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The Impact of Best Available Techniques (BAT) on the Competitiveness of European Industry

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PREFACE

The IPPC (Integrated Pollution Prevention and Control) Directive 96/61/EC lays down a framework requiring Member States to issue operating permits that contain conditions based on Best Available Techniques (BAT). It requires the European Commission to organize an exchange of information between Member States and the industries concerned with best available techniques. The European IPPC Bureau (EIPPCB), which is located at IPTS (Institute for Prospective Technological Studies), in Seville, Spain, organizes this exchange of information and produces BAT reference documents (BREFs) which Member States are required to take into account when issuing permits.

This report examines the impact of the implementation of BAT on the competitiveness of existing plants. The study focuses on three industries: cement, non-ferrous metals and pulp and paper. The principal methodology adopted is a case study approach contrasting the economic performance of plants that have adopted most of the elements of BAT with the performance of other 'non-BAT' plants in the various industries[1]. Part A of this report examines the lessons that can be drawn from the findings of the three individual industry investigations and makes a number of recommendations, while Part B provides a summary of each industry study. All the background papers on which this report is based are available; (see page 13).

The study has been directed by Professor David Hitchens (The Queen's University of Belfast) and has been undertaken by an interdisciplinary team with training and experience in the following areas: environmental regulation, industrial chemistry, chemical engineering, industrial economics and environmental economics. Outside consultants have provided skilled specialist engineering and business economics inputs for analyses of the cement and pulp and paper industries.

The study has been carried out under the auspices of DG Enterprise, European Commission, by the Institute for Prospective Technological Studies (IPTS), Seville, Spain.

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[1] Hitchens D M W N, JE Birnie, A McGowan, U Triebswetter, A Cottica *The Firm, Competitiveness and Environmental Regulation,* Edward Elgar 1998
Hitchens D M W N, U Triebswetter, J E. Birnie, W. Thompson, P. Bertossi, L. Messori, *Environmental Regulation and Competitive Advantage, A study of packaging waste in the European Supply Chain*, Edward Elgar 2000.

The European IPPC Bureau (EIPPCB) is also located at IPTS and this has facilitated meetings with the individual BREF authors, access to background material underlying the BREF documents, attending Technical Working Group (TWG) meetings and so on. The investigation has been facilitated and encouraged by IPTS and in particular by Luis Delgado, co-ordinator of the environmental group at the department of technologies for sustainable development and Per Sørup, head of unit for the department of technologies for sustainable development.

The team has liaised with officials at DG Enterprise, who have sponsored the study. Kevin Bream, Jose Gallego, Kim Holmström, Annalies DeRuiter, NathalieVercruysse and Karl Doutlik were very co-operative. Magnus Gislev at DG Environment and Bill Watts at DG Economic and Financial Affairs have also been very helpful. The team has also liaised with European industry associations and their environmental committees and various national associations. Expert advice has also been received from research associations and company personnel. In this regard we would like to thank the Confederation of European Paper Industries (CEPI) and members of their "Steering Group on the DG III Study on The Impact of BAT on Competitiveness," and in particular Annick Carpentier. Cembureau were very helpful and in particular Lars Hjorth. National cement associations have been very helpful and have facilitated access to cement plants. Eurometaux, the European Copper Institute and the European Aluminium Association were also very co-operative and we would like to thank them in connection with work on the non-ferrous metals study.

The fundamental inputs to the research are based on data drawn from more than 100 firms and plants across Europe, in Canada, USA and Brazil that have co-operated in the study. We would also like to thank the plant managers, technical managers and accountants who were very generous with their time by completing questionnaires and discussing with us the economic and environmental performance of their plants. We are grateful also for discussions on the competitiveness implications of BAT with chief executive officers (CEOs) of major companies in the sectors studied.

We would especially like to acknowledge the assistance of Jaakko Pöyry and in particular Petri Vasara, who acted as a consultant for us on the pulp and paper study, and Adrian Smith of Science and Technology Policy Research (SPRU). Professor Dr Karin Wagner of Fachhochschule für Technik und Wirtschaft (FHTW), Berlin helped us with the investigation of the cement industry. At IPTS, inputs and help with the research have been received from Michalis Vassilopoulos, Paul Crabb and Marion Rückebusch.

Responsibility for the interpretation of the data and any errors are of course ours alone.

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PART A

THE IMPACT OF BAT ON THE COMPETITIVENESS OF EUROPEAN INDUSTRY:

LESSONS LEARNED FROM THE STUDY

EXECUTIVE SUMMARY

This synthesis report brings together the main findings of the three industry studies (Cement, Non-ferrous metals and Pulp and paper) undertaken to test the impact of BAT on competitiveness. (The detailed findings for individual industries are given in the executive summaries to the individual reports and are attached as an annex (Part B) to this report).

The principal methodology adopted is a case study approach contrasting the economic performance of plants that have adopted most of the elements of BAT with that of other ‘non-BAT’ plants in the various industries. Competition from important producers outside the EU has also been considered.

The findings of the studies show that plants that have already adopted BAT and achieve a good environmental performance are viable in the long run.

However, and importantly, in many cases BAT plants have particular characteristics; they tend to be large, already strongly competitive, growing, endowed with quality skills, undertake an above average input of R&D etc. These advantages influence the cost of investment in, and compliance with, BAT.

We therefore issue a caution that the impact of BAT on industry competitiveness depends on how it is implemented. There are plants that would have technical difficulties in adopting all BAT, and there are plants for which prudent implementation is necessary in order to achieve a sustainable environmental and economic performance, thereby avoiding closure. It is important for industry to work with the regulator to schedule BAT implementation.

In some countries the average plant has ‘too far to travel’ to raise environmental standards quickly without consequent economic harm.

All these difficulties vary according to the industry in question and the type of BAT under consideration.

Deciding what the competitiveness effects of BAT will be depends to a large extent on foreknowledge of how IPPC will be, or is being, implemented.

A number of recommendations are made in order to improve the understanding of the likely implications of BAT for the sustainable environmental and economic performance of industry. In addition a number of factors which could usefully be taken into account when implementing IPPC are discussed.

INTRODUCTION

This synthesis report draws together the main arguments and conclusions given in three separate reports on the impact on competitiveness of the introduction of BAT to the cement, non-ferrous metals and pulp and paper industries. It also draws together the main findings of a set of appendices principally concerned with background scientific literature in the area and mechanisms for obtaining relevant data on the likely competitiveness implications of BAT at the time the BREF document is being compiled. It is also based on two consultants' reports. For fine detail, this synthesis report is not a substitute for the main reports.

An interdisciplinary team, which includes the following skills, has researched the question of the competitiveness effect of BAT: qualifications and experience in environmental regulation, industrial chemistry, chemical engineering, industrial economics and environmental economics[2]. Outside consultants[3] have provided skilled specialist engineering and business economics inputs for analyses of the cement and pulp and paper industries.

The team has liaised with officials at DG Enterprise with responsibility for the industries considered, European industry associations and their environmental committees, various national associations and regulatory bodies. Expert advice has been received from research associations and company personnel. A close relationship has been maintained with the IPPC Bureau at IPTS, Seville. The fundamental inputs to the research are based on data drawn from more than one hundred firms and plants across Europe, in Canada, USA and Brazil that have co-operated in the study.

There are many alternative definitions of competitiveness and this study has focused on medium- to long-run survival of individual plants in the face of a requirement to implement BAT and improve environmental standards. It has also tested whether the choice of BAT by members of the IPPC bureau is justified on the basis of the competitiveness status of plants from which industry examples of the use of BAT can be drawn.

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[2] Members of the team are: Frank Farrell, detached national expert from the Environment Agency for England and Wales; Dr Josefina Lindblom, formerly The Institute of Paper Science and Technology, Atlanta, USA and Chalmers University of Technology, Gothenburg, Sweden; Ursula Triebswetter, on secondment from the IFO research institute, Munich; Michalis Vassilopoulos , economist; David Hitchens, professor of applied economics, Queen's University, Belfast, N. Ireland, on leave of absence to lead the project.

[3] Professor Dr Karin Wagner, FHTW, Berlin; Jaakko Pöyry Consultants, Helsinki; Dr Adrian Smith, SPRU, University of Sussex, UK.

The methodology in this paper is as follows. First, several tests are undertaken of the competitiveness effects on those plants that have adopted BAT. In general these indicate few competitive disadvantages and a number of competitive advantages. This picture is derived from a balancing of: BAT that contribute to improved productivity; those that are associated with increased costs and no business benefits, and those that are correlated with either or both of (a) the existing strengths of competitive plants easing the implementation of BAT and (b) opportunity, perhaps through growth of capacity, for adopting appropriate environmental measures at minimum cost.

Second, tests are undertaken to identify special or unique factors associated with those plants that have adopted BAT. This is the matched plant analysis whereby non-BAT plants (or those identified in the industry as having average environmental protection) are compared with BAT plants and the question asked is whether the BAT plants have advantages over non-BAT plants that may suggest difficulty for wider implementation. The general answer to this question is that BAT plants are of a particular kind. BAT is (often, not always) associated with new plants, low technical age, high productivity, capacity growth, those plants with a history of undertaking environmental investments, good quality skills, relevant R&D etc.. These findings imply that a vigorous application of BAT or IPPC is likely to raise compliance costs for non-BAT plants as compared with BAT plants.

Third, by identifying BAT requirements of the non-BAT plants, detailed consideration is given to plants at risk. The analysis indicates different areas of sensitivity with respect to plant closure. There are cases of a lack of technical feasibility or very high investment requirements for particular types of plants e.g. long kilns and lepol kilns in the cement industry. There are cases where little environmental protection investment has taken place, for example in less stringently regulated Member States. A sharp increase in BAT investment is likely to close plants e.g. in the pulp and paper industry. While the number of plants at risk is relatively small (less than 20%) and the share of industry capacity smaller still, this small number can be raised or reduced further by the way in which IPPC is implemented in Member States. It is argued that the principal requirements are for realistic timescales and recognition by authorities and the plants themselves of the opportunity for implementation of BAT in a competitive way.

The report goes on to consider the strengths and weaknesses of the selected methodologies.

It argues that there is a requirement to obtain both a macro and a micro picture of the impact of BAT on individual industries throughout the EU, and recommends the approach adopted here with, where possible, the removal of areas of professional or expert judgement, which have been necessary for some of the current analysis. The study incorporates a number of tests and cross-checks of (a) the impact of BAT on competitiveness and (b) the difficulty/ease with which existing plants can implement BAT. The findings of the different approaches are reinforcing.

Finally, several recommendations are made for improving the economic knowledge, quality of data and skills of various parties involved in the choice and determination of BAT.

The study concludes: There is no evidence that BAT hindered those companies with BAT from remaining competitive both nationally and internationally (but sample companies have not always reached the expected levels of abatement for their BAT).

For reasons given in this study, it does not follow that early implementation of BAT by other firms or plants in the industries studied would similarly have little or no impact on their competitive performance. There are plants that would have technical difficulties in adopting all BAT, and there are many plants for which prudent implementation based on consideration of the firm’s own economic and environmental improvement plans and constraints is important for them to achieve a sustainable environmental and economic performance without closure.

1. AIM AND CONTEXT OF THE STUDY.

The aim of the BAT Competitiveness Project is to develop a methodology to assess the impact of the introduction of BAT (as defined in Directive 96/61/EC, known as the Integrated Pollution Prevention and Control (IPPC) Directive), on a firm's competitive performance, both in relation to the EU's competitors and within the EU.

The selected methodology is to be applied to three industries: cement, pulp and paper and non-ferrous metals. This report gives a critical overview of the study.

The report also makes recommendations with respect to the impact of BAT on competitiveness relevant to the EIPPCB, to members of the TWG, to DG Enterprise and DG Environment of the European Commisssion and to regulators.

Underlying considerations

While the focus of this study is on the relationship between environmental regulation and competitiveness, the main reason for the environmental regulation of industry is that the market mechanism fails to allow for a divergence between social and private costs and benefits arising from economic activities. Environmental policy corrects for the cost of these polluting activities, which would otherwise go ignored.

Where environmental policy is correcting a market failure it is not an economic cost to society and this is perhaps ignored when it is presumed that environmental policy reduces the competitiveness of firms.

The implication of environmental policy should be judged according to these costs and benefits rather than according to the impact on competitiveness alone.

Importance of competitiveness

However, the underlying reasons for an interest in the relationship between environmental policy and competitiveness arise because environmental policies are becoming increasingly stringent and comprehensive and international competitiveness has become a central goal of industrial policy. There is continuing debate regarding the effect of environmental regulation on the competitiveness of industry. There is also concern about the relationship between environmental policy, economic growth and employment.

