from batch bleaching and scouring are the non-continuous character of the waste stream and the higher liquor ratios.

Continuous counter current flows of textiles and water is now also possible in batch processing. Machines are now available with built-in facilities for waste stream segregation and capture. For example, the wash water from a previous load can be recovered and fully used in the bleach bath for the current load, which can then be used to scour the next load. In this way, each bath is used three times.

Optimisation of chemical processes in the textile industry (predominantly dyeing and finishing)

Since auxiliaries in general do not remain on the substrate after dyeing, they are ultimately found in the emissions.

The term "finishing" covers all those treatments that give the textile the desired end-use properties. Finishing may involve mechanical/physical and chemical treatments. Moreover, among chemical treatments one can further distinguish between treatments that involve a chemical reaction of the finishing agent with the fibre and chemical treatments where this is not necessary (e.g. softening treatments).

"One example for an innovation-oriented PT for the textile industry (polyester) is 100% substitution of conventional lubrifiying oils for hydro soluble oils in knitted fabric making and 100% water recycling with 50% reduction of energy consumption by 2010. The environmentally oriented PT could include a reduction of energy consumption of knitting and dyeing as well as a reduction of emissions and wastes to 30% of the current BAT by 2010. A reduction of chemicals consumption is a clean technology to avoid emissions"(Arias 2003).

Increase the amount of spun-dyed fibres

"Whilst commodity VSF (viscose staple fibres) are sold in a bleached or raw-white state, the specificity of spun-dyed VSF is that they are already dyed in the dissolving bath, that is to say before the fibres are formed by pressing the dope through spinnerettes.

The results of the Commission's market investigation suggest a distinction between commodity VSF and spun-dyed VSF. From a demand-side perspective, it should be noted that the vast majority of customers who responded to the Commission's questionnaire and who use spun-dyed fibres have denied that they would switch to raw-white commodity VSF in the event of a small but permanent price-increase of 5 to 10 % for spun-dyed VSF. The reluctance to switch amongst customers purchasing spun-dyed VSF was mainly based on price and quality considerations. Customers interviewed by the Commission stated that, compared to fibres dyed further downstream in the production process, spun-dyed VSF had superior colourfastness, particularly when exposed to sunlight (light-fastness). In addition, customers also mentioned that the investment necessary for dyeing fibres in the downstream production process was considerable. It was also pointed out that there were applications for which the use of spun-dyed VSF was absolutely necessary, in particular coloured household wipes and certain kinds of fancy yarn (bicolour yarn)."[38](European Commission 2004a)

Supercritical CO_2 dyeing for PET and PP

CO_2 dyeing of PES and PP can be carried out under optimal isothermal and isobaric conditions at 120°C and 300°C. Dye uptake and fastness properties are very similar to water dyeing. Nevertheless some precautions need to be taken.

CO_2 dyeing has a number of advantages:

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[38] http://europa.eu.int/eur-lex/pri/en/oj/dat/2004/l_082/l_08220040319en00200072.pdf (L 82/37)

- almost zero water consumption
- zero off-gas emissions (CO_2 can be recycled)
- no drying step necessary after dyeing
- levelling and dispersing agents are not needed at all or, in some cases, they are added in very small amounts
- the dyestuff residues can be recycled.

Nevertheless, the investment cost for the equipment is high and this is a significant drawback, especially when considering that PES textiles are normally lowpriced products.

Implementation of computer aided process control (fuzzy logic, etc.)

Significant improvements in process reliability are achievable with the use of fuzzy logic (i.e. expert systems based on self-learning software systems, which auto-enlarge their knowledge by algorithms). The application of fuzzy logic in the textile industry is the object of a number of research projects. Two examples concern the control of the sizing process and the control of the condensation reaction of cross-linking agents.

The main advantages are the improved process control, which subsequently can result in increased productivity and enhanced quality of the final product. Indirect environmental benefits are associated with the potential savings in energy and chemicals as a result of the improved process control. The main limitation in the implementation of these expert systems in the textile industry is often the lack of a reliable database.

12 IRON AND STEEL INDUSTRY

12.1 Characterisation of the Iron and Steel sector

12.1.1 Branch structure

Production of steel uses large and expensive equipment. This is one reason why the sector consists of large companies. The bulk of the production in Europe is ensured by the Arcelor-Mittal Group, with 46.9 Mt in 2004. Even the 60^{th} largest company, SSAB, still produced 4.1 Mt.

The European confederation of iron and steel industries (EUROFER) represents 96% of the iron and steel industries in Europe. The last 4% of the iron and steel industry is represented by European Independent Steelworks Association (IESA).”(Markussen et al. 2002)

12.1.2 Product classes

The product range varies, as there are many different applications used by the iron and steel industry. Usually, iron and steel companies produce intermediate products in different forms like sheets, coils, tubes, etc. Products vary in steel quality as well, from pig iron to high alloyed steel. Both ferritic, martensic and austenitic steel is produced at different qualities. Different metals like chromium, nickel, etc. are used to achieve specific properties.

Category	Mt
Ingots and semi-finished material	51.0
Railway track material	2.7
Angles, shapes and sections	17.7
Concrete reinforcing bars	14.8
Bars and rods, hot-rolled	9.1
Wire rod	17.9
Drawn wire	4.9
Other bars and rods	3.9
Hot-rolled strip	3.2
Cold-rolled strip	3.6
Hot-rolled sheets and coils	50.0
Plates	20.6
Cold-rolled sheets and coils	29.8
Electrical sheet and strip	3.4
Tinmill products	6.4

Galvanised sheet	24.3
Other coated sheet	6.8
Steel tubes and fittings	23.8
Wheels (forged and rolled) and axles	0.3
Castings	0.6
Forgings	0.8

Table 24: This table is from IISI (International Iron and Steel Institute) and shows the export of different products in 2003

12.1.3 Important stakeholders for the implementation of PT

The sector consists mainly of large companies, of which a considerable number are outside Europe. There is tough international competition. Price is the main factor. The production of special and high steel qualities specifically designed for certain customers may also represent an asset in terms of competetiveness. Customers are mainly companies, e.g. car industry, construction industry. The customers generally have an environmental management system and may therefore have an interest is buying products produced with less environmental impact.

12.2 Components of PT:

12.2.1 Regulation background and environmental relevance

12.2.1.1 Dominating environmental parameters

The emissions from the industry are significant at European level, especially emissions to air and generation of waste. Considerable work has been undertaken to address environmental issues. Emissions have been reduced during the last few decades, but there are still significant emissions. The iron and steel industry is responsible for significant CO2 emissions. According to the International Iron and Steel Institute[39], "the average emission for the reporting companies is 1.6 tonnes of CO2 for every tonne of crude steel produced."

Iron and steel production is one of the basic industries, providing other industries with pre-products. Large amounts of raw materials are handled and processed.

The EPER database[40] contains environmental data about IPPC installations in the EU15 for which emission levels were reported in 2001 (9124 installations in total). Such information has been reported for a total of 171 installations in the iron and steel industry. The sector is very **energy** intensive (and also autoproducer).

This information can not be considered as an inventory of pollutant emissions by the manufacturing industry in the EU and it has to be used and interpreted cautiously. However, the size of the total emissions to air and water reported for the iron and steel installations covered as compared to the total

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[39] IISI, 2004, The Measure of Our Sustainability, Report of the World Steel Industry

[40] http://www.eper.cec.eu.int/eper/Emissions_Source_category.asp?CountryCode=EU&Year=2001&ActivityId=20

emissions reported by all the industry installations provides an indication of the most critical polluting substances emitted by the sector. This is shown in Table 25.

Regarding **air emissions**, the EPER database shows important contributions from the iron and steel industry for CO2 and for many of the air pollutants (including NOx, SOx, AOX, heavy metals, phosphorus, phenols, nitrogen, fluorides, DCM (dichloromethane), 1,2-DCE (dichloroethane), cyanides, chlorides and brominated diphenyl ethers).

Regarding **water emissions**, HAP, particulate matters, total carbon, and heavy metals (Cd, Pb, Cu, Hg, Ni, Zn) are significant.

The contribution to ***waste*** *generation* ***(***oil and oil emulsions, slag, metal hydroxide sludge and hazardous waste) is also significant.