IPPC and competitiveness

The IPPC Directive 96/61/EC lays down a framework requiring Member States to issue operating permits for certain industrial installations. These permits must contain conditions based on best available techniques (BAT) as defined in the Directive. That these techniques are ‘available’ requires that they should be ‘developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator’ (Article 2(11) of 96/61/EC).

This study is concerned with economic viability and, in particular, ‘existing plant competitive performance’ following the introduction of BAT.

Assumptions about the implementation of BAT

The impact of BAT on existing plants is assessed on the assumption that plants are required to meet all the BAT requirements stated in the BREF. This is a strict assumption. In accordance with Article 9(4) of the IPPC Directive, the BREF preface states the need to take account of local considerations (see below), while the BREF is concerned with generic BAT.

"The determination of appropriate permit conditions will involve taking account of local, site-specific factors such as the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. In the case of existing installations, the economic and technical viability of upgrading them also needs to be taken into account. Even the single objective of ensuring a high level of protection for the environment as a whole will often involve making trade-off judgements between different types of environmental impact, and these judgements will often be influenced by local considerations."

Some consideration of BAT requirements is also taken into account in the present study.

Definitions of competitiveness

The definition of competitiveness is not straightforward. There are many possible definitions. Here they are divided into two categories: those appropriate to macro- and those appropriate to micro-economic considerations.

At the *macro level*, competitiveness is often linked to long-run increases in living standards; for example, The World Economic Forum defines competitiveness as 'the ability of a country to sustain high rates of growth in GDP per capita'. The OECD defined a nation's competitiveness as:

> The degree to which it can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the incomes of its people over the longer term.

Long-run increases in living standards come about through economic growth and the achievement of higher productivity levels. In fact, most commentators would emphasise the need to judge the impact of environmental regulation by measuring the effect on productivity (while often questioning the usefulness of the concept of competitiveness).

One focus of the research literature has been on the effects of environmental regulation on trade, to test for a loss of comparative advantage in environmentally sensitive industries. The questions addressed are whether highly regulated industries suffer in terms of exports, whether production moves abroad and whether firms increase their investment into less regulated countries[4]. (Less attention has been paid to the impact of regulation on the products actually traded; stringent regulations can exclude or prohibit the trade of non-complying imports).

Stringent environmental regulation does not imply that a country that raises environmental standards will lose business in the way that firms might, but rather that it will give rise to some change in industrial composition and maybe a fall in living standards (if we do not count the environmental benefits achieved through environmental protection).

[4] Such movement is complicated by other factors leading to international investment. In fact existing foreign investment by those firms in countries with lower environmental standards was in plants with higher environmental standards than their EU plants.

Environmental regulation is expected to give rise to more specific impacts on firms and industries than can be observed from macro studies. The negative impacts are expected to be greatest for certain pollution- and resource-intensive sectors (chemicals, mining, oil refining, pulp and paper) for which environmental costs are above average.

Environmental regulation may also have positive competitiveness implications for some sectors and spur firms to develop more resource-efficient methods and to reduce costs.

Factors influencing the competitiveness of firms

Box 1 shows the factors that affect the output and employment of firms.

BOX 1.

Taxonomy of factors affecting a firm's competitiveness[5]

1 **Raised costs**: direct costs of compliance; indirect costs include increase and diversion of investment to end-of-pipe technologies; clean technologies; running costs; impact of policy instruments e.g. increased price of energy and water, increased cost of waste, emission charges.

2 **Significance of environmental costs in total costs**; size of cost differential with competitors.

3 **Extent of competition**: price/non-price competition; degree of product differentiation; monopoly elements; price elasticity of demand; local versus national/international markets; extent of international competition.

4 **Competitive strengths/ weaknesses** of the sector in non-environmental areas including labour quality, capital, technology, management, innovation, productivity, product quality.

5 **Size of firms**: economies of scale in investment and running costs of environmental initiatives.

6 **Investment cycle**: extent to which sector is characterized by large sunk costs; frequency and size of investment.

7 **Demand by customers and consumers** for increasing environmental performance of the firm.

8 **Technological innovation**, raised productivity, improved management, reduced costs, factor substitution. Influenced by type of sector and extent to which technically advanced.

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[5] OECD, (1993), *Environmental Policies and Industrial Competitiveness*, Organisation for Economic Co-operation and Development, Paris.

These factors can be summarised as sets of positive and negative impacts:

Negative impacts

The impact on competitiveness, or firm output and employment, will be greater where demand is sensitive to price increases (is price elastic); where firms face strong competition (from countries where regulation is less stringent); where the environmental compliance costs rise and the differential cost penalty relative to domestic and external competitors is greater; where margins and profits are tight; and where environmental costs rank high among the threats facing the firm. The reverse circumstances will lessen the impact of regulation.

Positive impacts

However, environmental regulation may also have positive competitiveness implications for some sectors and may encourage firms to develop more resource-efficient methods and to reduce costs. Environmental regulation can yield competitiveness benefits through (1) stimulating innovation (2) improving efficiency (3) creating comparative advantages (4) spinning off new production activities and advantages.

2. MEASUREMENT OF A FIRM'S COMPETITIVENESS

This leads to the question: what are appropriate measures of the competitive performance of firms?

One such measure is profitability, but this depends on the type of market structure within which the firm is operating. For example, in a situation where the firm has some monopoly power, then competitiveness is not inconsistent with above average profitability. In fact, many industries are operating under conditions of oligopoly.

This suggests that a single measure of competitiveness may be inappropriate. In this study a number of indicators are used. These include output measures of performance – profitability, productivity and growth – and input measures of performance (on the input side of efficiency and competitiveness), namely: physical and human capital, R&D spending etc..

Focus of this study

The focus of this study is on the economic viability of BAT and hence the impact of BAT on the economic performance and viability of plants. Principally the interest is on the impact of BAT on existing plants. Two questions are asked: Is a BAT plant viable? Is the application of BAT to existing plants likely to lead to a significant number of closures? While the approach is relevant to the question of the impact of BAT on the industry as a whole, it does not attempt to establish what adjustments are likely to take place following the implementation of BAT; for example, whether BAT will lead to the expansion of existing European BAT plants or to an increase in imports at the expense of those plants that become uncompetitive following BAT implementation. That said, some light is thrown on this matter in the pulp and paper study.

Previous work in the area

What do previous studies in the area tell us about the impact of regulation on competitiveness and about factors that facilitate or inhibit the adoption of environmental initiatives? At current levels of regulation there does not seem to be any serious trade-off between competitiveness and environmental protection:

Jaffe, Peterson, Portney and Stavins (1995)[6], in a survey article, concluded "... there is relatively little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competition". Or, as Porter and van der Linde (1995) put it, "... it is striking that so many studies find that even the poorly designed environmental laws presently in effect have little adverse effect on competitiveness".

Why do environmental policies have negligible effects on competitiveness? Probably the most important reason is that the cost of complying with regulation is a small fraction of total costs, sufficiently small to be overridden by differences in labour costs, exchange rate variations and so forth. Second, although stringency varies between countries, the differential in compliance costs between major trading partners is unlikely to be large. (In the present case IPPC is also concerned with an incremental change.)

[6] Jaffe, A.B.; Peterson, S.R.; Portney, P.R. and Stavins, R.N. (1995), Environmental regulation and the competitiveness of US manufacturing: What does the evidence tell us?, Journal of Economic Literature, 33, 132-163

Technological improvement helps to compensate for increases in the severity of regulations; firms may be starting from a position with some super-normal profits (this means they have some capacity to absorb increased costs); there may be partial substitution away from the more expensive factors of production and, lastly, environmental compliance costs are typically less than one per cent of total costs. At the same time, it would be unwise to generalise from the evidence available that regulations in general boost the international competitiveness of a region/nation.

It is very important to note that at least up until now, the power of environmental regulation to do a great deal of harm or good to company competitiveness within the EU has been limited. This is not to imply that further upward pressure on standards of regulation is unlikely to have much by way of trade-off with competitiveness. To the extent that there is a trade-off between environmental outcomes and company competitiveness, we would ideally wish to know how strong this is. Additionally, if the political judgement is that environmental outcomes should be attained even at the cost of diminished competitiveness, then the aim would be to design policies where this cost is minimized.

Hypotheses Tested

The research undertaken here is focused on a set of hypotheses (see Box 2). The basic hypothesis is that the implementation of BAT could place firms at a competitive disadvantage and lead to the loss of markets, particularly to countries with less stringent regulation. The regulated firm needs to redirect resources from other profitable opportunities, costs and prices rise, and markets and customers may be lost.

On the other hand the implementation of BAT, although it may represent a short-term cost and burden to the firm, could push firms on to a higher growth path by forcing them to make product and process changes that yield higher competitiveness. In fact the relationship between BAT and competitiveness is likely to be two-way: the fact that the firm is competitive may lead to the early implementation of environmental initiatives while at the same time environmental initiatives are expected to have consequences for the competitiveness of firms.

The study seeks to capture both these negative and positive factors which influence the costs or benefits arising from an adjustment to the implementation of BAT.

Box 2 The detailed hypotheses

(i) The implementation of Best Available Techniques (BAT) could place firms at a competitive disadvantage and could be reflected in the loss of markets to imports from countries with less stringent environmental regulation.

(ii.) High environmental standards and strict enforcement, although they may represent a short term cost and burden to the firm, could in the medium and longer term push firms on to a higher growth path by forcing them to make product and process changes that yield higher competitiveness. If this happened it would represent part of the so-called "double dividend", i.e. gains in environmental performance would also be accompanied by increased economic performance.

(iii.)The proportional cost of compliance (relative to turnover) by the firms is likely to be a negative function of the productivity level (i.e. firms which in general have the management and other capabilities to produce high productivity and competitiveness also find it easiest to adapt to the specific challenge posed by environmental measures).

(iv). The proportional cost of compliance is also likely to be a negative function of the size of plants/firms.

(v.) The age of the plant and machinery in each firm is likely to affect environmental outcomes, costs of compliance and the number of clean technology initiatives undertaken. The younger the capital stock the better the environmental outcomes. Plants with very old capital stock may also be at the point of replacement investment.

(vi.) Plants with a higher proportion of skills, or those with strong R and D efforts, are more likely to introduce a large number of clean technology initiatives and be more successful in reducing environmental costs.

(vii.) Where multinational branch plants are sampled in those parts of the EU with the lower environmental standards/enforcement, they will generally have higher environmental standards than indigenously owned plants making similar products.

(viii.) Relations within the supply/production chain are likely both to influence and be influenced by the level of environmental standards, e.g. a manufacturer may find it easier to increase the environmental standards of its products if it has a reliable and competent base of suppliers to draw on. A manufacturer may be forced to upgrade product and process environmental standards by pressure coming from the customers of plants in the three sectors under study.

(ix.) Location can affect the cost of compliance and adoption of clean technology. There are important competitiveness differences between countries in the Community, and underlying these differences are differences in productivity and skills, the capacity for advanced research and development and differences in cost of capital (e.g. amount of supportive subsidies). Since these may be important factors influencing the ability of a firm to adapt efficiently to regulations, there is the potential for environmental policy to influence the competitiveness of firms differentially between regions and countries.

Methodology

The general approach adopted in this study is one of a number of possible approaches to the measurement of the competitive implications of BAT. While a case study approach which examines the actual experience of plants is adopted, an alternative approach might, for example, involve modelling the impact of BAT on costs of production. Given price elasticity of demand, the effect on industry output and employment can be estimated.

The methodology has been applied to three sectors for which finalized (after submission to DG Environment) versions of BREFs were available. The choice was very limited. The three sectors studied are pulp and paper manufacture; cement and lime production; and non-ferrous metals production processes. Across the three industries there are important variations in the cost and economic impacts of the BAT elements recommended.

The main approach for all three studies is based on individual plant case studies where plants with and without BAT are compared.

The application of this methodology for each industry has differed slightly.

1. The cement study compares the average performance of plants in different countries having different degrees of environmental stringency, and therefore different mixes of BAT and emission standards. The study seeks to compare the average environmental and economic performance of plants in country A with counterparts in countries B, C, D etc.. BAT and non-BAT are defined by emission achievements alone. This has proved to be a less preferred approach compared with 2(a) which allows for a better capture of BAT plants.

2 (a). In the cases of non-ferrous metals and pulp and paper, attempts are made to compare the economic and environmental performance of individual plants with and without BAT, irrespective of the European country of origin (though the sampling is restricted to particular Member States of the EU).

Plants identified as ‘BAT’ plants (having many or all of the elements of BAT and a strong environmental performance) are matched with representative plants within the EU.

This approach tests for the ease of implementation and for competitive effects arising from the implementation of BAT. Following the hypotheses set out above it asks the questions: What are the competitive implications arising for firms with BAT? Do they have particular characteristics or circumstances for implementation that suggest difficulty in the competitive implementation of BAT by representative plants elsewhere?