Depending on the pollutant, different processes are more or less involved. For instance:

NOx emissions are particularly emitted by energy plants

PM10 are primarily emitted by basic oxygen furnaces and also by coke ovens. Pig irons contribute to total particulates emissions as well

SOx emissions are mainly emitted by energy plants

	number of industry installations covered in the EPER database		emissions reported by the iron and steel installations as a percentage of the total emission reported		
				water emissions	
	iron and steel industry sector	all manufacturing sectors	air emissions	direct emissions	indirect emissions
Methane, CH_4	12	944	0.74	0.00	0.00
Carbon monoxide, CO	66	400	60.86	0.00	0.00
Carbon dioxide, CO_2	66	1021	17.52	0.00	0.00
Hydrofluorocarbons (HFCs)	3	91	0.15	0.00	0.00
Dinitrogenoxide (N_2O)	10	236	0.53	0.00	0.00
Ammonia, NH_3	8	223	0.92	0.00	0.00
Non methane volatile organic compounds (NMVOC)	16	752	1.44	0.00	0.00
Nitrogen oxides, NOx	95	1586	12.09	0.00	0.00
Sulphur oxides (SOx)	54	943	11.97	0.00	0.00
Nitrogen, total	26	436	0.00	13.89	9.12
Phosphorus, total	8	567	0.00	2.35	1.01
Arsenic and its compounds	41	400	19.15	6.41	1.65
Cadmium and its compounds	72	402	39.69	29.06	9.71
Chromium and its compounds	97	499	55.80	13.52	0.18
Copper and its compounds	68	509	21.75	8.57	1.04
Mercury and its compounds	44	428	24.21	12.89	1.25
Nickel and its compounds	99	1029	12.38	26.22	1.12
Lead and its compounds	124	609	58.05	10.31	18.19
Zinc and its compounds	158	955	56.72	21.42	5.40
Dioxines and furans (PCDDs and PCDFs)	28	72	47.19	0.00	0.00
Pentachlorophenol (PCP)	1	1	100.00	0.00	0.00
Trichloroethylene (TRI)	2	105	1.37	0.00	0.00
Benzene	15	209	10.69	0.00	0.00
Benzene, toluene, ethylbenzene, xylenes (as BTEX)	1	101	0.00	0.27	0.00
Organotin compounds	3	9	0.00	60.15	0.00
Polycyclic Aromatic Hydrocarbons (PAH)	31	141	15.92	56.83	1.34
Phenols	18	345	0.00	10.20	38.95
Total Organic Carbon (TOC)	27	1400	0.00	3.09	0.38
Chlorides	5	212	0.00	2.77	0.00
Chlorine and inorganic compounds (as HCl)	24	288	20.00	0.00	0.00
Cyanides, total CN	23	102	0.00	20.34	39.32
Fluorides	23	188	0.00	9.19	8.61
Fluorine and inorganic compounds (as hydrogen fluoride)	20	143	11.86	0.00	0.00
Hydrogen cyanide (HCN)	8	35	8.61	0.00	0.00
PM10 (Particulate matter less than 10 µm)	51	390	31.86	0.00	0.00

Table 25: Overview of the most important substances emitted to air and water by the iron and steel sector as compared to the overall impacts from industry in the EU25 Based on EPER

To identify the processes having the biggest influence on air pollution we rely on the data of the RAINS[41] model published by IIASA.

The RAINS projection also suggests that the share of emissions from blast furnaces and sinter plants will become more important as the emissions of other sectors are reduced.

	10-20%	5-10%	3-5%	1-3%
NOx		Combustion: 6.9%		
PM10			Basic oxygen furnace: 4.9%	Electric arc furnace: 1.7%, Coke oven: 1.4%, Combustion: 2.0%
PM2.5		Basic oxygen furnace: 6.2%		Electric arc furnace: 2.2%, Coke oven: 1.6%,
TSP			Basic oxygen furnace: 3.2%	Pig iron 1.9%, Electric arc furnace: 1.2%, Combustion: 2.6%
SO_2	Combustion: 11.3%			

Table 26: Share of relevant pollutant emissions for the Iron and Steel industry in the RAINS model sectors in the year 2000 for the EU-25.

12.2.1.2 Overview of relevant regulations

Directives	Direct impact	Comment
IPPC Directive (96/61/EC) (including BREFS)	High	Via BREF determination of BAT for pig iron or steel production installations with a capacity of more than 2.5 t/h and also for coke ovens and combustion installations exceeding 50 MW Old installations have to fulfil the same requirements as those imposed for new installations by 31.10.2007. The first BREF was adopted in December 2001. A revision has started.
EIA Directive (97/11/EC)	Low	Environmental Impact Assessments are mandatory for production installations
NEC Directive (2001/81/EC) and CAFÉ programme	High	The Directive contains national emission ceilings for NO_x, SO_2, VOC and NH_3. The influence strongly depends on the country situation, but in view of the importance of the sector in the total emissions, the impact may be significant. New targets are expected to be proposed in 2007
LCP Directive (2001/80/EC)	High	Contains emission limits for combustion sources and special gases produced by the steel industry
ET Directive (2003/87/EC)	High	Influence depends on country situation
Water Framework Directive (2000/60/EC)	Low	Influence on energy production by 2015. Effect cannot be quantified yet. Side effects on waste water may be possible
Dangerous substances Directive (76/464/EC)	Low	Forbiddance of some substances. The directive has been transformed into others

Table 27: Overview of the environmental legislation and the relevance for the iron and steel industry.

[41] The **R**egional **A**ir **P**ollution **IN**formation and **S**imulation model (RAINS) has been developed by IIASA. The model was used for the development of international agreements such as the 1999 Gothenburg Protocol under the United Nations Economic Commission for Europe (UN/ECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) as well as for the 2001 European Community Directive on National Emission Ceilings of certain atmospheric pollutants (Directive 2001/81/EC).

12.2.2 Technological situation and innovation background

The technological situation is different in each company. The revision of the first BREF document for iron and steel is at a very early stage. One preliminary step is to define the issues to be revised in the existing BREF. A substantial decrease in energy consumption and carbon dioxide emissions has been achieved during the last 10–20 years in the EU15. Industry claims to be close to the theoretical demand at least for blast furnaces with current technology (e.g. presentation of Anders Ullberg, SSAB at IVL conference, March 2004). Only completely new technologies could bring about substantial future reductions in CO2 emissions and energy consumption. The ongoing research made by the industry is promising in that sense (see ULCOS project)[42].

The potentials of new combinations of existing technologies should be investigated.

For example energy reduction potentials may still be achieved by combining the process steps or by integrating downstream activities. However, the integration is a matter of site capacities. The combination of the "near net shape/strip caster" with integrated mills will take longer, because of the limitation of the capacities of the new equipment (Worrell et al. 2004). The combination of "near net shape/strip casters" and mini mills could also have a high potential to reduce the direct energy consumption in the steel production. However, the extent of the overall reduction is not always clear because the assessment should take into account the upstream energy use which would entirely depend on the way electricity is produced. Scrap availability is also a limiting factor for mini-mills.

Box 1: There is a variety of techniques available, giving the potential for further improvements. One example of emerging technologies is the "Near Net Shape Casting/Strip Casting":

Box 1

Near Net Shape Casting/Strip Casting - Technology Description

Near net shape casting and strip casting are the most recent developments in metal shaping. Currently, metals are cast in ingots or slabs. The ingots and slabs need to be reheated after casting to roll them in the final shape. Near net shape/strip casting integrates the casting and hot rolling of steel into one process step, thereby reducing the need to reheat the steel before rolling it. Strip casting directly casts a strip of 1–10 mm. This technology leads to considerable capital cost savings and energy savings. It may also lead to indirect energy savings due to reduced material losses.

The specific primary energy savings for this technology are estimated at 95% compared to the 1994 average energy intensity of casting and rolling. Compared to a state of the art casting and rolling facility, the specific energy savings are estimated at about 90%. Fuel savings are 98% compared to the 1994 average energy intensity and electricity savings are estimated at 74%.

The total energy savings will depend on the penetration rate of near net shape/strip casters into the market. Little new construction is expected in the US steel industry, but the industry will need to reorganize to reduce over-capacity. This will most likely happen in the integrated segment of the industry. Near net shape/strip casters are expected to first penetrate the secondary steel or mini-mill market due to the limited capacity of the current equipment.

A recent assessment of multiple emerging energy-efficient technologies assumed a 30% penetration rate by 2015 (Martin et al., 2000). The great benefits of this technology will make this technology an attractive alternative when the current casters and/or rolling mill need to be replaced. Therefore, in this study we assume a slightly higher penetration rate by 2025. Assuming that by 2025, 40% of steel is cast using near net shape/strip casting technology, this would result in estimated primary energy savings of nearly 160 TBTU, or 10% of total projected primary energy used in the iron and steel industry (Worrell et al. 2004).

42 http://ica.cordis.lu/search/index.cfm?fuseaction=proj.simpledocument&PJ_RCN=7525751&CFID=4970184&CFTOKEN=93432955)

The use of mini-mills are expected to increase. "Concerning the technology mix, the integrated steelworks are expected to lose their predominant position due to their higher costs. Production via mini-mills would raise its share from 34% of the world installed capacity by 2000 to 55% by 2030." (Hidalgo et al. 2005). This is however a possible share at the global level in a reference scenario, and assuming no shortage of scrap. The evolution may be different for different regions and for other scenarios.

There are solutions for improved monitoring and control, slag and dust reduction or re-use, acid recovery, energy efficiency etc. Global direct emissions from the Iron and Steel sector are expected to decrease by around 15% by 2030 as compared to 1990 levels. This is due mainly to the lower energy consumption (a 29% reduction is expected by 2030 as compared to 1990 levels), resulting from the shift to cleaner and cheaper technologies and fuels. Such energy efficiency improvements are reached at the expense of solid fuels. Technological improvements in the secondary routes avoid a higher increase in the consumption of electricity" (Hidalgo et al. 2005).

The review of the BREF document will consider new possibilities of technologies that can be implemented for further improvements. Some important examples are:

- PROven Single Chamber Pressure Control System
- emission process optimising sintering (EPOSINT)
- foaming techniques at pig iron pretreatment
- new concepts for electric arc furnaces

The ULCOS project is much more ambitious than the BREF. It is aimed to develop steelmaking production technologies with CO2 emissions reduced by more than 50%. These new technologies are expected to be commercially available in 10-20 years time.

12.2.3 Market background and performance target criteria

12.2.3.1 Sector-specific issues for allocation and aggregation

Allocation of environmental parameters is possible in most cases, as long as it is not necessary to dedicate emissions to a specific steel grade. A difficulty would be to compare effects of using new resources and recycled steel (as mining is not included). Also, using surplus heat, e.g. from hot water or flue-gas for district heating, can lead to allocation problems for the definition of PT. Although this will not reduce the emissions at the steel sites, the emissions in the region will be reduced as a result of reduced need for heat generation plants.

A difficult problem is how reduced environmental impact while during usage of products can be handled. Although the idea of the project is to address production processes, it is important to avoid sub-optimisation, i.e. improved emission situation from production processes that results in a worse situation during product using. Conversely, whereas a higher alloyed steel (like high strength steel) might imply higher environmental impacts during steel production, life cycle impacts of the product using such high strength steel could be reduced (one example is the car which is made lighter and will use less fuel).

Therefore if the most practical approach would be to focus on the improvement of the process, the evaluation of PT should point out possible negative effects in upstream or downstream processes.

A comprehensive approach should also be used for the whole process (allowing, e.g. internal recycling), but technological improvements could be identified for different unit operations. Due to data availability, the most practical approach is probably to set the system boundaries for the measurement of PT at each production site. It will also allow companies to choose where in their processes improvements can be made most efficiently.

12.2.3.2 Are there proactive companies?

As the iron and steel BREF-document shows, several companies are introducing a number of new technologies in order to manufacture their products more efficiently and to avoid emissions.

The proactive companies could be identified through comparison of their environmental reports. In addition information sources such as Eurostat, Eionet, UN and EPER could be used.

The Odyssee project[43] provides energy indicators for the different sectors in the EU15. Energy consumption for the iron and steel industry are reported with energy per ton crude steel in the different countries (see next figure). These data illustrate both the impact of the electric arc furnace (EAC) on energy consumption and, also, the fact that, for similar EAC share, the level of energy performance can significantly differ from country to country, and thus from plant to plant.

This clearly shows the existence of improvement potentials and that some companies are more advanced than others in terms of performance improvements.

Such proactive companies would likely be interested in products with a PT-label. Another possibility is the involvement of public procurement. Already today specific requirements are set up, also regarding environmental performance of suppliers. A possibility will be to demand that products have been produced according to PT criteria or use PT-criteria material.

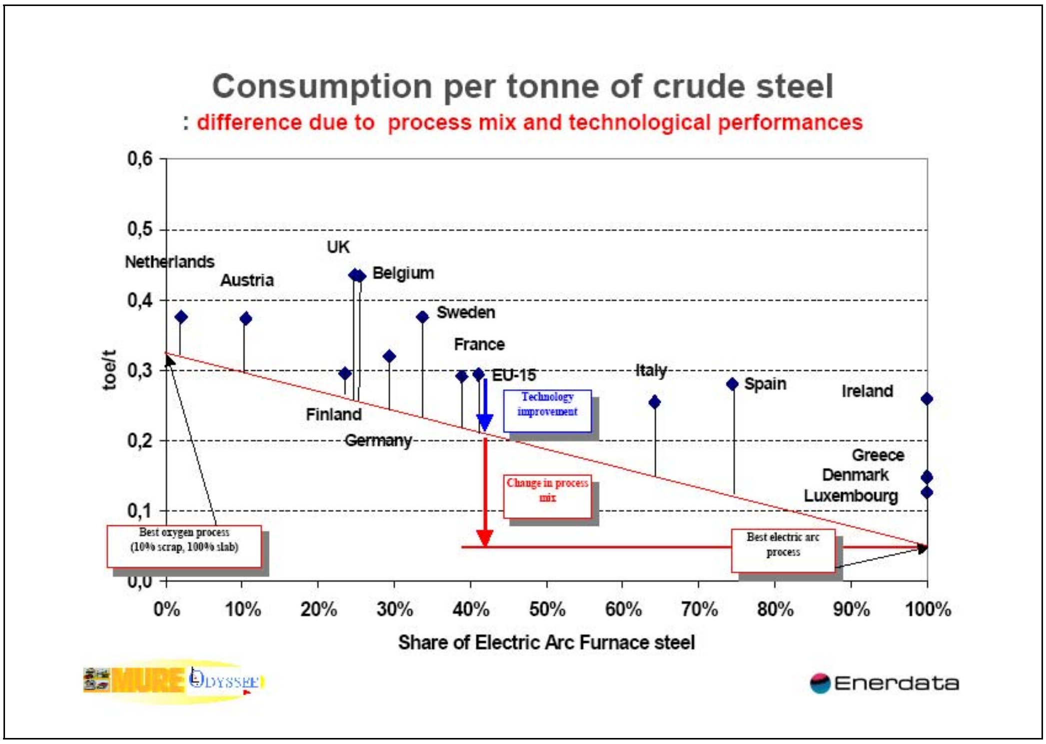

Figure 3 : Consumption of energy per tonne of crude steel

[43] http://www.odyssee-indicators.org/Reports/sectors_industry.html

12.2.4 Control component(s) to avoid undesired impacts

The social impacts of performance targets are divided mainly into the impacts on consumer and user behaviour, and the impact on jobs and on the working situation.

The quality of products is essential for the users. The iron and steel industry has a wide spectrum of consumers and users and attention should be paid to the potential changes induced by PT to the quality of products.

The situation of workers is important too. "Structural change in industries often leads to mass redundancies. If these layoffs are concentrated geographically and affect groups of workers with very specific human capital, serious problems in local labour markets can arise. Governments and firms typically design special plans to cope with such problems (Winter-Ebmer 2000).

12.3 Target systems identified through literature review

Labelling systems

In this study we could not find any environmental labelling system which has been developed for the iron and steel sector.

Comprehensive assessment of the environmental impact during production of steel beds has been made using life-cycle methods. The Environmental Product Declarations (EPD) is one system for describing the environmental performance of products in a quite comprehensive way. Specific rules for different product categories have been developed. One category is "Steel products". As the EPD system has specific requirements that are sometimes recognised as too complicated, a somewhat simplified version, the "stepwise EPD" is also available.

There could be a labelling system for new technologies ("PT-qualified"). But, it would be important, that the labelling system is widely accepted, so that iron & steel companies can use it, e.g. for environmental reporting. It would also be needed to make customers aware of the possibility to reduce their environmental impact when purchasing PT-steel.

Certification systems

Important certification systems are the international ISO standards according to the ISO 9000 and 14000 groups for quality and environmental management. Many steel companies are certified according to ISO 14001 for environmental management.

Certification of products based on their production processes seems to be successful particularly when companies purchase their own raw materials, although further down the supply chain, companies are able to regulate their incoming material quality by requesting data from suppliers

The Steel Recycling Institute (SRI), a unit of the American Iron and Steel Institute gives information about a steel certificate, LEED[44] which is a trademark for Leadership in Environment and Design. It is a specific certife for the recycled content of steel building products. Steel certificates exist also in order to assure a certain product quality. Such certificates can be requested for each shipment of products.

Emission trading system

Regarding the impact of **market-based mechanisms** in the EU, the review of the **EU emissions trading** system made by McKinsey and Ecofys (2005)[45] provides interesting findings regarding the effect of the system on long-term decisions and on innovation in the sector.

For 50% of all the companies surveyed, the EU ETS plays a key role in long-term decisions and for 48% it is only one of many other issues. In the steel industry, 86% of the companies involved in the survey consider that ETS plays a key role in their decisions.

The survey also showed that "about half of the companies claim a strong or medium impact on decisions to develop innovative technology". The proportion is even higher in the steel sector (84%).

This means that the ETS is likely to stimulate innovation on energy technologies with of course a direct impact on CO2 emissions. On can also expect more indirect impacts on other energy-related air emissions.

12.4 Possible environmental improvement strategies for PT

A possible system of performance targets could include the following parameters in order to be quite comprehensive and to cover different environmental effects:

Effect category	**Parameter**
Climate effects	Carbon dioxide emissions
Acidification, eutrophication	Sulphurous oxide emissions (SO_2)
	Nitrogen oxide emissions (NO_x)
	Emissions of organics to water (TOC)
Toxic effects	PCDD/F, PAH emissions
	Particulate emissions (TSP, PM 10, PM 2.5)
	Heavy metal emissions (Cr, Pb, etc.)
	Amount of hazardous waste
Resource efficiency	Total amount of waste
	Water consumption

Table 28: Parameters for performance targets
Note: Organic emissions (TOC) to water can consist of very different compounds. Basically the main threats to the environment are: organic compounds are used as carbon source, contributing to eutrophication. Other organics might cause toxic effects on the environment.