The measurement of BAT, and therefore the identification of BAT plants, has differed across the three industries. In non-ferrous metals, it is measured by the strength of the BAT input, with total BAT input equal to the sum of individual BAT strengths.

In the cement sample, a BAT plant is identified as a plant with low emissions.

In pulp and paper, BAT is measured by the number of BAT implemented by mills and the resultant emissions i.e. by both environmental inputs and outputs.

In the Jaakko Pöyry subcontract for the paper and pulp study, a ‘BAT plant’ is defined as one having 80% of the number of possible BAT. These are further defined as the “mainstream but not fine-tuning BAT” (The 80% measure is also a subjective one.)

Despite these measurement variations, the research has assumed that most BAT must be in place. In fact the actual number of BAT required is subject to local variation in environmental performance, and this variation is reflected in the definition of BAT adopted across the three studies[7].

2(b). In the pulp and paper sector and with respect to competition from outside the EU, the same methodology is applied. The economic performance of representative competitor plants in country A (outside the EU) is compared with BAT firms within the EU.

2(c). BAT plants were selected from a number of sources including industry sources (trade associations) and various directories. There is no census showing a list of BAT used by plants from which a random sample could be drawn.

[7] Local variation in BAT implementation was influenced by a number of pressures besides regulation, including customer requirements, pressure from environmental groups and local residents.

Selected BAT plants were matched with representative plants in the industry, identified from the same sources. They were matched by size and product produced.

Sample sizes are reasonably respectable but their adequacy depends on the variability of key variables in the population data.

In total about 16% of European cement plants in target EU countries were included in the overall sample. In non-ferrous metals, for the selected metals, 45% of EU plants are included and 69% in target EU countries. In pulp, 25% of mills in target EU countries are included. In white line chipboard this is 34%, and in paper 38%.

3. There are differences in the estimation of the economic impact of BAT. In the cement and pulp and paper studies, the economic implications of BAT are considered both at the level of the individual BAT and at the plant level.

4. In the non-ferrous metals study the economic impact of all BAT adopted by the plant are considered at the plant level only.

5. In the case of the non-ferrous metals study an attempt is made to measure the quality of individual BAT inputs while in the other studies the effect of all BAT and other environmental inputs adopted is measured by aggregate plant environmental performance data i.e. by examining emissions data.

6. The pulp and paper study has also incorporated another quite different approach. Here a macroeconomic approach is adopted where the impact of BAT on plants above and below average environmental and economic performance is considered and threats from firms outside the EU are examined.

7. Implications of the implementation of BAT for productivity and plant performance have been the subject of interviews with suppliers of environmental technologies in the pulp and paper sector.

8. Each study carefully documents the extent of representativeness of the sample data, the source of sample names (often, but not exclusively, European industry associations) for plants within and outside the EU

Questionnaire-based approach

Questionnaires have been constructed in order:

1. To ask managers about the economic effects of adopting environmental initiatives. For each BAT, managers are asked a series of questions on the impact of that initiative on plant performance. Answers were backed up where possible by records and annual audited accounts (it was recognized that managers may respond strategically, so objective data were collected and checked for consistency and against external alternative sources where possible).

2. To measure the impact of compliance costs or the implementation of initiatives on overall firm performance, as judged by a comparison between matched plants.

3. To relate the importance of environmental costs to other factors influencing the firm's competitive performance. Respondents were asked to specify the competitive advantages and disadvantages they faced, including those arising from environmental regulation and costs, again backed up by evidence where possible. Respondents were requested to rank the competitive advantages and disadvantages they faced. In principle the research would seek to estimate the marginal impact of BAT on the competitiveness of plants relative to other advantages and disadvantages.

4. To analyse the influence of human and physical capital, R&D and plant size on compliance costs and ease of implementation of BAT.

Two-way relationship

5. In addition, the relationship with competitiveness is potentially two-way i.e. a firm or plant's competitiveness may influence the firm's adjustment to regulation and the cost of compliance, because firms with high economic performance will have strong capabilities including management and workforce skills, R&D, up-to-date equipment and methods of production. Hence, they may be able to implement BAT and absorb compliance costs more readily.

6. In the case of the pulp and paper industry a macro approach is based on data from Jaakko Pöyry's own privately compiled database combined with expert judgement to estimate BAT investment requirements, effects on profit margins and numbers of mills at risk.

3. COMPETITIVENESS EFFECTS OF BAT

Summary of findings

1. Primary/front-end measures have a generally positive impact on productivity and plant performance, while secondary measures have a mixed impact. Some have a positive impact, others are neutral and others have a negative effect.

2. When BAT measures as a whole are related to plant performance, strong BAT/environmental performers are not disadvantaged. In many cases there are special circumstances that facilitate good environmental performance at minimum compliance cost and these are considered further below.

3. Many sample plants with a strong environmental performance are able to use this as a competitive strength. Only infrequently is environmental performance considered a competitive disadvantage.

4. Choice of BAT by the IPPC bureau is based on plants that have implemented BAT competitively.

Industry findings:

Cement

In the case of cement, the analysis of the impact of BAT on the competitiveness of individual plants rests on a three-stage approach.

A sample of 41 plants in 4 EU countries– Germany, Italy, Spain and the UK – and one non-EU country, Poland, is drawn. All processes i.e. dry, semi-dry/semi-wet and wet are considered, with dry accounting for 29 of the plants sampled.

Emissions to air are the dominant environmental impact and primary and secondary measures to reduce dust, NO_x and SO_2 are considered.

Only 3 plants in the sample are operating at BAT emission levels and they achieve the BAT limit for NO_x without using a secondary measure and thereby incurring a secondary cost.

The number of BAT per plant is a function of legislative stringency between countries and, in decreasing order, are Germany, Italy, UK, Poland and Spain. Three tests are made of the economic implications of BAT.

1. *The economic experience of undertaking individual BAT.*

Primary measures have a positive cost and quality implication, they have positive paybacks and positive implications for competitiveness (as defined by a reduction in costs). Investments in primary BAT are a feature of new, modern and updated processes. Similarly, energy saving and process improvements have the same positive outcomes.

Secondary BAT for NO_x, SO_2, dust and noise have either mixed, neutral or negative effects. It is from this set of BAT that negative competitiveness implications can arise (see Table 1).

Table 1. Information about the drivers and effects of NO_x reduction measures.

NO_x reduction	Low NOx	MSC	SNCR
No. of plants reporting	16	5	4
Driver	1x cost; 2x legislation; 8x process 4x new plant 1x upgrade	4x legislation 1x new plant	4xlegislation
Year	1985-1998	1988-1995	1995-1999
Capital cost (€ million)	0.1-0.4	Up to 3.75	1.2-1.5 (0.07 for a test)
Operating cost per t of clinker (€ million)	0-0.5	0.4	0.25-0.85
Reduction of NO_x in mg/Nm^3	Reduced in 9 cases	Substantial (from 1000 to 700)	Substantial (from 900 to 100-200; From 800 to 400)
Subsidies	0	0	0
Payback	3-4 years	n.a.	n.a.
Other capital items	0	0	0
Maintenance	Increased in one case	Reduced in one case	Higher
Process efficiency	Increased in two cases	0	Negative in one case
Employment	One time reduced	0	1 person in one case for maintenance
Training	In two cases	In one case	Three times for process operators
Capacity	0	Increased	0
Output	0	0	0
Profitability	Increased in one case	-	Decreased

2. Implications of environmental protection and performance on the overall economic performance of cement plants.

The approach to this question has been tackled by comparing similar groups (by product) of plants in each of the four Member States and Poland, where environmental performance following environmental regulatory stringency differs.

Table 2. Average number of measures implemented (within the last 10 years) per plant classified by country.

Type of BAT	Germany	Italy	Spain	UK	Poland
Average number of general primary measures per plant					
Expert system	0.8	0.6	0.6	0.2	0.
Automatic quality control	1.0	0.7	0.6	0.2	0.3
Precalciner	0.5	0.9	0:0	0.8	0.3
Modern clinker cooler	0.5	0.3	0.4	0.2	0
New or modernised mill	0.6	0.3	0.6	0.8	1
Raw material storage closed	0.8	0.3	0.2	0.2	0.3
Clinker closed	0.9	0.7	0.6	0.6	1
Paving, fugitive dust	1.0	0.7	0.4	0.2	0.3
Optimal fuel feeding	0.1	0	0	0.2	0.3
Optimal burning process	0.3	0	0	0.2	0.5
Continuous measurement	1.0	0.7	0.4	0.8	0.3
Average no. of general primary measures per plant	**7.5**	**5.2**	**3.8**	**4.4**	**4.3**
Average number of NO_x primary measures per plant					
MSC	0.3	0.1	0	0	0
low-NO_x burner/ flame cooler	0.9	0.6	0.6	0.6	0.8
Sum of NO_x primary measures	**1.2**	**0.7**	**0.6**	**0.6**	**0.8**
Sum of total primary measures per plant	**8.7**	**5.9**	**4.4**	**5.0**	**5.1**
Average number of secondary measures per plant					
SNCR	0.4	0	0	0	0
Absorbent addition	0.5	0.1	0	0	0
wet scrubber	0	0	0	0.2	0
Sum of secondary measures per plant	**0.9**	**0.1**	**0**	**0.2**	**0**
Sum of all measures per plant	**9.6**	**6.0**	**4.4**	**5.2**	**5.1**
No. of plants	8	7	5	5	4

This analysis shows no linear relationship between average number of BAT and plant performance measured by productivity for dry kilns (see Table 3). The productivity of German plants with a good environmental performance is shown to be lower than that of other countries, while that of Italian plants with a relatively good environmental performance is shown on average to be higher than that of other countries. Low physical productivity at German plants is explained by excess capacity and a wider variety of products produced.

Table 3. Average labour productivity (measured as cement tonnes per employee year in cement, kiln and maintenance departments) and number of hours worked per week.

Country	Germany	Italy	Spain	UK	Poland
Productivity	8,550	10,500	9,700	10,000	7,100
Hours worked per week	38	40	40	40	41

*For the labour productivity measure it was not possible to distinguish between different technologies of kilns within the same plant. Therefore some of the output and employment of the semi-dry/semi-wet and wet technologies are included.

In the case of semi-wet/semi-dry technology there is a clear relationship (on average) between numbers of BAT in Germany, Italy and the UK and average productivity levels at sample plants, but in this case no secondary measures have been implemented. The report is inconclusive on the likely effects of secondary measures but it is presumed their implementation will lead some plants to close.

Investment, on the other hand, is higher in Germany (per tonne, on average) than at counterpart plants in other EU countries sampled. Similarly, profitability at German plants owned by three major cement companies was reported to be similar to that in plants owned by the company in other EU countries, despite low capacity utilisation and strong environmental regulation in Germany.

The analysis therefore concludes that strong existing environmental performance does not negatively affect German economic performance, despite low productivity and low capacity utilisation. Hence, it is argued that while more BAT are associated with more stringent regulation, they do not have a negative impact on economic performance.

3. Important factors that influence plant competitiveness and relative importance of environmental regulations and costs.

Competitive advantages and disadvantages were mainly connected with product quality and range, raw material quality, plant location relative to the market and transport costs. More stringently regulated German and Italian plants did report environmental standards and costs as a major competitive disadvantage (Table 4), primarily as a consequence of secondary measures for NO_x and SO_2. The report argues that despite the additional costs, these plants were profitable in part as a consequence of costs counterbalanced by the use of cheaper alternative fuels (improved cost competitiveness and profitability were the main drivers behind the use of cheaper fuels).

Table 4. The three most important competitive disadvantages by country.

Importance	Germany	Italy	Spain	UK	Poland
First	Labour costs	Environm. costs	Labour quality	Location	Age of plant
Second	Enforcement of environmental regulation	Age of plant	Location	Age of plant	Size of plant
Third	Environm. costs	Labour costs	Quality of raw material	Size of plant	Manufacturing costs

The use of alternative fuels can help to overcome cost advantages (net of transport costs) enjoyed by non-EU countries where there is no requirement to introduce secondary abatement techniques.

Non-ferrous metals (NFM)

The non-ferrous metals considered in this study are international commodities. They compete on world markets and face world prices. The study focuses on the metals: aluminium, copper, lead and zinc.

48 plants are included in this study and they represent between 57% and 100% of the relevant population of plants in the target countries. Main countries included are Spain, Germany, UK and Italy (plants were also visited in Sweden, Belgium and the Czech Republic).

The NFM BAT have been simplified to ten BAT factors and it is the impacts of these factors on competitive performance that are considered.

The principal methodology for assessing environmental inputs used is a derivative of the Operator Performance and Risk Assessment methodology employed in the UK. This methodology ranks BAT on a five-point scale on the basis of strength of input. A score of 4 signifies BAT and across 10 factors a score of 40 indicates a BAT plant (provided a minimum of 4 is scored for each factor). The major weakness in the application of this methodology, recognised in the study, is that individual BAT factors are not given an appropriate weight but merely summed arithmetically.

The focus of the environmental impact is on air, particularly fugitive emissions. Ninety per cent of plants visited had adequate air and water abatement plant. Most require low cost improvements e.g. modern filter materials and/or extensive maintenance. The main impact of IPPC is on improving fugitive emissions and there are significant differences in emissions between plants.

Four tests of the economic impact of BAT are undertaken.

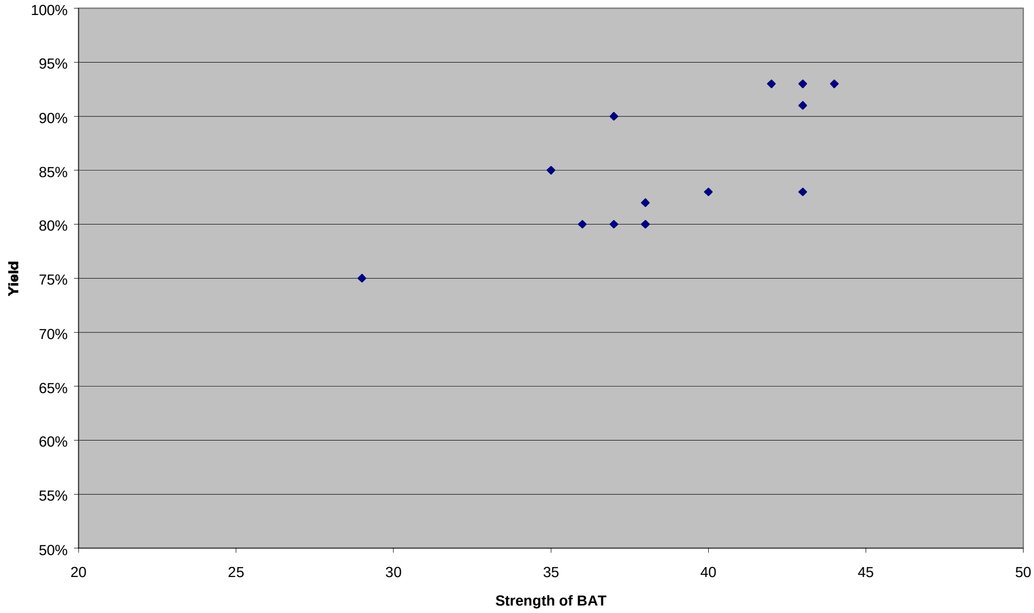
1. Based on plant visits, environmental inputs, as described above, are related to physical productivity, energy use and use of raw materials.

Analyses show a positive correlation between high BAT scores and physical labour productivity. There are also positive correlations found between BAT and reductions in energy use and yield of metal (material productivity).

The close association between BAT and production efficiency has meant that there was no average relationship in this sample between individual Member State stringency of regulation and BAT performance, as in the cement case.

It is argued that labour productivity, metal yield and energy reduction are all closely related to improvements in profitability (see Figure 1). Capital costs as measured by technical age (also correlated with productivity) are achieved at low expense provided that improvements are undertaken progressively (over time). In fact IPPC drives to improve efficiency in terms of use of raw materials and energy and is consistent with this.

Figure 1. Secondary aluminium - strength of BAT and yield.



Note Metal yield is an important measure of profitability. It is important to note that extra yield represents a significant additional income because of the value of the extra metal recovered. The following graph shows the correlation between yield and the strength of BAT.

2. Assessment of the economic effects of individual BAT is reflected in an analysis of the impact of ten BAT factors on plant performance (Table 5) and future BAT requirements by sample plants. The ten BAT factors that apply to the Non-ferrous Metals Industry are summarised in the following table. Examples of the techniques have been included and typical costs have been quoted from the cost annex of the BREF document.

Table 5. BAT factors applicable to existing processes.

BAT factor	Example	Total cost range €	Comment.	Net cost (-) or benefit (+)
1 - Storage & handling	Enclosure	100000 to 200000	Prevents up to 5% loss of raw material	Negative to neutral
2 – Pretreatment	Swarf centrifuging	120000	10% increase in throughput	Positive
3 - Process control	Interactive system	100000	10% increase in productivity	Positive
4 - Management and supervision	Environmental system	50000	Productivity increase	Positive
5 - Metallurgical process	Metal pumping system	300000	10% increase in yield	Positive
6 Fume collection Enclosure Hooding Molten transfers	Increased fan capacity	50000	Ongoing operating cost	Negative
	Furnace enclosure	200000	Dust recovered	Negative
	Intelligent dampers	50000	Dust recovered	Neutral
	Launder system	100000	Dust recovered	Neutral
7 - New or upgrade of abatement Dust SO_2 VOC	Change of EP to fabric filter	1000000	Ongoing operating cost	Negative
	Modern bags	100000	6 month payback	Positive
	Scrubber	1000000	Ongoing operating cost	Negative
	Afterburner	500000	Ongoing operating cost	Negative
8 – Waste water treatment	Change of reagent to NaHS	50000	Equal operating cost	Neutral
9 - Process residues	Greater mixing in furnace	20000	Residue reduced to 30%	Positive
10 - Energy Efficiency Recovery O_2	Oxy-fuel burners	50000	Reduction in gas volume and 30% increase in capacity	Positive

Examples are given for secondary metal production plant producing ~ 25000 t/yr, Costs have been calculated from the Cost Annex of the BREF and from responses to a questionnaire.

The differential cost of upgrade of plants to meet BAT standards is considered and will require, where necessary, further controlling of the process and making incremental changes in abatement plant and gas extraction systems. Implementation of BAT will involve improvements in productivity and reductions in energy use, leading to positive returns on investments required. Where additional costs were expected to be incurred these are shown to be minor.

3. An analysis of perceived competitive advantages and disadvantages following BAT implementation indicated 6 responses where environmental cost was reported as a disadvantage. All six related to installations which were not using all or most of the BAT and were less efficient producers.

No plants that were achieving BAT standards reported any European or worldwide competitive disadvantage arising from environmental protection. Some claimed that there were competitive advantages linked to the use of BAT.

4. Based on a published survey, a comparison of financial performance and environmental performance of the majority of primary copper plants world wide.

The analysis, in this case, is based on a comparison of costs (including operating maintenance and capital) with environmental performance (measured as sulphur capture). Plants in those areas with high environmental performance i.e. EU and Japan, were more efficient and had lower costs than plants in other world areas or regions. The relationship was also found to be true for profitability, but these data are not considered fully reliable.

Pulp and paper

Work undertaken on the pulp and paper industry is based on three products: kraft pulp, white line chipboard and copy and specialty paper. Two broad methodologies were used - the first centres on a set of case studies matching BAT plants with representative plants in the industry. The sample includes 26 mills located in Europe (Sweden, Finland, Austria, Germany, France, Italy, Spain and Portugal) and 10 strong pulp competitor plants in North and South America.

The second method is based on a macro study of the additional investment required and plant vulnerability, given the cost performance and environmental status, of all mills in the EU, North and South America and Asia. The pulp and paper study is larger and more wide-ranging than the other industry studies and is presented at greater length. It is also the study that has extended the micro methodology to relevant regions in North and South America to assess the competitive threat. The macro methodology considers the impact of BAT on worldwide competition.

TESTS OF COMPETITIVENESS EFFECTS

In both the micro and the macro studies one set of tests is based on the impact of environmental inputs and environmental performance on economic performance, production costs, labour productivity, exports and volume growth.

In the micro study, mills are classified into three groups (A, B and C) according to the number of BAT they use and plant emissions. Strong BAT/emission performers are in Group A (these are called BAT mills). In pulp, there are 5 A mills (of 11 sampled). In white line chipboard, there are five A mills (of 10 sampled). In copy paper, there are 3.

FINDINGS

MICRO-ANALYSIS

Comparisons of BAT 'A' plants with matched plants.
On three tests of performance, findings show that pulp and paper A mills have stronger economic performance. White line chipboard A mills also have strong economic performance but are less distinguished from their B counterparts.

INDIVIDUAL INDUSTRY FINDINGS

Productivity
Pulp Physical labour productivity and sales per head are higher for A mills
White line chipboard There is lower productivity at A mills on average but there is also a wide variability in productivity performance indicating no significant difference beetween A and B mills. This was also the case on the measure of sales per head.
Paper A mills have higher productivity than B/C mills. Sales per head are also higher for A mills in copy paper but not in specialty paper.

Costs
Pulp Costs per tonne were lower for A mills compared with B and C mills.
White line chipboard Where costs were available (for medium sized plants), matched A mills incurred lower costs per tonne than their counterpart B mills.
Paper Costs were lower per tonne in the A mills compared with the B/C mills.

Volume growth
Pulp Volume growth (measured for the last five years) is greater for A mills than B/C mills.
White line chipboard Show similar growth rates between A and B mills.
Paper A mills show significantly higher growth rates.

INTERNATIONAL COMPETITION IN PULP

International competitors in Canada and Brazil are not advantaged by low costs of environmental compliance. Pulp A mills are not threatened by international competition.

Pulp In Brazil and Canada, competitors sampled included A, B and (in Canada) C mills. Differential environmental costs were not the source of competitive advantage; indeed European markets were claimed to be a driver for improving the environmental performance of plants in Canada and especially Brazil.

Brazilian mills have a set of advantages. Their environmental performance (at visited mills) is above the present average for Europe and market growth, modern technology, strong productivity, low labour cost, low raw material cost and high hard woodpulp quality, together with the prospect of future growth, not only facilitate the further take-up of clean technology but are also a source of strong economic performance and competitive threat.

Competitive threat is based on factors other than environmental costs. Canadian mills have the advantage of good quality wood but at high prices. While their environmental performance and cost were lower than that of their EU counterparts, their productivity was lower too.

Neither in Brazil nor Canada did sample mills derive a cost or competitive advantage from lower environmental costs relative to A mills in Europe.

COMPETITIVE ADVANTAGES AND DISADVANTAGES ARISING FROM ENVIRONMENTAL COSTS AND PERFORMANCE RELATIVE TO OTHER FACTORS

Strong environmentally performing mills reported a derived competitive advantage. Few mills reported environmental costs as a competitive disadvantage.

(a). *Pulp*: Environmental strength was recognized as a competitive advantage arising from environmental certification more than performance. No “A” mill reported environmental costs as a competitive disadvantage.

(b). *White line chipboard:* Of the five “A” mills, 2 claimed a competitive advantage from environmental performance and one a competitive disadvantage.

(c). *Paper:* Of the three “A” mills studied one reported environmental costs a disadvantage with respect to competition outside the EU.

IMPACT ON PROFITABILITY OF INDIVIDUAL BAT

A summary of the findings of the impact of individual BAT on profitability is given in Table 6 for pulp. There are similar findings for the other two products. The table shows differences in reporting by BAT “A” mills from “B” and “C” mills sampled. For “A” mills, end-of-pipe techniques have a negative impact on profitability. For “B” and “C” mills, more BAT are reported to have negative impacts. (Where a negative impact on profitability was reported this did not necessarily imply a negative impact on competitiveness/market share).

Table 6. Impact of BAT on profitability.

	A mill Regulatory driven investment	**A mill Non-regulatory driven investment**	**B mill Regulatory driven investment**	**B mill Non-regulatory Driven investment**
Positive impact On profitability		Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO_2 from the RB Dry debarking, Brown stock washing, Evaporation	Brown stock washing, Evaporation	Dry debarking
Neutral impact On profitability	Control of NOx from RB	Reuse of condensates, Spill monitoring, Reuse of cooling waters, Electrostatic precipitators	Reuse of condensates, Spill monitoring, Control of NOx from RB, Electrostatic precipitators	Reuse of cooling waters
Negative impact on profitability	Primary treatment, Secondary treatment, Concentrated malodorous gases		Primary treatment, Secondary treatment, Concentrated malodorous gases, Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO_2 from the RB	

COST OF INDIVIDUAL BAT

Despite the difference in the economic experience of implementing BAT, there was no systematic difference between the cost of BAT. While not always the case, ‘A’ mills had often invested early in BAT and sometimes spread their investment over time.

DATA FOR INDIVIDUAL GRADES

Pulp: There was no clear-cut relationship between the cost of BAT and the environmental performance of the BAT. There was some evidence to suggest that investments in combinations of BAT lowered the cost of individual BAT.

White line chipboard: The cost of implementing BAT is independent of whether mills are designated “A” or “B”.