[44] See http://www.recycle-steel.org/leed.html: "*LEED™ is Leadership in Energy & Environmental Design. The LEED Green Building Rating System™, as promulgated by the US Green Building Council, aims to improve occupant well-being, environmental performance and economic returns of buildings using established and innovative practices, standards and technologies.*"

[45] McKinsey & Company, Ecofys, 2005, Review of the EU emissions trading system – survey highlights, study for the EC Commission (DGENV)

Performance targets could be set up for each production site as described in section 12.2.3.1. In order to compare performance, the values should be measured per ton steel produced. The maximum total amount of emissions for each site is covered in a better way by permits from the authorities.

The system could include a label with a 3–5 grade scale, e.g. similar to the energy labelling for refrigerators.

An option for the definition of targets could be to set two categories: the average for Europe and a frontrunner level, e.g. the best 10% in Europe. All parameters should at least meet the average European level, but in order to get a better PT evaluation, the frontrunner level should be met. Depending on the scientific and political demands, some parameters could be made more important, e.g. a better PT evaluation is only possible if carbon dioxide emissions are reduced to the frontrunner level.

13 CEMENT INDUSTRY

13.1 Characterisation of the cement sector

13.1.1 Branch structure

Almost 3 tons concrete are used annually per inhabitant in the world. The industry produces 1.6 billion tons of cement annually (CSI 2002).

In 2003, the EU had a 14% production share of cement from the world's total (CEMBUREAU 2004). International trade handle only 6 to 7% of the total production, mainly due to the high transportation costs (IEA 1999). Cement is hardly transported for long distances (300 km seems to be a maximum for inland transport). However bulk transportation by sea is economically feasible and actually plays a growing role. Bulk shipping has, to some extent, changed that, and it is now cheaper to cross the Atlantic Ocean with 35000 tonnes of cargo than to truck it 300 km. However, in large countries transportation costs normally cluster the markets into regional areas, with the exception of a few long-distance transfers (where, for example, sea terminal facilities exist) (Szabo et al. 2006).

The demand for cement in Europe grows increasingly slower, even with a tendency to stabilise (CEMBUREAU 2004). Despite this, the average cement consumption per inhabitant in Europe is still over 50% higher than worldwide. In the coming years, one can expect further growth of the world cement production. This would be accompanied by a decreasing share of European cement industry.

The cost of cement plants is usually above 150M€ per Mton of annual capacity, with correspondingly high costs for modifications. The cost of a new cement plant is equivalent to around 3 years of turnover, which ranks the cement industry among the most capital intensive industries. Long time periods are therefore needed before investments can be recovered and plant modifications have to be carefully planned and must take account of the long-term nature of the industry (CEMBUREAU 2005).

The cement industry is very energy intensive. Each tonne of cement produced requires 3 to 6 Gt energy.

On the other hand, it has a low labour intensity. With the development of modern automated machinery and continuous material handling devices, the cement industry has become a process industry using a limited amount of skilled labour. A modern plant is usually operated with less than 150 people (CEMBUREAU 2005).

The european cement industry is represented by the European Cement Association CEMBUREAU. Since 1 January 2005, CEMBUREAU has been composed of 25 national cement producers associations. These are associations from the European Union countries (except for Cyprus, Lithuania, Malta and Slovakia) and Turkey, Norway, Switzerland.

13.1.2 Product classes

Although cement is produced in several different qualities and varieties, the differences between products are rather small when it comes to the actual production steps. Most, if not all cement types are based on more or less the same clinker. The differences between the products are mostly due to the ratio of clinker, and what type of additional material added to the cement product. The EU has its own standardisation. The following tables (New Eurocements 2000) describe the system, and detail the different cement blends there are on the market:

British Standard		Cement	BS EN 197–1 cement notation	Clinker content, %	Content of other main constituents, %	BS EN-197-1 cements manufactured in the UK
To be withdrawn	To co-exist beyond 1 April 2002					
BS 12[1)]	BS 4027	Portland cement	CEM I	95 – 100	–	✓
–	BS 146[3)]	Portland-slag cement	CEM II/A–S	80 – 94	6 – 20	
			CEM 11/B-S	65-79	21-35	✓
–	–	Portland-silica fume cement	CEM II/A–D	90 – 94	6 – 10	
–		Portland-pozzolana cement	CEM II/A–P	80 – 94	6 – 20	
			CEM II/B--P	65 – 79	21 – 35	
			CEM II/A–Q	80 – 94	6 – 20	
			CEM II/B–Q	65 – 79	21 – 35	
BS 6588[1)]		Portland-fly ash cement	CEM II/A–V	80 – 94	6 – 20	
			CEM II/B–V	65 – 79	21 – 35	✓
–			CEM II/A–W	80 – 94	6 – 20	
			CEM II/B–W	65 – 79	21 – 35	
–		Portland-burnt shale cement	CEM II/A–T	80 – 94	6 – 20	
			CEM II/B–T	65 – 79	21– 35	
–		Portland-limestone cement	CEM II/A–L	80 – 94	6 – 20	
BS 7583[1)]			CEM II/A–LL	80 – 94	6 – 20	✓
–			CEM II/B–L	65 – 79	21 – 35	
			CEM II/B–LL	65 – 79	21 – 35	
–		Portland-composite cement	CEM II/A–M	80 – 94	6 – 20	
			CEM II/B–M	65 – 79	21 – 35	
–	BS 146[3)]	Blastfurnace cement	CEM III/A	35 – 64	36 – 65	✓
BS 4246[2]	–		CEM III/B	20 – 34	66 – 80	✓
			CEM III/C	5 – 19	81 – 95	
–	–	Pozzolanic cement	CEM IV/A	65 – 89	11 – 35	
–	BS 6610		CEM IV/B	45 – 64	36 – 55	
–	–	Composite cement	CEM V/A	40 – 64	36 – 60	
			CEM V/B	20 – 39	61 – 80	

NOTE. See the National Foreword and National Annex N.A to BS EN 197–1 for additional information on the reasons for the withdrawal or continued co-existence of current British Standards and the BS EN.

1) These three British Standards will be withdrawn on 1 April 2002

2) This British Standard will be withdrawn to a time-scale dictated by the revision of BS 146.

3) BS 146 is to be revised to remove any conflict with BS EN 197–1 and to include the current BS 4246 cement.

Table 29: European Equivalents to British Standard Cements

CEM I	Portland cement: comprising Portland cement and up to 5% of minor additional constituents
CEM II	Portland-composite cement: comprising Portland cement and up to 35% of other single constituents
CEM III	Blastfurnace cement: comprising Portland cement and higher percentages of blastfurnace slag
CEM IV	Pozzolanic cement: comprising Portland cement and higher percentages of pozzolana
CEM V	Composite cement: comprising Portland cement and higher percentages of blastfurnace slag and pozzolana or fly ash

Table 30: Nomenclature fort he main cement types

S – blastfurnace slag
D – silica fume;
P – natural pozzolana;
Q – natural calcined pozzolana;
V – siliceous fly ash (e.g. pfa);
W – calcareous fly ash (e.g. high-lime fly ash);
L and LL – limestone;
T – burnt shale;
M – two or more of the above.

Table 31: Nomenclature fort he second main constituent

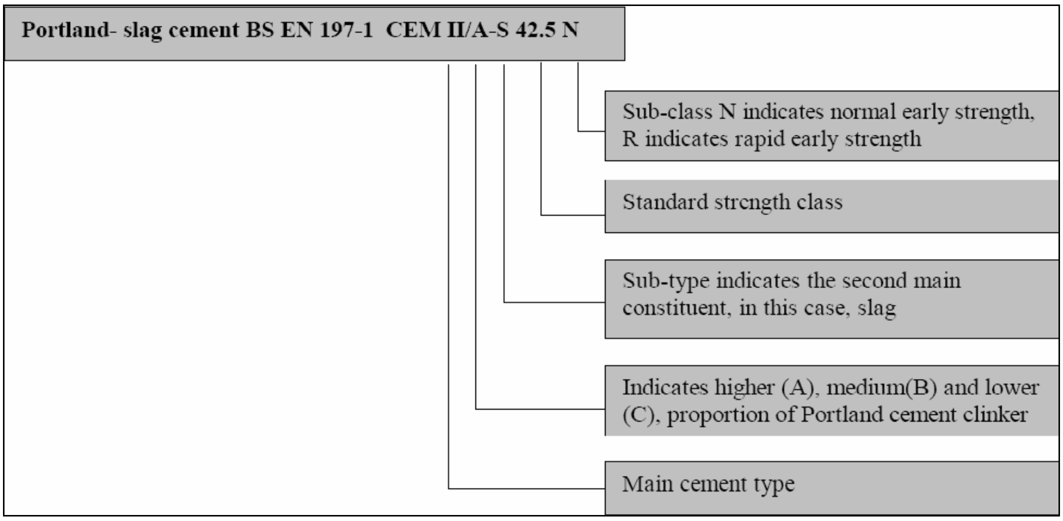

Figure 4: An example of a standard designation

Within the EU, only 43% of the sold cement is of type CEM I (European Commission 2001). The average clinker/cement ratio in Europe is 81% for the total amount of cement sold (WBCSD 2002). The usage of blended cement is influenced by cement standards, construction standards, and the availability of the added raw materials (like, e.g. blast furnace slags and fly ashes). The blended cement takes a longer time to reach full strength, but then it is most often stronger than the pure Portland cement. The global potential to lower CO_2 emissions due to adding secondary materials to the cement lies between 5% and 20%, with large local variations (IEA 1999).

More radically different cement types are also proposed, e.g. the Australian firm TecEco has developed a new type of "eco-cement" in which some 50%-90% of the Portland cement is replaced with reactive magnesia. It has been claimed that CO_2 emissions from the manufacture of eco-cement are almost 20%

lower than from Portland cement production (N.n. 2003). In Japan there is also a special type called Ecocement that is more or less produced from waste incineration residues (Taiheiyo 2005). However, these radically different types form only a very tiny fraction of the cement production in total.

Although produced from natural raw materials which vary from plant to plant, cement can be considered a standard product, there are only a few classes of cement and in each class, products from different producers can generally be interchanged. Therefore, price is the most important sales parameter next to customer service; quality premiums exist but are rather limited (CEMBUREAU 2005). However, if customers want to take an extended responsibility for the environmental situation, like, e.g. performing Green public procurement, or buying more "green products" in the context of fulfilling "ISO14001 objectives and targets", this statement may not be quite so valid.

13.2 Components of PT:

13.2.1 Regulation background and environmental relevance

13.2.1.1 Dominating environmental parameters

Air emissions are the most significant impacts for this sector.

The EPER database[46] contains environmental data about IPPC installations in the EU15 for which emission levels were reported in 2001 (9124 installations in total). Such information has been reported for a total of 205 installations in the cement sector.

This information can not be considered as an inventory of pollutant emissions by the manufacturing industry in the EU and it has to be used and interpreted cautiously. However the size of the total emissions to air and water reported for the cement installations covered as compared with the total emissions reported by all the industry installations provides an indication of the most critical polluting substances emitted by the sector. This is shown in Table 32.

Besides CO2 emissions, important air emissions are NOx, CO, heavy metals (arsenic, cadmium, chromium, mercury), particulates along with dioxins and PAH. This is also emphasised in other sources (Josa et al. 2004) and in the BREF on cement (European Commission 2001).

[4646] http://www.eper.cec.eu.int/eper/Emissions_Source_category.asp?CountryCode=EU&Year=2001&ActivityId=20

	number of industry installations covered in the EPER database		% of the total emissions reported
	cement industry	all manufacturing sectors	
Methane, CH_4	1	944	0.04
Carbon monoxide, CO	111	400	5.45
Carbon dioxide, CO_2	184	1021	19.83
Dinitrogenoxide (N_2O)	6	236	0.10
Ammonia, NH_3	17	223	3.59
Non methane volatile organic compounds (NMVOC)	11	752	0.34
Nitrogen oxides, NO_x	198	1586	25.76
Sulphur oxides (SO_x)	90	943	4.50
Arsenic and its compounds	12	400	3.09
Cadmium and its compounds	21	402	5.34
Chromium and its compounds	8	499	2.59
Copper and its compounds	7	509	1.64
Mercury and its compounds	64	428	13.75
Nickel and its compounds	16	1029	1.48
Lead and its compounds	14	609	1.43
Zinc and its compounds	14	955	0.49
Dichloromethane (DCM)	1	205	0.04
Dioxines and furans (PCDDs and PCDFs)	3	72	3.84
Benzene	29	209	2.89
Polycyclic Aromatic Hydrocarbons (PAH)	10	141	3.05
Phenols	2	345	0.00
Total Organic Carbon (TOC)	1	1400	0.00
Chlorine and inorganic compounds (as HCl)	31	288	5.01
Fluorine and inorganic compounds (as hydrogen fluoride)	3	143	0.45
PM10 (Particulate matter less than 10 µm)	73	390	12.38

Table 32: Overview of the most important emissions to air by the cement sector as compared to the overall impacts from industry in the EU25Based on the EPER database

The cement industry produces about 5% of global anthropogenic CO_2 (Schneider et al. 2002); half of this is from the chemical process of clinker production and 40% from burning fuel. The remaining 10% is split between electricity use and transportation (CSI 2005).

The following table (European Commission 2001) shows that the range between the best and the worst performing plants is substantial. Thus there ought to be a large potential for improvements at many plants, and it also shows that there are already plants performing considerably better, and still could manage to stay on the market. From some large and environmentally ambitious companies figures for CO_2 emissions in kg/t cement are reported.

Emission ranges from European cement kilns

	mg/Nm^3	kg/tonne clinker	tonnes/year
NO_x (as NO_2)	<200–3000	<0.4-6	400-6000
SO_2	<10–3500	<0.02-7	<20-7000
Dust	5–200	0.01-0.4	10-400
CO	500–2000	1-4	1000-4000
CO_2	400-520 g/Nm^3	800-1040	0.8-1.04 million
TOC	5-500	0.01–1	10-1000
HF	<0.4-5	<0.8-10 g/t	<0.8-10
HCl	<1-25	<2-50 g/t	<2-50
PCDD/F	<0.1-0.5 ng/Nm^3	<200-1000 ng/t	<0.2-1 g/year
Metals:			
Σ (Hg, Cd, Tl)	0.01-0.3 (mainly Hg)	20-600 mg/t	20-600 kg/year
Σ (As, Co, Ni, Se, Te)	0.001-0.1	2-200 mg/t	2-200 kg/year
Σ (Sb, Pb, Cr, Cu, Mn, V, Sn, Zn)	0.005-0.3	10-600 mg/t	10-600 kg/year

Note: Mass figures are based on 2000 m^3/tonne clinker and 1 million tonnes clinker/year. Emission ranges are one-year averages and are indicative values based on various measurement techniques. O_2-content is normally 10%.

Table 33: Emission Range from European cement kilns

Energy consumption is one of the drivers for the large environmental burden from the cement sector. Comparing the situations in different parts of the world is interesting:

Japan is the leading country when it comes to energy efficiency in the cement sector. Europe (4.1 GJ/t cement on average) could not compete with Japan (3.1 GJ/t), but many other parts of the world show much higher energy consumption patterns, e.g. the average US (5.3 GJ/t) or Chinese plant are well above the European average plant, regarding energy consumption (Worrell et al. 2001).

The patterns are similar for emitted CO_2. The reasons for the low Japanese consumption are mainly efficient production facilities with almost exclusively the dry technique, and comparatively low clinker content in the cement.

In the US, many plants (25%) use the wet system and high clinker content. The European figures lie between the Japanese and the US figures. The clinker content is closer to the one in Japan (81% compared to 80%) (European Commission 2001), (Aahmann 2004).

13.2.1.2 Overview of relevant regulations

Directives	Direct impact	Comment
IPPC Directive (96/61/EC)	High	Via BREF determination of BAT for installations with production capacity of more than 500 t/d. By 31.10.2007, old installations have to fulfil the same requirements as those imposed to new installations.
EIA Directive (97/11/EC)	Low	Environmental Impact Assessments are mandatory for production installations, but there is no direct influence.
NEC Directive (2001/81/EC) and CAFE programme	High	The Directive contains national emission ceilings for NO_x, SO_2, VOC and NH_3. The influence strongly depends on the country situation. Cement industry has significant SO_2 and NOx emissions. New targets are expected to be proposed in 2007.
LCP Directive (2001/80/EC)	High	The Directive contains emission limits for the combustion sources.
Waste incineration Directive (2000/76/EC)	Medium	Contains emission limits for co-combustion of waste in cement kilns.
ET Directive (2003/87/EC)	Medium	Influence stongly depends on country situation. Trading scheme causes additional costs (Schleich and Betz 2004).
Water Framework Directive (2000/60/EC)	Low	Influence on energy production by 2015. Effect cannot be quantified yet.
Dangerous substances Directive (76/464/EC)	Low	Forbiddance of some substances.

Table 34: Overview of the environmental legislation and its relevance for the cement industry

13.2.2 Technological situation and Innovation background

"The clinker kiln is the main consumer of thermal energy. Almost 90% of the total energy consumed by the system is due to the production of clinker and, thus, cements with lower clinker contents consume less energy. The distribution between electrical and thermal energy is factory dependent." (Josa et al. 2004)

"The average energy consumption of wet rotary kilns (wet process) almost doubles that of the dry process, because the evaporation of water from the feed material requires substantial energy." (Szabo et al. 2006/ available online July 2004)

Precalcinator and preheater both improve the energy efficiency of the process. "*Precalcinator decreases the energy consumption by 8-11%*" (Szabo et al. 2006). It enables also the use of waste as fuel and may reduce the NO_x emissions. Nevertheless the use of waste may cause new emissions with negative environmental impacts.