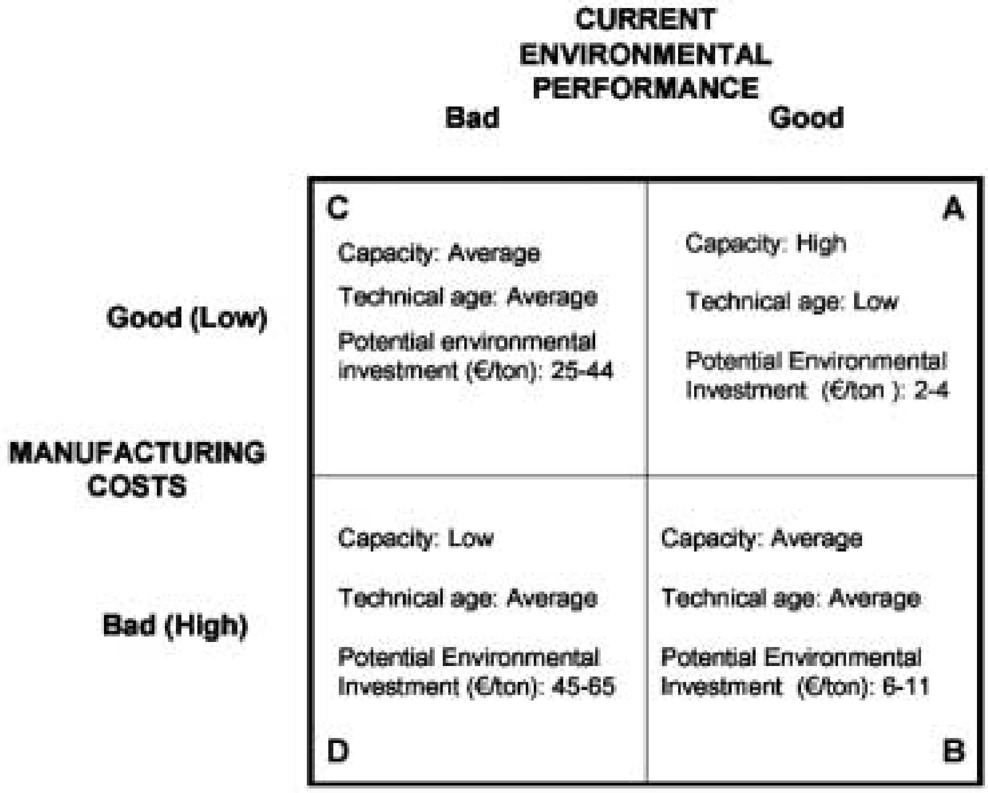
Paper: With the exception of ‘balanced white water’ there was no difference between “A” and “B”/”C” mills with respect to the cost of BAT. There was no relationship between individual BAT costs and age of plant.

SUPPLIERS’ VIEW ON IMPACT OF BAT ON COMPETITIVENESS

Four meetings with major producers of BAT equipment took place. These companies produce a wide range of pulp and paper technologies. Their view is that there is no effect from BAT on competitiveness except when firms have to make a step change in technology. However, if the mill has been investing continuously there are no difficulties. They emphasized the positive relationship between environmental performance and productivity performance and therefore competitiveness.

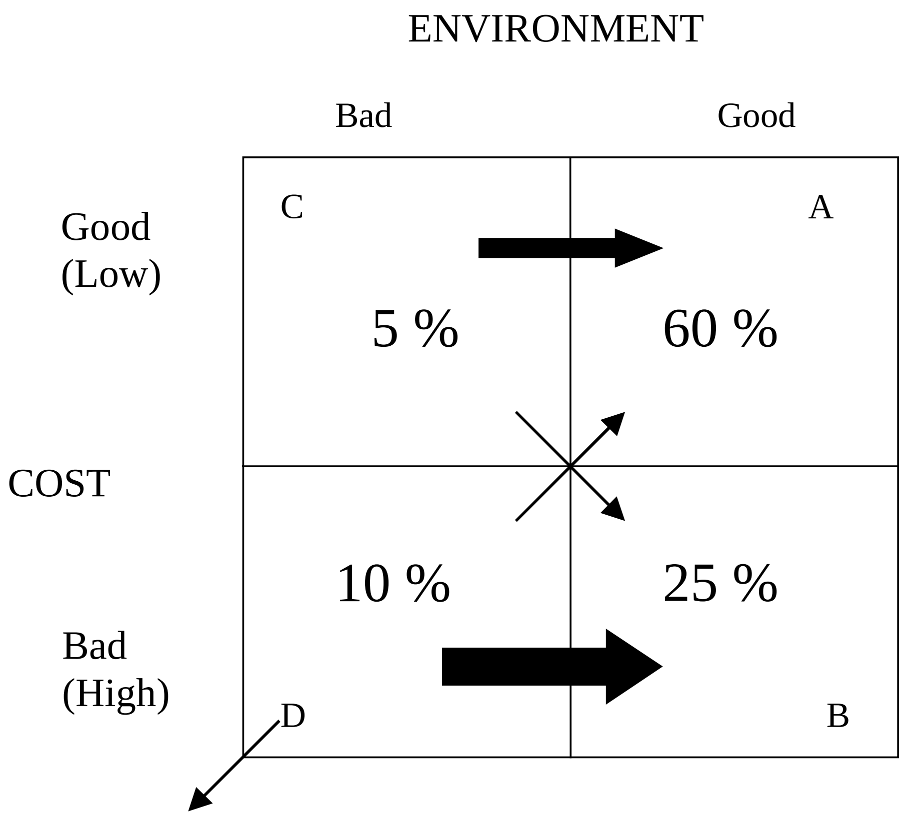
MACRO-ANALYSIS

Figure 2. Environmental investment requirements and characteristics of example European bleached kraft pulp producers (Jaakko Pöyry).



The macro analysis was undertaken by consultants Jaakko Pöyry. The approach adopted is (a) to estimate the percentage of plants with above and below average environmental performance and costs of production (approximated from a mix of variables and expert opinion) and (b) to estimate investment requirements to meet 80% of BAT needs, assuming a stringent implementation of BAT based on data from a single plant for each of the quadrants (investment requirements are given assuming total investment needs are divided by tonnage output in only one year i.e. it is not spread over the useful life of the asset).

Figure 3. Potential impact of BREF-recommended investments on the competitiveness of bleached kraft pulp producers within Europe (Jaakko Pöyry). The horizontal axis shows environmental performance and the vertical axis, manufacturing cost.



Results are shown in Figures 2 and 3. They show that 60% of output in the kraft pulp sector already reaches above-average environmental and economic performance, while plants in Box D are vulnerable because of low environmental and poor cost performance of the plant. The percentage of capacity considered to be vulnerable, having high costs and poor environmental standards i.e. those in Box D, is 10% in pulp, 10% in copy paper, and 15% in white line chipboard. The capacity is vulnerable but much will survive and move to A or B as shown by the arrows in Figure 3. It should also be noted that no competitive (replacement) growth in capacity (or take over) from within the EU, e.g. by plants operating in A, is considered.

4. FACTORS ASSOCIATED WITH ENVIRONMENTAL PERFORMANCE AND THE COST OF COMPLIANCE

This section presents those factors which favour or hinder the implementation of BAT by plants. These are divided into three sets of factors following the testing of the hypotheses considered above. They are identified as (a) positively associated with strong BAT implementation or (b) being *a priori* expected to influence implementation, but are found to have a neutral impact, and (c) characteristics of plants associated with few BAT or obstacles to the implementation of BAT. The method for identifying these differences is based on comparisons between matched (BAT with non-BAT) plants.

Factors associated with BAT implementation in the three sample industries:

Table 7 gives a summary of factors that are correlated or otherwise associated with the implementation of BAT. The evidence for each industry studied is shown in Tables 8-11.

The findings show:

1. In many cases and for certain industries there are factors that correlate with environmental and BAT performance by individual plants. Such plants are competitive and have high productivity, are modern or technically up to date, are growing, or have high quality human capital inputs (including skills, management and R&D).

2. Past continuous investment in environmental initiatives is important in determining the size of investment required for the implementation of BAT. Past environmental investment can be related to the plant location and the history of regulation in that region.

3. Ownership can be important for reasons of economies in finance, use of human capital and, where necessary, plant rationalisation.

4. Having environmental management systems is a neutral factor in influencing environmental performance and the take-up of BAT. Why this is the case requires further investigation.

Table 7 summarises those factors that were found to be significant attributes of BAT/non-BAT plants. The table lists, under ‘favouring’ factors, those identified as important attributes of ‘BAT’ plants. Those listed as ‘neutral’ are factors expected to influence implementation, although evidence indicates that they are unimportant in this study. Those that have a negative effect are those factors for which the study has accumulated evidence to signify this. The table summarises factors for the three industries, hence e.g. age of technology may be an important factor in one industry but not in another. The individual industry detail is shown in Tables 8-11.

Table 7. Factors influencing the implementation of BAT (summary for three sectors).

	Favouring	**Neutral**	**Factors that may have negative effect**
Regulatory Framework	X	X	
Plant characteristics			
New plant	X		
Plant size	X	X	X
Technology		X	
Current technology	X	X	X
Technical age	X	X	X
Process control	X		
Original plant age		X	X
Plant performance characteristics			
Labour productivity	X	X	X
Current price/cost relationship/profitability		X	
Volume growth	X	X	X
Production costs	X	X	
Energy efficiency	X		X
Existing competitive disadvantages			X
Environmental characteristics			
Prior investment in environmental protection and rate of investment	X		X
Current environmental performance			X
Environmental management		X	
Plant inputs			
R&D	X		X
Skills	X	X	
Innovation	X	X	
Price of inputs	X		
Other			
Location		X	
Ownership	X	X	X

Table 8. Cement: Factors influencing the implementation of BAT.

Favouring	**Neutral**	**Hindering**
Stricter national regulations	Labour productivity	Loose regulation
New plant	Price/cost relationship; sales per head	Outdated kiln/lack of modern methods
Large kilns	EMAS/ ISO 14000	Small kiln
Precalciners	Age of kiln	Lack of updating
Multi-stage combustion	Location	Independent ownership [Delete this extra vertical line]
High yearly investments		
Continuous measuring		
Continuous improvement		
Expert systems		
International ownership		
Skills		

Table 9. Non-Ferrous Metals: Factors influencing the implementation of BAT

Effect on environmental performance			
Metal sector	**Factors that help**	**Factors that are not important**	**Factors that have a negative effect**
Primary copper	Innovation in process development, Skills, Technical age.	Stringency of regulation, Size, EMS	Lack of prioritisation Timing
Secondary copper	Innovation in process development, Skills, Technical age.	Stringency of regulation, Size, EMS	Lack of prioritisation Timing
Secondary lead	Innovation in process development, Skills, Technical age	Stringency of regulation, Size, EMS	Lack of prioritisation Timing
Secondary aluminium and salt slag processing	Innovation in process development, Skills, Technical age	Stringency of regulation, Size, EMS	Lack of prioritisation Timing

Table 10. Kraft pulp: Factors influencing the implementation of BAT.

Characteristics for mills with higher environmental performance and many BAT	Characteristics which do not seem to be linked to environmental performance	Characteristics for mills with lower environmental performance and fewer BAT
Large size		Small size
Low and medium age of equipment		Old age
High productivity		Low productivity
High sales per head		Low sales per head
Volume growth		Little volume growth
Production costs		
Strong R&D		Weak R&D
High skills		
	Average annual environmental investment in % of sales over the five last years	
	Production costs	
	Regional location within the EU	
	Environmental management systems	
Strict regulation and strict enforcement		Soft regulation and/or soft enforcement
High degree of energy efficiency		Low degree of energy efficiency

Table 11. White line chipboard: Factors influencing the implementation of BAT.

Characteristics for mills with higher environmental performance and many BAT.	Characteristics which do not seem to be linked to environmental performance.	Characteristics for mills with lower environmental performance and fewer BAT.	Further work is needed to provide conclusions.
	Mills of all sizes can be found among both “A” and “B” mills.	Predominantly small mills in the sample are “B” mills.	
	Original age and most often technical age.		
	Productivity.		
	Volume growth.		Volume growth (wider spread needed).
	Export, degree or direction.		
R&D focusing on environment.	R&D focusing on quality and production.		
High environmental investments.		Low environmental investments.	

5. COMPETITIVENESS IMPLICATIONS FOLLOWING SHARP IMPLEMENTATION OF BAT AND IPPC

This section is based on an analysis of investment needs by non-BAT plants sampled. The findings can be summarised as follows:

In cement, for dry technology, competitive risks will be minimized provided that implementation is undertaken appropriately and there is opportunity to offset raised costs following the adoption of secondary measures. In the semi-wet/semi-dry sector there are many concerns about the likelihood of closure following a stringent implementation of BAT.

In non-ferrous metals there are many fewer competitiveness problems associated with the introduction of BAT than shown for the other two studies, although there are different levels of investment required by different plants. Few plants risk closure.

In pulp and paper Jaakko Pöyry have estimated the percentage of capacity and number of plants requiring different levels of investment to meet 80% of the required BAT. They estimate that across the product types the number of plants at risk of closure following a sharp implementation of BAT is 20% or less.