A description of the cement manufacturing process is made in the BREF document (European Commission 2001):

The basic chemistry of the cement manufacturing process begins with the decomposition of calcium carbonate ($CaCO_3$) at about 900 °C to leave calcium oxide (CaO, lime) and to liberate gaseous carbon dioxide (CO_2); this process is known as calcination. This is followed by the clinkering process in which the calcium oxide reacts at a high temperature (typically 1400°C to 1500°C) with silica, alumina, and ferrous oxide to form the silicates, aluminates, and ferrites of calcium which comprise the clinker. The clinker is then ground or milled together with gypsum and other additives to produce cement.

There are four main process routes for the manufacture of cement :

- in the **dry process**, the raw materials are ground and dried to raw meal in the form of a flowable powder. The dry raw meal is fed to the preheater or precalciner kiln or, less often, to a long dry kiln

- in the **semi-dry process,** dry raw meal is pelletised with water and fed into a grate preheater before the kiln or to a long kiln equipped with crosses

- in the **semi-wet process,** the slurry is first dewatered in filter presses. The filter cake is extruded into pellets and fed either to a grate pre-heater or directly to a filter cake dryer for raw meal production

- in the **wet process**, the raw materials (often with a high moisture content) are ground in water to form a pumpable slurry. The slurry is either fed directly into the kiln or first to a slurry drier."

The choice of process is to a large extent determined by the state of the raw materials (dry or wet). A large part of world clinker production is still based on wet processes. However, about 78% of Europe's cement production is from dry process kilns, a further 16% of production is accounted for by semi-dry and semi-wet process kilns, with the remainder of European production (about 6%) now stem from wet process kilns. The ratio of wet systems is decreasing (European Commission 2001).

"The average energy consumption of wet rotary kilns (wet process) almost doubles that of dry process, because the evaporation of water from the feed material requires substantial energy" (Szabo et al. 2006). Precalciner and pre-heater improve the energy efficiency of the process. "Precalcinator decreases the energy consumption by 8 to 11%".

All processes have the following sub-processes in common:

- winning of raw materials
- raw materials storage and preparation
- fuels storage and preparation
- clinker burning
- cement grinding and storage
- packing and dispatch (European Commission 2001)

The process is schematically described in next figure:

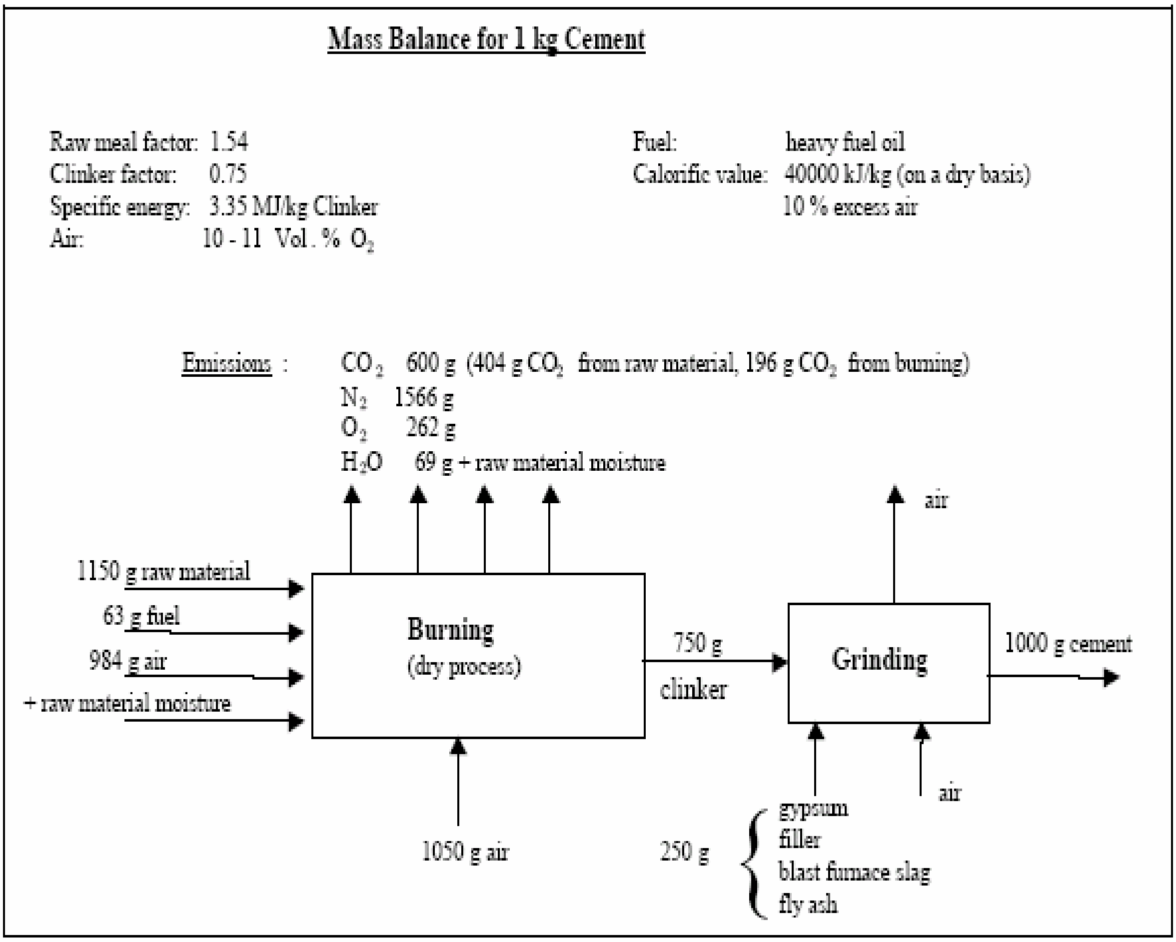

Figure 5: Mass Balance for 1 kg Cement (from European Commission (2001))

The cement production uses large amounts of energy. The sector shares many environmental problems with the other energy intensive sectors. The technology solutions for environmental improvements are to a large extent common for NO_x, SO_2 and particulates. The same technology solutions that are used for Large Combustion Plants are used also in this sector. The high combustion temperatures are a problem, considering the formation of NO_x, but it is also an advantage when other fuel sources are to be burnt, like e.g. hazardous waste fractions. A detailed description of the different options to abate NO_x, SO_2 and dust, lies out of the scope of this report. However, the following tables from European Commission (European Commission 2001) summarise the most important aspects:

Technique	Kiln systems applicability	Reduction efficiency	Reported emissions		Reported costs [3]	
			mg/m^3 [1]	kg/tonne [2]	investment	operating
Flame cooling	All	0-50 %	400-	0.8-	0.0 -0.2	0.0-0.5
Low-NO_x burner	All	0-30 %			0.15-0.8	0
Staged combustion	Precalciner	10-50 %	<500-1000	<1.0-2.0	0.1-2	0
	Preheater				1-4	0
Mid-kiln firing	Long	20-40 %	No info.	-	0.8-1.7	No info.
Mineralised clinker	All	10-15 %	No info.	-	No info.	No info.
SNCR	Preheater and Precalciner	10-85 %	200-800	0.4-1.6	0.5-1.5	0.3-0.5
SCR – data from pilot plants only	Possibly all	85-95 %	100-200	0.2-0.4	ca. 2.5 [4] 3.5-4.5 [5]	0.2-0.4 [4] No info. [5]

1) normally referring to daily averages, dry gas, 273 K, 101.3 kPa and 10% O_2
2) kg/tonne clinker: based on 2000 m^3/tonne of clinker
3) investment cost in 10^6 euros and operating cost in euros/tonne of clinker, normally referring to a kiln capacity of 3000 tonne clinker/day and initial emission up to 2000 mg NO_x/m^3
4) costs estimated by Ökopol for a full scale installation (kiln capacities from 1000 to 5000 tonne clinker/day and initial emissions from 1300 to 2000 mg NO_x/m^3), operating costs ca. 25% lower than for SNCR
5) costs estimated by Cembureau for a full scale installation

Table 35: NOx reducing systems

The relation between costs and abatement ratios for NO_x reduction is shown in next figure:

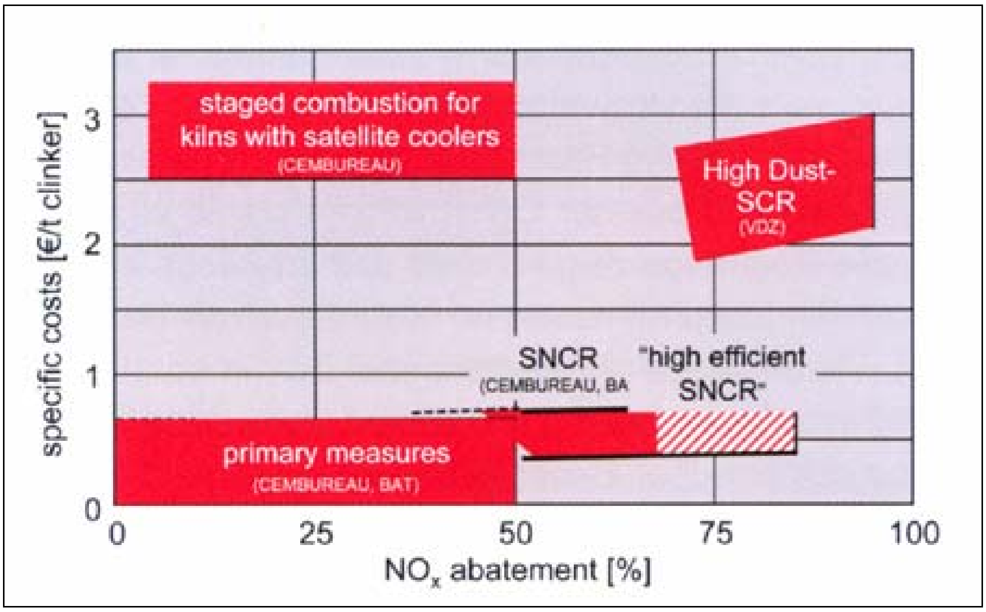

Figure 6: Ratios for NOx reduction (Cement int 2003)

Technique	Kiln systems applicability	Reduction efficiency	Reported emissions mg/m³ [1]	kg/tonne [2]	Cost [3] investment	operating
Absorbent addition	All	60-80%	400	0.8	0.2-0.3	0.1-0.4
Dry scrubber	Dry	up to 90%	<400	<0.8	11	1.4-1.6
Wet scrubber	All	>90%	<200	<0.4	6-10	0.5-1
Activated carbon	Dry	up to 95%	<50	<0.1	15 [4]	no info.

1) normally referring to daily averages, dry gas, 273 K, 101.3 kPa and 10% O_2
2) kg/tonne clinker: based on 2000 m^3/tonne clinker
3) investment cost in 10^6 euros and operating cost in euros/tonne clinker
4) this cost also includes an SNCR process, referring to a kiln capacity of 2000 tonne clinker/day and initial emission of 50-600 mg SO_2/m^3

Table 36: SO2 reducing systems

Technique	Applicability	Reported emissions mg/m³ [1]	kg/tonne [2]	Cost [3] investment	operating
Electrostatic precipitators	All kiln systems	5-50	0.01-0.1	2.1-4.6	0.1-0.2
	clinker coolers	5-50	0.01-0.1	0.8-1.2	0.09-0.18
	cement mills	5-50	0.01-0.1	0.8-1.2	0.09-0.18
Fabric filters	All kiln systems	5-50	0.01-0.1	2.1-4.3	0.15-0.35
	clinker coolers	5-50	0.01-0.1	1.0-1.4	0.1-0.15
	cement mills	5-50	0.01-0.1	0.3-0.5	0.03-0.04
Fugitive dust abatement	All plants	-	-	-	-

1) for kiln systems normally referring to daily averages, dry gas, 273 K, 101.3 kPa and 10% O_2
2) kg/tonne clinker: based on 2000 m^3/tonne clinker
3) investment cost in 10^6 euros and operating cost in euros per tonne of clinker for reducing the emission to 10-50 mg/m^3, normally referring to a kiln capacity of 3000 tonne clinker per day and initial emission up to 500 g dust/m^3

Table 37 : Particulate reducing systems

Improvement in the energy efficiency of the process

The following BAT descriptions are taken from the BREF on cement (European Commission 2001):

Process selection: The selected process has a major impact on the energy use and air emissions from the manufacture of cement clinker. For new plants and major upgrades, the best available technique for the production of cement clinker is considered to be a dry process kiln with multi-stage preheating and pre-calcination. The associated BAT heat balance value is 3000 MJ/tonne clinker.

General primary measures: The BAT also include the following general primary measures:

- a smooth and stable kiln process, operating close to the process parameter set points, is beneficial for all kiln emissions as well as the energy use. This can be obtained by applying:
- process control optimisation, including computer-based automatic control systems.
- the use of modern, gravimetric solid fuel feed systems.
- minimising fuel energy use by means of:
- preheating and pre-calcination to the extent possible, considering the existing kiln system configuration.
- the use of modern clinker coolers enabling maximum heat recovery.

- heat recovery from waste gas.
- minimising electrical energy use by means of:
- power management systems.

grinding equipment and other electricity based equipment with high energy efficiency.

There are many more emerging techniques such as fluidised bed cement manufacturing technology and staged combustion combined with SNCR are mentioned, the use of microwaves or plasma in the cement-making process, co-production of cement and electricity.

Shifting to a more energy efficient process (e.g. from (semi) wet to (semi) dry process): Wet processes are more energy consuming, and thus more expensive. Plants using semi-dry processes are likely to change to dry technologies whenever expansion or major improvement is required. Generally, plants using wet or semi-wet processes have only access to moist raw materials. To change process type implies large investments, in the vicinity of 10 million € for an ordinary plant (European Commission 2001), (Aahmann 2004).

CO_2 reducing systems: CO2 emissions levels are of the same magnitude of the amount of produced cement. Almost half of these emissions is the unavoidable release of CO_2 from the raw material, $CaCO_3$, 40% stems from burning fuel, and the remaining 10% is split between electricity use and transportation (CSI 2002).

Substantial measures consist in improving the energy efficiency of the cement production (see next paragraph). Other options are briefly described:

Replacing high carbon fuels by low carbon fuels

An exchange from oil or coal to natural gas would decrease the net CO_2 emissions.

The use of waste fractions as fuels is also increasingly popular in the cement sector. The high combustion temperatures are beneficial when different types of hazardous wastes are considered. In some cases it could be very cost efficient, especially if the capacity for waste incineration with energy utilisation is large enough in a region. Today, burning waste fractions in the cement plants represents about 15% of total fuel consumption by the cement industry in the European Union and there is still considerable growth potential. Cement plants are using waste as alternative fuels in 12 EU15 countries, and in about one-third of all cement plants in Europe (UNEP, 2003).

The net change in CO_2 emissions resulting from the substitution of fossil fuel by waste is less clear. To fire spent tyres that otherwise would be deposited, is approximately CO_2 neutral. In the emission trading scheme, the firing of “fossil wastes” has not been allowed to use as a CO_2 decreasing measure, which seems reasonable. The system must be defined cautiously and a thorough investigation of this issue is needed when envisaging PT.

Applying lower clinker/cement ratio (increasing the ratio additives/cement), blended cements: This has been discussed under 11.1.2.

Application of alternative cements (mineral polymers):

WBCSD has described many strategies to develop new types of cement, that decrease the environmental impact (WBCSD 2002). This include:

- use of larger ratios of renewable and waste materials, such as fly ash, rice husk ash, and waste concrete components, by including superplasticizer

- new pozzolanic additives (e.g., kaolin-montmorillionite-illite clays and palm oil fuel ash)
- cement with increased reactivity or lower calcium content, such as Energetically Modified
- cement (EMC) and cement with higher belite content
- creating cement-like products produced through new processes (e.g., geopolymers, polymer concrete made from recycled PET resin, chemically bonded ceramics made from magnesium oxide and phosphate powders, cement made through polyvinyl alcohol polymerization).

Removal of CO2 from the fluegases: The abatement of CO_2 from fluegases is amongst the future technologies that will contribute to CO2 emission reductions.

13.2.3 Market background and performance target criteria

Between 30% and 40% of production costs (excluding capital costs) are needed for energy consumption, making cement a very energy intensive industry sector. Traditionally, the primary fuel used is coal while a wide range of other fuels is also in use (including petroleum coke, natural gas and oil). In recent years the use of waste as fuel has become an ever more important issue.

The cement industry is also a capital intensive industry, since the investment for a new plant roughly equals 3 years turnover.

Due to relatively high transport costs for cement, there is not a completely functioning international market in Europe. For example, an oligopoly situation is present in Sweden, with one dominant producer (Aahmann 2004).

This must be considered in more detail when the system is planned. One cannot rule out the possibility that a performance target system could enhance trade of cement across borders, due to the preference of customers for the environmentally better produced cement types.

The cement is often sold on a “split” market, consisting of a regional market and an international “spot market”. This price on the regional home market is in the vicinity of 70 - 80 €o, while the price on the spot market is considerably lower, 30 - 40 US$ (Aahmann 2004).

13.2.3.1 Reasonable time-scales for PT

The investments are often large in this sector. For an ordinary plant size, investments for considerably raising energy efficiency lie in the order of 10 M€ (Aahmann 2004). Equipment for flue gas cleaning is also quite expensive for such large plants. Therefore, rather long timeframes seem to be needed.

However, there are already several proactive companies, e.g. the 16 companies involved in WBCSD’s strategic initiative for the cement sector. Thus, there are already companies performing extra well regarding environmental issues. Several companies have already or are about to implement/plan investments for environmental improvements. These companies could with short notice, fulfil environmental targets if they are formulated in a reasonable manner. This means that the system of PT could, in principle, be applied immediately, which means as soon as the targets have been negotiated. For the PT to be efficient in the long run, and send the right signals to the producers, long-term future targets ought to be presented already at the start of the system. It could be reasonable with a timeframe of approximately 2-3 years until the first targets should be met. Too long timeframes may lead to less interest from the customers.