Detailed individual industry findings are as follows:

Cement

DRY TECHNOLOGY

The competitive risk arises from the implementation of secondary measures (Table 12). Where these have been implemented successfully, additional costs have been offset by the use of cheaper alternative fuels.

For dry technology the analysis shows little competitive risk arising from implementation of BAT primary measures. As indicated above, secondary measures are a different matter. Both German and Italian plants argued that these measures led to a competitive disadvantage, irrespective of plant size, cost or ownership. Despite the additional costs associated with secondary measures, the plants in Italy and Germany were nevertheless profitable. However, the additional costs associated with secondary measures were importantly offset (in Germany but also at many Italian plants) by the use of cheaper (alternative) fuels. There are special problems for small, old and independent kilns in adjusting to BAT investment requirements and simultaneously remaining competitive in the short run.

Reported impacts of complying with IPPC.

For plants operating dry technology there were two major concerns. The most important is a possible requirement for a reduction of NO_x to 500 mg/m^3. The second concern is for dust reduction measures. Stricter dust levels were expected by many plants. In most cases the plants accepted that this was expensive in capital costs but necessary. Optimisation of processes went on in all plants and was seen as a continuous task.

Table 12. Examples of future BAT investment in the dry process.

	Type of BAT	**No. of plants**	**Effect on business**
NO_x reduction measures	Exchange of burner	2	Slightly negative
	Flame cooling	1	Neutral
	Expert system	2	Beneficial
	Alternative fuels	3	Beneficial
	Precalciner and alternative fuels	2	Beneficial
	SNCR	5	Negative
SO_2 reduction measures	Wet scrubber	1	Negative
Dust	Bag filters	1	Higher operation costs
	EP	1	Negative but necessary
Optimisation of process	Expert system	2	Beneficial
	Improved process	1	Beneficial
	Change in transport system	2	Beneficial

SEMI-DRY/SEMI-WET

In the semi-dry/semi-wet sector, in a number of instances it was doubted whether plants could comply with BAT and remain competitive with emphasis placed on affordability and timing of necessary investments. Implementation of primary measures was in some cases likely to be very costly and for some old and small plants where environmental measures have been neglected closure is expected. Closure in a number of cases may be forestalled by scheduling the implementation of measures. No plant visited had implemented secondary measures in this sector and at the moment there is no full-scale implementation of SNCR. If this is required by IPPC then such plants may not survive the investment requirements. In some instances such an installation may not be technically possible.

Poor performers

In a number of cases poor environmental performers sampled in the semi-wet/semi-dry category are expected to close anyway, hence the implementation of BAT will not be the original cause of the closure but will hasten the process.

Non-Ferrous Metals

The responses and observations show that in general, existing plants in the sectors studied can incorporate BAT relatively easily, provided that they use innovation and planning to prioritise the work needed.

Table 13. European plants classified by environmental performance.

Metal Produced	No of plants in EU	Environmental Performance			Characteristics
		A Good	B Medium	C Poor	
Primary copper	4	4			Plants very evenly matched in all respects
Secondary copper	6	3	2	1	The worst environmental performer has closed. It also had poor economic performance.
Secondary aluminium	50	18	22	10	The 4 worst performers have closed but more closures may result from the local market decline in UK.
Secondary lead	30	18	9	3	Environmental standard driven by Air Quality Directive. Poor performers are vulnerable.
Salt slag	10	4	4	2	Recent investment has made significant improvements to environmental performance.
Waelz oxide	8	3	3	2	Recent, low-cost investments have made significant improvements to environmental performance and yield.

Table 13 summarises the environmental performance of European plants in the target sectors in 3 groups: A, B and C.

Group A includes companies which already use BAT and will incur no additional compliance costs.

Group B includes those companies with 9 out of the 10 BAT factors. They will incur minor costs by making small improvements such as optimising the way the process is controlled. Improvement can be achieved by improving the skill base of the company to develop the processes or by using external sources of skill. This course of action can improve productivity and will have a medium-term payback.

Group C includes companies with 7or 8 of the BAT factors and these will need to implement more major improvements. Generally these improvements will be driven by the need to increase fan capacity or improve extraction equipment to capture fugitive emissions. These project costs will be higher and probably will not have an economic benefit. Estimates show that differential compliance costs should not be great. In some cases the collected gas volumes will be too high for existing abatement plant and additional expenditure will be needed. This will be a higher cost and will affect plants operating with marginal profits. Investment in this type of project is best achieved during other investment or process improvement.

8 % of the industry are included among the poor performers and have fewer than 6 BAT factors, very low productivity and yield. Most of these poor performers have already closed. IPPC may ultimately close other companies with weak economic and environmental performance.

LIKELY IMPACT OF IPPC ON SOME PLANTS

Table 14 lists differential costs for the take up of IPPC quoted by the companies in Group B. The interpretation is based on the environmental assessment and anticipates the implementation of all of the BAT factors even if the company anticipates no change. The data therefore represent "the worst case" i.e. rigorous application of IPPC.

Table 14. Non-ferrous metals: Likely impact of IPPC on some plants.

Differential impact due to IPPC	Motivation driver and obstacles	Work needed	Effect on emissions	Likely project cost €	Effect on productivity	Economic effect		Capital and running cost.
						Margin	Yield	
Improved fan capacity	Some fugitive emissions	Increase fan capacity by 25000 m^3/h	Reduction of fugitive emissions	€ 120000 = 1.2 €/t over 5 years	No change	- 2 €/t*	No effect	1 €/t* 50 kWh
Optimisation of extraction	Small fugitive emissions	Survey and adjustment of extraction.	Reduction of fugitive emissions	Minor	No change	No change	No change	Minor effect
Optimisation of extraction	Some fugitive emissions	Survey and adjustment of extraction.	Reduction of fugitive emissions	Minor	No change	No change	No change	Minor effect
No anticipated costs	Use of all BAT factors	None	No reduction needed.	Nil	No change	No change	No change	No change 8 companies in the sample.
Improved fan capacity	High level of fugitive emissions	Increase fan capacity by 50000 m^3/h	Reduction of fugitive emissions	€ 240000 = 0.6 €/t over 5 years	No change	- 2 €/t*	No effect	1 €/t* 100 kWh
Reduced gas volume	High level of fugitive emissions	Use of oxygen if feasible	Reduction of fugitive emissions	Minor	Increase possible	+ 2 €/t	No effect	< 1 €/t
No effect likely effects on Employment and Skills. * Based on increased electricity usage								

Work needed was assessed from the scoring of BAT strength. Costs have been calculated from the Cost Annex of the BREF.

Pulp and paper

ESTIMATES OF INVESTMENT REQUIREMENTS AND MILLS AT RISK OF CLOSURE FOLLOWING SHARP IMPLEMENTATION OF IPPC

A number of factors are listed which are expected to affect the cost of compliance with environmental regulation and the implementation of BAT. These include R&D, skills innovation, age of technology, the degree of product specialisation and the distance from home markets.

The Jaakko Pöyry analysis stresses that the competitive impact will be a function of (i) the ease of implementing BAT at a relatively low cost of compliance, (ii) the potential for specialisation to absorb the costs of compliance, (iii) the extent of international exposure for the product and (iv) for those in category D, the need to make large environmental investments.

For the three selected products, the macro study estimates the investment cost of BAT. This investment cost refers to total investment required to meet 80% of the most important BAT immediately, expressed per tonne of output produced in year 1 (not per tonne of output across the expected lifetime of the asset).

Four cases are considered where mills are divided between above-average and below-average economic and environmental performance. Mills are divided into groups A to D. D mills have above average costs and below average environmental performance. These mills may (a) improve economic and environmental performance and survive, (b) exit the industry with production replaced by successful plants (i) elsewhere in the EU or/and (ii) internationally (e.g. Latin America, Asia etc.).

CHARACTERISTICS OF PLANTS IN CATEGORIES A TO D, BAT INVESTMENTS REQUIREMENTS (EXPRESSED AS 80 % OF TOTAL BAT INVESTMENTS REQUIREMENTS DIVIDED BY CURRENT YEAR OUTPUT) AND EUROPEAN PRODUCT CAPACITY ASSIGNED TO THE CATEGORY.

CASE A, GOOD ENVIRONMENTAL AND ECONOMIC PERFORMANCE

Pulp: high capacity, low technical age, 2-4 euros/tonne, 60 % of capacity

Copy paper: high capacity, average technical age, 0.5-2 euros/tonne, 45% of capacity
White line chipboard: high capacity, low technical age, 0.5-2 euros/tonne, 30 % of capacity

CASE B, GOOD ENVIRONMENTAL PERFORMANCE AND POOR ECONOMIC PERFORMANCE

Pulp: average capacity, average age, 6-11 euros/tonne, 25% of capacity
Copy paper: high capacity, average technical age, 2-5 euros/tonne, 35 % of capacity
White line chipboard: 10 % of capacity

CASE C, POOR ENVIRONMENTAL PERFROMANCE AND GOOD ECONOMIC PERFORMANCE

Pulp: average capacity, average technical age, 25-44 euros/tonne, 5% of capacity
Copy paper: 10 % of capacity
White line chipboard: 45 % of capacity

CASE D, POOR ENVIRONMENTAL AND ECONOMIC PERFORMANCE (MILLS AT RISK)

Pulp: low capacity, average technical age, 45-65 euros/tonne, 10 % of capacity
Copy paper: 10 % of capacity
White line chipboard: low capacity, high technical age 9-15 euros/tonne, 15 % of capacity

In addition a number of other factors are listed by Jaakko Pöyry as risking the survival of particular mills (see Table 15).

Table 15. Pulp and paper: endangered species.

Kraft pulp	**Copy Paper**	**WLC**
Too small and/or old (with no major revisions done in recent past) • are lacking raw material to enlarge their production • still use active (gas) chlorine in bleaching (found only outside Western Europe) • are major net buyers of energy • are high consumers of water/tonne of pulp • are far from the national/local limits of water or air discharges Percentages of "endangered species" by region: • Europe: 15 %	• too small and/or old (with no major revisions done in recent past) • are lacking raw material to enlarge their production if integrated or have, long term, higher than average costs of buying raw material if non-integrated • still use active (gas) chlorine in bleaching at the pulp mill connected to the paper mill (found only outside Western Europe) • are competing with small-scale bulk grade production or have too many low return grades which increases the number of grade changes, reduces production and lowers competitiveness • have below-average quality and/or service • are far from the national/local limits of water or air discharges Percentages of "endangered species" by region: Europe: 20 %	• too small and/or old (with no major revisions done in recent past) • are lacking raw material to enlarge their production if integrated or have, long term, higher than average costs of buying raw material if non-integrated • still use active (gas) chlorine in bleaching at the pulp mill connected to the paper mill (found only outside Western Europe) • are distant from high-volume export markets and are competing with larger scale FBB or SBS production for the home market production and lowers competitiveness • have below-average quality and/or service • are far from the national/local limits of water or air discharges • have insufficient/out-dated facilities for stock preparation of the recycled fibre base Percentages of "endangered species" by region: • Europe: 15 %

6. FINDINGS RELEVANT TO IMPLEMENTING BAT COMPETITIVELY

For each industry, analysts emphasised the importance of prioritizing environmental initiatives, a careful timing of those initiatives and time to undertake them. Special consideration is recommended for those initiatives expected to yield a positive economic return. The detail for each industry is given below.

Cement

Sufficient time for planning investments is important in the cement industry. Installations have a life cycle of about 20-30 years and require heavy investments. As major changes in the equipment are usually expensive (e.g. the improvement of EPs, implementing MSC or a precalciner into existing equipment) in comparison to a completely new installation, it will be economically beneficial if investments are planned in anticipation of future environmental requirements.

Time is also important to develop, test and evaluate new methods. Depending on technology, type of raw materials, type and quality of fuel etc. environmental measures might lead to different outcomes. Notification of stricter emission levels in advance allows time to find means for improving processes in the most economical way. For reduction of most emissions, experiences are published and easily accessible. In particular, international companies have the advantage of being able to transfer experience among their plants.

The length of time to react to the provisions also depends on the present state of the plant. No plant will be able to move from a low to a high BAT-associated level/standard immediately. Plants which are more backward may need more time, but even these plants should be required to state their plans and how and when they will achieve the BAT-associated emission levels.

Non-Ferrous Metals

Based on the experience of the best performers, the most effective route for most plants in this sector to comply with IPPC will be to improve elements of existing plants by developing the way that the technology is used e.g. by using better methods of controlling and optimising the process.

For poor performers, as for good ones, improvement to the "front end" of a process (e.g. process control) is of primary importance, followed by development of the process itself. Skills and the way that they are implemented and directed can be used by medium and poor performers to improve both of these elements. For example, in cases where under-designed gas collection is the main issue, process improvements can reduce gas volumes to a level that is acceptable, although some plants need to up-rate fan sizes and possibly the size of abatement plant.