13.2.3.2 Sector specific issues for allocation and aggregation

The main allocation problem is how to count **waste fuels**. Should the company be allowed to discount some part of the emissions of CO_2, if spent tyres are fired as sometimes advocated by the cement industry (e.g. Lafarge, 2004)? This is not allowed in the emission trading schemes. Similar questions could be raised when other types of emissions are considered.

Firing hazardous waste in a cement kiln – thus under high combustion temperatures – could be considered as an advantage as it could avoid extra waste incineration. The issue must be thoroughly assessed when envisaging a PT system where cement companies are granted advantages for avoided incineration. An additional complication is of course the different waste handling systems present today in different parts of Europe.

Besides this specific problem, there will hardly be any allocation problems, since the production process is relatively straightforward and the system borders are naturally the whole plant. A labelling system could also include parameters from the "mining" part of the life-cycle, but this is by no means necessary in the first phase of a PT system.

13.2.3.3 Potential for PT to drive innovation, to get a wider spread of existing technology, or to phase out the worst

With a multilevel eco-labelling scheme all three variants are possible, at least in theory. The more demanding the target levels are, the more will they drive innovation, under the condition that the stakeholders really make ambitious efforts to comply with the tougher targets. Innovations are also driven efficiently by the long term perspectives, with increasing and foreseeable demands. A growing market for environmentally better produced products, combined with a road map for the future PT levels, would be a clear signal that the innovation of today will have a market of tomorrow.

Since there is no well established habit among customers of putting environmental demands on basic building materials like cement, it might be wise to start in a rather modest way. A classification/eco-labelling system, aiming at informing potential proactive customers of the environmental performance could be envisaged, including different performace classes. This would make it a more useful tool, in the sense that both the laggards and the more proactive stakeholders could be addressed by the system.

13.3 Possible improvement strategies for PT

13.3.1 Target systems identified through literature

13.3.1.1 Labelling systems

An eco-labelling system for cement products seems rather uncomplicated to establish. Internationally there are a few examples of eco-labelling systems for cement. In Australia, Independent Cement and Lime Pty Ltd's blended cement products have been assessed and accepted as compliant to the requirements of the Australian "Good Environmental Choice" (AELA 2004).[47]. In Japan, the Ecomark label initiative has included some cement products with high contents of recycled materials such as blast furnace cement[48].

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[47] The requirements of the verification are publicly available at http://www.aela.org.au

[48] http://www.jeas.or.jp/english/

In the EU, there is a standardised categorisations scheme for cement products. The products are classified according to the ratio of added material other than clinker within the cement (See 13.1.2).

13.3.1.2 Certification systems

WBCSD is developing a certification system for reporting the emissions from cement plants.

Many individual cement manufacturers have implemented Environmental Management systems, like ISO14001 and EMAS.

13.3.2 Possible options

The PT could be formulated with some general targets applying to the whole European market, e.g. average levels for all sold cement products within one year. The environmental parameters that should be included in such targets are emissions of **CO2, SO2, NOx and particulates**. Targets could be formulated as an overall average, complemented with targets for the averages of the top or bottom performing 10% of the market. These targets are addressing the whole cement industry, and must be broken down, in order to get the market stakeholders involved. This could be achieved by an eco-labelling scheme, with several levels. The same environmental parameters mentioned above could be used as the criteria for the different levels. The eco-labelling system could then be used as a basis for attempts to improve the market conditions, e.g. for Green Public Procurement activities.

A possibility is to have a more flexible system for the eco-labelling system. To achieve a certain label, a minimum sum of credits for all the included environmental parameters must be passed. But the individual company could choose to make more efforts on some of the parameters and a little less on the others. However, a minimum standard for every parameter must be reached. Something similar has been implemented for greenhouse farming in the Netherlands. Maximum limits for other emissions like dioxins could be included.

To fine-tune the different levels for the general targets for the whole European cement sector, as well as for the eco-labelling schemes, is out of the scope for this limited report. If the system should be based on voluntary agreements, the development of the PT system ought to be made by a group including all relevant stakeholders. The WBCSD could, of course be an important player, as well as experienced research institutes and NGOs.

13.3.2.1 How could the PT be made dynamic over time?

It is important, not only in this sector, that all stakeholders are aware of the tougher demands of the future PT, in order to send the right signals to those who develop the technology solutions of tomorrow. Therefore, it is important that future PT are planned and presented already today. There will be a need for adjusting the targets to new technology and market possibilities.

If an eco-labelling system would be available, the categories and levels need updating, either by adding new categories, or to have a planned increase in the demand for each level. It should be possible to include new parameters for the different categories.

Ideas for making the PT dynamic could be borrowed from the socalled Top Runner programme in Japan[49]. "The average of the best performing 10% of today should be the average of all sold products within three years".

[49] http://www.eccj.or.jp/top_runner

Of course, systematic reviews are necessary. It could be undertaken in connection with BAT review. Also new future targets should be decided upon. If necessary, new parameters can be included in the evaluation, to take new scientific knowledge about environmental impacts into account. On the other hand, other parameters might be excluded, if they are no longer an issue.

13.3.2.2 Are there customers willing to make environmental demands?

No studies on this issue have been found. Since the cement cost is only a small part of the production costs for new buildings, reasonable increases of costs for an environmentally better product, might be possible to handle from an economic point of view. However, if all building materials are more costly, the total increase of costs for building materials could be troublesome for the proactive customer.

One must keep in mind that some of the environmental measures give lower costs for energy production and waste handling. Also costs for raw materials could be lowered. In that case, the proactive companies could be able to keep the prices for the environmentally better cement as low as possible, in order to maintain, and even increase their market.

13.3.2.3 Are there proactive companies?

The Cement Sustainability Initiative (CSI) is the joint contribution of ten major cement companies, working with WBCSD, to promote sustainable development within the cement sector, www.wbcsdcement.org. CSI has identified six key areas: climate protection, fuels and raw materials, employee health and safety, emissions reduction, local impacts, internal business processes. For each of these six areas, there are both joint projects for all companies complimented by individual actions.

Examples of the actions are:

- to develop a Carbon Dioxide Protocol for the Cement industry. (Project already delivered)
- to work with WBCSD/World Resources Institute (WRI) and other organisations to investigate public policy and market mechanisms for reducing CO2 emissions
- to investigate methods to track the performance of the cement industry, including the development and use of key performance indicators.

Also individual companies show ambition to decrease their environmental impact. For example, Lafarge, one of the worlds largest cement companies, have a target to decrease CO2 emissions by 10% from 1990 until 2010. This target seems likelty to be achived. With this regards, it is worth noting that the starting point for Lafarge is among the companies that has the lowest average CO2 emissions.

13.3.2.4 Level of definition for PT

There might be an argument for making a categorisation for the dry and wet systems. The wet systems are more energy demanding. It has been claimed that for some raw materials, only wet systems are possible. If the wet and dry systems would be treated alike, the companies that have to use a wet raw material and thus the wet method, would have a disadvantage when using PTs. However, there are many different ways to improve energy efficiency and to decrease CO_2 emissions, and therefore it might not be absolutely necessary to separate the two production systems in the formulation of PT. This is an issue that has to be thoroughly scrutinised if the cement sector is chosen for developing PT.

There is no reason not to choose the whole plant as the natural system border.

As already discussed, the main allocation problem is how to count waste fuels and this question requires using an appropriate system definition.

14 LIST OF ABBREVIATIONS

BAT	Best Available Technique
BREF	Best Available Technique Reference Document.
CAFE	Clean Air for Europe
CHP	Combined Heat and Power
EIA	Environmental Impact Assessment
EPER	European Pollutant Emission Registry
ETS	Emission Trading System
LCP	Large Combustion Plants
NEC	National Emission Ceilings Directive (EU-Directive 2001/81/EG).
ETAP	Environmental technology action plan
RAINS	Regional air pollution Information and Simulation model
RCF	Recycled fibres
RES	Renewable Energy Sources
SME	Small medium enterprise
STM	Surface Treatment of Metals
STS	Surface Treatment Using Solvents
VOC	Volatile Organic Compounds

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Abstract

One of the main actions of the European Environmental Technologies Action Plan (ETAP) is: "*Setting ambitious targets to improve the environmental performance of technologies within a given timeframe. This should encourage technological development while preparing the markets to accept and prepare for these high standard environmental technologies*".
On request of DG Environment, the JRC-IPTS launched a project on Performance Targets for Industry Processes (PT-PRO project), with the objective to further define concepts and to identify the conditions necessary to implement the concept of Performance Targets. The project was carried out with the help of ITA, ÖAW, GMV/IVL, FEA and TNO.
This report provides a definition of the main elements of Performance Targets and an overview of the general principles for their implementation. Based on four case study sectors (the iron & steel, cement, pulp & paper and the textile industries), an illustration of these different elements is provided in relation with a range of industry sectors and their environmental challenges, existing regulations, technical potentials, market situations and organisational structure. The report also discusses the best conditions and limitations of setting Performance Targets for the industry and the possible value-added.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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