The improvement of skills is an area where many companies have had success by adapting established systems. Many of these improvements relate to management issues. The study presents a methodology for ranking required BAT and the means of improvement. Using such a methodology it is possible to identify the areas that need to be improved, the techniques that are available to give the improvement and the influences and obstacles involved. The factors can then be used to establish the priorities for a particular site and a timetable for improvement.

Pulp and Paper

The answers collected to the question about future investment in order to meet the BREF ranges show that most mills have already thought about IPPC and are searching for ways to comply with it. On water issues, the expectation of a reduction of COD and BOD emissions by secondary treatment was mentioned frequently. This is the crucial investment and small and medium-sized mills in particular complain about the additional costs arising from this investment.

On air issues, investments in a variety of BAT in order to reduce all kinds of emissions are discussed at the mills. However, two mills claimed not to know of a technical solution for a further reduction of SO_2 and dust emissions down to the BREF ranges.

The results of this study point out the necessity for the firms of planning and timing the BAT investments.

While not always the case, “A” mills invested early in BAT and sometimes spread their investment over time. The details were as follows:

Pulp: “A” mills have invested over an earlier period. B/C mills show a higher investment as a percentage of turnover in the last five years. A mills took turns between investing in cheap and expensive BAT, or they were new mills. B/C mills spread out their few BAT investments.

White line chipboard: Mills with a good environmental performance can either spread their investments or undertake investments in environmental technology more intensively over a short period of time. This is partially explained by regulatory pressure. Southern European plants have started environmental investment late and Northern European companies have started early.

Paper: A mills started with their BAT early but, in many cases, so did also the B/C mills. There was no pattern of differentiation.

In discussing future investment required to meet IPPC, pulp mills on many occasions reported that a reduction in emissions in small steps is cheaper for them. The implementation of existing BAT were in all sectors, often but not always, spread out over a long period of time. Jaakko Pöyry argues that the possible speed of upgrading differs case by case and that there may be the possibility of combining environmental investments with other investments (for capacity increase or quality improvement). These opportunities play a major role in determining whether or not a company should invest in a single jump or choose a stepwise approach. Jaakko Pöyry also set out a set of example investment packages with financial and economic consequences e.g. to reduce emissions to air or water, or for mills with low environmental performance.

7. METHODOLOGICAL FINDINGS

The studies in this report have been based principally on comparing plants that have already implemented BAT with similar plants that have implemented fewer BAT and by asking what might be the impact on existing plants of stringent implementation of BAT.

A key approach has been to ask what are the characteristics of BAT plants? How did they become BAT plants? How do they differ from plants in the industry with average and weaker environmental performance? How do environmental performance and compliance costs differ by plant size and other plant characteristics?

Studies of the three industries are based on face to face interviews using a detailed questionnaire. The questionnaires used for each industry are standardized and the experience of implementing these questionnaires is set out in the three industry studies.

Data have also been collected on the requirement for BAT but the quality of this varies by industry and the method of assessing the needs and their impact varies also.

In addition, some data are obtained from statistical databases and a number of assessments rely upon professional judgement.

One methodology differs. The study of non-ferrous metals uses ratings to measure principally the strength of BAT but also other variables. In this case the extent of the effect of BAT on competitiveness was measured using a questionnaire, by conducting interviews and by making observations of the process methods during site visits. Table 16 shows the careful definitions made for the various scores.

Table 16. Criteria for Measuring the Strength of the BAT Factor.

BAT factor	**Score of 1**	**Score of 2**	**Score of 3**	**Score of 4**	**Score of 5**
Generic description	**None of the techniques is used.**	**Some of the techniques are used. Development considered**	**Most of the techniques are used. Some development.**	**All of the techniques are used. Some development.**	**All of the techniques are used or exceeded. Constant development.**
1 - Storage & handling	Open storage of dust-forming material VOC emissions from tanks.	Shielded storage of dust-forming material.	Shielded storage of dust-forming material. Oily material in bunded areas, tanks back-vented.	Covered, shielded storage of dust-forming material. Oily material in bunded areas, tanks back-vented.	Enclosed storage of dust-forming material. Oily material in bunded areas, tanks back-vented.
2 - Pretreatment	No pre-treatment	Some pre-treatment to optimise the size	Some pre-treatment to remove organic material or optimise the size	Pre-treatment to remove organic material or optimise the size	Effective pre-treatment e.g. to remove organic material and blend the furnace charge to provide a constant feed
3 - Process control	Manual control of process and abatement. No procedures/ instructions. No monitoring of parameters. Frequent process deviations.	Manual control. Poorly written procedures/ instructions. Poor monitoring of parameters. Frequent process deviations.	Operating procedures available and implemented. Control of some process operations e.g. combustion conditions. Limited process deviations.	Effective operating procedures available and implemented. Control of some process operations e.g. combustion conditions. Limited process deviations.	Fully automatic control based on key process parameters. Comprehensive procedures/instructions being followed. Rare process deviations.
4 - Management and supervision	Ineffectively managed, poorly defined reporting structure and no clearly identified responsible person. No identifiable supervision breakdown maintenance only.	Poor management control but skills present. Poor supervision but skills present. Some planned maintenance.	Fair management control with skills present. Improvements being made. Controlled by responsible person. Maintenance is planned	Plant effectively maintained and managed with well-trained, competent personnel aware of all consequences. Fully trained, responsible operators reacting to process variations	Commitment to planned maintenance. Environmental performance demonstrated within management policy. Fully trained meisters or supervisors reacting to process variations
5 - The process	Basic process not included in the BREF conclusions on BAT.	Some processes included in the BAT conclusions	Majority of process included in the BAT conclusions	Process included in the BAT conclusions including the control and monitoring aspects.	Process included in the BAT conclusions, combined with effective, continuous development.
6 - Fume collection	Open or semi-sealed furnaces with inadequate extraction systems.	Open or semi-sealed furnaces with fair extraction systems.	Semi-open furnaces with good extraction of gases	Semi-sealed furnaces with good extraction of gases	Sealed or fully enclosed furnaces with good, high volume extraction.
7 - Abatement or upgrade of abatement	Basic process not included in the BAT conclusions. Replacement or total upgrade needed.	Some of the process included in the BAT conclusions. Some upgrade needed. e.g. improved filter bags	Majority of the process included in the BAT conclusions. Upgrade needed in near future e.g. continuous monitoring	All of the process included in the BAT conclusions including the control and monitoring aspects. No upgrade needed. Regular maintenance carried out.	Process included in the BAT conclusions combined with good monitoring and control systems. No upgrade needed. Regular maintenance and improvements.
8 - Wastewater treatment	Basic process not included in the BAT conclusions.	Some of the process included in the BAT conclusions	Majority of the process included in the BAT conclusions	Process included in the BAT conclusions.	Process included in the BAT conclusions with effective, continuous development.
9 - Process residues	No attempts to minimize or re-use process residues	Some attempts to minimize or re-use process residues	Effective attempts to minimize or re-use process residues	Good minimization practices.	Good minimization practices with continual reviews.
10 - Energy efficiency/ recovery	No energy recovery practised and no investigations made about possibilities	No energy recovery practised. Investigations made about possibilities	Limited energy recovery practised. Some investigation of other opportunities.	Energy recovery practised where plant design showed possible areas	Energy recovery practised. Continuous investigation of other opportunities.

There is a need for both a *micro* and a *macro* approach in order that the impact on all firms in the industry can be assessed. The macro counterpart of the micro approach in pulp and paper has been undertaken by Jaakko Pöyry; it is assessed by the author of the non-ferrous metals study (he is also the author of the non ferrous metals BREF) and is a less complete aspect of the cement study.

Strengths and weaknesses of methodologies used

STRENGTHS

- Micro plant study recognizes differences existing between plants. These are important when considering the implementation of BAT.
- Difficulty in measuring a number of variables (e.g. strength of BAT) can be overcome by scoring but requires an element of judgement and a means of weighting the factors.
- A micro study allows for the possibility of measuring and ranking factors which influence the implementation of BAT and compliance costs
- Managers can answer the detailed questions about the impact of specific environmental initiatives on a firm’s performance
- Broad categorization by critical variables related to the implementation of environmental initiatives by all firms in the industry is important to judge the impact on the industry as a whole.
- Plant managers and CEOs are very forthcoming. There was very little problem in obtaining data from them and there was a sense of honesty in responses to questions or otherwise a straightforward refusal to reply.
- Overseas visits facilitate an understanding of environmental performance, environmental costs and general competitive strengths and weaknesses, all of which helps in the assessment of competitive threats.

WEAKNESSES

- It is difficult to obtain a range of satisfactory performance measures e.g. to include plant profitability and cost measures across all plants.
- It is difficult to achieve statistical representativeness of the industry.
- Sometimes it is difficult to achieve co-operation from individual firms and from industry in particular countries.
- In some cases of inputs to the main study and despite very high quality work, there has been an undue dependence on ‘expert opinion’,

- 'professional judgement', proprietary information, and use of private databases to follow the methodologies used and the calculations undertaken.

- There can be significant problems in completing data sets.

- There can be problems identifying plants with the full range of BAT and plants that also reach strong environmental performance standards.

- Data on use of individual BAT are usually unquantified except in the case of the non-ferrous metals study.

- There is a wide variation in cost data and difficulty in isolating the cost of BAT and its relation to environmental performance.

- It is difficult to show which BAT lead to particular emission reductions.

- In some cases in this set of studies, particularly in the cement investigation, there are too few BAT/strong environmentally performing plants analysed.

LESSONS LEARNT FOR FUTURE USE OF THE METHODOLOGIES ADOPTED IN THIS STUDY

The combination of a micro study of the effects of individual BAT together with a macro backdrop showing plants at risk following a sharp implementation of IPPC has worked well in this report.

The design of the micro study:

1. Has enabled the economic effects of individual BAT measures by different types of plants to be studied. This has allowed a separation to be made of those BAT measures with positive effects on competitiveness and business performance from those with negative effects. Importantly it has also allowed for a documentation and understanding of the variation in the economic effects by different plants for the same BAT (found to be particularly important in the pulp and paper study, related in that case to the motivation for the implementation, whether as part of an investment programme or simply for regulatory reasons). This variation implies that the

competitiveness implications of BAT vary by type of plant/form of implementation.

2. Has allowed for a balancing of the overall impact of the implemented BAT on business performance.

3. Has allowed measurement and understanding of factors that can influence the cost of compliance with IPPC e.g. plant size, the link between R&D and environmental initiatives, the importance of the timing of the implementation of BAT.

4. Has allowed for the relative importance of environmental costs and advantages against other business advantages and disadvantages to be gauged.

5. By sampling plants of different sizes the differential impact of BAT on SMEs and large firms has been studied.

6. By matching plants between those with many BAT and those reflecting both average and below-average environmental performance in the industry, factors that act as facilitators and obstacles to the implementation of BAT have been made clear.

7. It has been very important to interview and assess the productive and environmental performance of international competitors in this study. This component is strongly recommended.

8. Interviews with suppliers of BAT have also been important.

Measurement of variables

9. It is difficult to obtain complete and reliable data from any one firm. It is therefore important to obtain as large a sample as possible. This improves the statistical reliability of the results.

10. There were many warnings from European industry associations on the sensitivity of many questions e.g. on profitability and R&D input. We did not experience this. Many firms were willing to answer these “sensitive” questions.

11. We used three measures of BAT performance. One based on the number of BAT implemented and the environmental performance of the plant, another based on plant emissions only and the third based on a rating of the strength of use of individual BAT. We would recommend a combination of the three techniques in the measurement of BAT input by the plant.

Macro measures:

12. It is important to have an understanding at the macro level of the relative importance of the set of variables known or found to be important in facilitating/inhibiting the implementation of BAT, and of those plants likely to be vulnerable to closure following implementation as a result of inhibiting factors e.g. plant age, and other weaknesses.

13. The problem in obtaining such macro measures is that much of the data is not published or is incomplete. In the pulp and paper study much of the work undertaken by Jaakko Pöyry, the industry consultants, involved providing distributions of those variables considered *a priori* important in influencing the implementation of BAT. Even the considerable data base of Jaakko Pöyry has important data gaps, which for this study were completed using internal expert opinion. It is necessary to avoid an exclusive reliance on expert opinion and therefore attempts are required to use alternative sources to check the validity of estimates made. This was the approach adopted by the lead researchers in this study. Hence, the IPTS sample data were used to check aspects of the Jaakko Pöyry estimations, and technical advice from two major companies was also obtained. Jaakko Pöyry were also questioned closely on their use of expert advice and the consistency of their estimates.

8. RECOMMENDATIONS

Dealing with industry groups

While industry associations were very helpful in arranging meetings and access to plants, there was in some cases a tendency for them to act strategically rather than scientifically at the meetings. While this of course is also characteristic of the behaviour of Member States and environment groups at TWG meetings, the co-operation of industry is especially important since industry is an important source of data and evidence to judge the impact of BAT on competitiveness.

Economic knowledge of various parties involved

Experience undertaking this project shows that there is a wide range of views taken on the meaning of competitiveness and factors which influence competitiveness by civil servants at EU and national level, members of the IPPC Bureau and by “BAT and Competitiveness” representatives at industry associations. It is recommended that workshops be offered on the economics of competitiveness and economics of the environment for members of these groups to broaden their understanding of the underlying issues.

Quality of economic data

The quality of economic data provided to BREF authors has not been checked in a systematic way. Nevertheless, it is important to emphasise the need to be clear in reports about methods adopted, assumptions made, exact sources of data etc. Unfortunately this is not always done, which can create uncertainty about the validity of results presented. It is important that methodologies should be sufficiently explicit so that studies can be checked and, if necessary, replicated.

Additional skills for the IPPC Bureau

As discussed above, more critical economic skills and reliable and relevant economic data are important for the BREF process and elementary statistical awareness is important too. Analysis of responses to questionnaires by the authors of 5 completed BREFs indicates the importance of this (Box 3):

BOX 3

- The BREF authors have some knowledge of factors that influence plant competitiveness.
- Some competitive issues were taken into account by the authors when the BREFs were produced. Industry comments during the consultation stages included the issue of competitiveness.
- The main measures used were change in site output and change in productivity. These were taken into account by the anticipated increase in efficiency and the reduction in energy and material use of the BAT processes.
- The data supplied for the BREF were quite good overall, but data for emissions to land were poor. Data for capital and operating costs were reasonable. The reliability of the data followed the same pattern.
- Site visits, own research, industry, Member States and equipment suppliers all provided reasonable amounts of data for the work.
- Site visits were important to enable a proper assessment of the data and to resolve the way that pressure was applied to change the BAT conclusions.
- The BAT conclusions tended to be reduced slightly in severity during consultation. Most of the influence came from industry and southern Member States. These influences include competitiveness arguments put forward by industry representatives.
- BREF authors found discussion with the sources of comment, discussion with TWG members and the use of own knowledge, observations and data the most effective ways to deal with pressure to change conclusions.

In this study we have reported facilitating factors and obstacles. These could usefully be taken into account during the production of a BREF. The question can be asked under what circumstances are individual BAT relatively easily and cheaply implemented and under what circumstances is this costly and difficult. A list of relevant factors is included in this study.

Not only can such judgements be made from appropriate reports but it is also important for BREF authors to make many visits, to see representative installations (with and without BAT) and verify extra-EU competitive threats for themselves. We have used methods and tests that have been successful in a case study approach.

Some understanding of how IPPC may be implemented is an essential backdrop to a judgement of economic implications as indicated in this report. This has been a continuous problem in discussing the question of the impact of BAT on competitiveness with industry members. In the TWG there is a division of views (Box 4).

BOX 4

The experts were asked how rigidly the IPPC Directive and the BAT recommendations would be implemented in their country.

Norway, Germany, Sweden and UK thought that the IPPC Directive would be applied rigidly and Belgium, Spain and Finland thought that there would be some concessions.

Only Germany thought that the BAT conclusions would be rigidly applied while Norway, Belgium, Sweden and Spain thought that there would be some concessions and Finland and UK thought that the BAT conclusions would be applied flexibly.

Work of the technical working group (TWG)

Members of the NFM and pulp and paper TWGs were invited to complete questionnaires.

They made a number of key comments relevant to the question of competitiveness (Box 5).

Box 5

1 SMEs (small and medium-sized enterprises) are under-represented at the TWG and are under-represented in membership of industry associations. They are also a vulnerable group.

2 More information is required on costs and competitiveness factors, which should be considered within a formal framework.

3. Many of the hypotheses considered in this study are relevant but not sufficiently considered at the TWG.

More consideration could be given by the TWG to factors that influence the competitive implementation by plants across the relevant industry and an estimation of competitiveness impacts across the industry.

9. FURTHER WORK

DG Environment, DG Enterprise and DG Economic and Financial Affairs

It has been argued and shown that work needs to be undertaken on how IPPC is expected to be implemented in order (a) to better understand the impact of BAT on the competitiveness of existing industry and its effect on plant closures and (b) to facilitate the scientific selection of BAT.
Many plant managers/industrialists argued that IPPC would bring about an even playing field. However it must be recognized that any rapid change will disadvantage those plants that have to improve the most because they are starting from a lower level.

Economic and Cross-Media BREF

Examining factors which influence competitiveness and how these might be measured and introduced into the BREF process are appropriate topics for the ‘Economic and Cross-Media Bref’. To date this is not being given any prominence in that study.

10. POLICY IMPLICATIONS

There is no evidence that BAT hindered those companies using BAT and achieving good environmental standards from remaining competitive both nationally and internationally (but sample companies did not always reach the emission levels associated with their implemented BAT, nor did they necessarily implement all the BAT).

For reasons given in this study it does not follow that early implementation of BAT by other firms or plants in the industries studied would similarly have little or no impact on their competitive performance. There are plants that would have technical difficulties in implementing all BAT, and there are many plants for which prudent implementation based on consideration of the firm's own economic and environmental improvement plans and constraints is important for them to achieve a sustainable environmental and economic performance without closure.

PART B

REPORTS OF INDIVIDUAL INDUSTRIES:

THE CEMENT STUDY
THE NON-FERROUS METALS STUDY
THE PULP AND PAPER STUDY

THE CEMENT STUDY

THE PRODUCT

Cement is a binding agent and important building material. It consists mainly of compounds of calcium oxide (CaO), silicic acid (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3). There exists a wide variety of cements but each type is standardised according to agreed norms. Cement quality standards are relatively easy to meet and the product is internationally competitive.

THE STRUCTURE OF THE INDUSTRY

While there are about 250 cement plants in the EU (operated by 64 firms), there has been much consolidation of the industry through merger and acquisition since the 1970s. Plant size and energy efficiency have risen and small and inefficient plants have closed. European firms (and especially the major European firms: Heidelberger (Germany), Holderbank (Switzerland), Italcementi (Italy) and Lafarge (France) have also invested heavily overseas, notably in North America, North Africa and more recently in the Eastern European market. Concentration of production in the industry is high, as shown in Table 17.

Table 17. Market share and number of plants owned by the three largest producers (1996).

	France	Germany	Italy	Spain	UK	Poland
Market share of largest 3 manufacturers	82%	48%	55%	56%	94%	57%

Source: the Cement Industry, Dec. 1997, Dresdner-Kleinwort-Benson, April 1998; The Global Cement Report 1998

MARKETS

Cement is a heavy, low unit price product and transport costs are an important factor governing the producer’s customer base. Most cement is delivered by road and in Western Europe transport costs usually limit supply to a radius of 200 km.

Cheap rail freight and low production costs have led to imports from Eastern Europe and also from elsewhere by sea. Transport by water is cheap and, once handling charges have been paid, distance matters little. Cement prices at ports are often lower than inland (the difference can be as much as 20%). Despite this threat from imports, customer need for just-in-time deliveries of cement of uniform quality limits competition.

THE PROCESS

There are four main processes for the manufacture of cement: the dry process (widespread in the EU and accounting for 78% of production in 1996), the semi-wet/semi-dry processes also frequently used in the EU, and the wet process responsible for just 6% of production in 1997.

MEASURING THE IMPACT OF BAT ON THE COMPETITIVENESS OF PLANTS IN THE INDUSTRY

The impact of BAT on competitiveness was assessed by examining the effect on a sample of plants in four Member States (Germany, UK, Italy and Spain) and one adjacent non-EU country (Poland). The choice of countries provided a variation in current environmental regulation, cement production technologies and processes, current use of BAT, plant size, ownership and vulnerability to imports. Plants sampled in Poland represent an external EU threat. Table 18 provides an overview of the characteristics of plants sampled in each country. Individual plants were sampled from directories while industry associations facilitated access to plants.

The study focuses on dry and semi-wet/semi-dry technologies. Wet technology plants were also included in the sample but this is now an old energy-intensive technology and closure or replacement by dry or semi-dry technology was the strategy adopted by those sampled.

Table 18. Characteristics of the sample plants in the main sample countries

	Germany	Italy	Spain	UK	Poland
Sample size	11	10	5	9	6
Capacity range of kilns in tonnes/day	800-5000	600-3000	900-3000	600- 3000	500-8000
Capacity range of plant in tonnes/day	2000-5000	1200-3000	2000-3000	1300-4000	1000-8000
Years of investment of kilns	1955-1995	1965-1992	1965-1996	1965-1998	1974-1999
Dry technology Semi-dry technology Wet technology	8 3	7 3	5 0	4 3 2	3 1 2
Multi-national National	7 4	6 4	4 1	8 1	6 -

THE STUDY CONSIDERED THE FOLLOWING LIST OF BAT

Process selection

The selected process has a major impact on the energy use in, 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 precalcination. The associated BAT heat balance value is 3000 MJ/tonne clinker.

General primary measures

BAT for the manufacturing of cement includes 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 for energy use. This can be achieved 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 precalcination 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 electrical equipment with high energy efficiency.

- Careful selection and control of substances entering the kiln can reduce emissions:
  - When practicable, selection of raw materials and fuels with low contents of sulphur, nitrogen, chlorine, metals and volatile organic compounds.

Oxides of nitrogen

BAT for reducing NO_x emissions is the combination of the general primary measures described above and:

- Primary measures to control NO_x emissions:
  - Flame cooling
  - Low-NO_x burner

- Staged combustion

- Selective non-catalytic reduction (SNCR – easier for dry kilns than for semi-dry kilns).

Staged combustion and SNCR are not yet used simultaneously for NO_x reduction.

Oxides of sulphur

BAT for reducing SO_2 emissions are the combination of the above described general primary measures and:

- For initial emission levels not higher than about 1200 mg SO_2/m^3:
  - Absorbent addition.

- For initial emission levels higher than about 1200 mg SO_2/m^3:
  - Wet scrubber
  - Dry scrubber.

Dust

BAT for reducing dust emissions are the combination of the above described general primary measures and:

- Minimisation/prevention of dust emissions from fugitive sources

- Efficient removal of particulate matter from point sources by application of:
  - Electrostatic precipitators with fast measuring and control equipment to minimize the number of CO trips
  - Fabric filters with multiple compartments and 'burst bag detectors'.

Collected Particulate Matter

- The recycling of collected particulate matter to the process wherever practicable, is considered to constitute BAT. When the collected dusts are not recyclable the utilisation of these dusts in other commercial products, when possible, is considered BAT.

METHOD OF CLASSIFICATION OF THE ENVIRONMENTAL PERFORMANCE OF SAMPLE PLANTS

The BREF document defines as a BAT-associated process a multi-staged preheater/precalciner with a heat balance of 3000 MJ/t. This heat balance was not reached by any of the plants sampled. However, 15 sample plants have a preheater/precalciner. Most of these were found in Italy, four each in Germany and the UK and one in Poland.

Since no sample plant achieves the BREF definition of the best available process and heat balance, "BAT plants" in this analysis were defined as those that achieved the BAT-associated emission levels for NO_x, SO_2 and dust. Plants that conformed with two of these levels are designated "middle performers" and those that satisfied just one or none of the limits are called "poor performers".

BAT-associated emission levels:
NO_x - 200 - 500 mg/m^3
SO_2 - 200 - 400 mg/m^3
Dust - 20 - 30 mg/m^3.

Of the 29 plants sampled in the *dry process* only 3 conform with the BAT-associated emission levels for dust, SO_2 and NO_x. All of them have precalciners and fulfil the BREF definition of a BAT process, except for the heat balance. One of the German sample plants has also implemented multi-stage-combustion and a de-SO_2 measure. All of them reach the NO_x level without any secondary NO_x reduction measure. See Table 19.

Table 19. Number of dry process technology plants by environmental classification.

Countries	BAT	Middle	Poor	All plants
Germany	2	5	1	8
Italy		6	1	7
Spain		1	4	5
UK	1		4	5
Poland		1	3	4
Total	3	13	13	29

The remaining sample plants are evenly distributed between middle and poor performers. The middle performers are mainly German and Italian plants. All exceed the BAT-associated NO_x emission range of 200 - 500 mg/Nm^3. All German plants have NO_x levels below 800 mg/m^3 (following national environmental regulation), while all the Italian plants sampled, with the exception of one plant which has multi-stage combustion, have emissions above this level.

All plants in the poor performing category exceed BAT associated NO_x and dust emission levels.

A count of the average number of BAT measures implemented by plants in each country is shown in Table 20.

Table 20. Average number of measures implemented (within the last 10 years) by sample plants in each country – dry process.

Type of BAT	Germany	Italy	Spain	UK	Poland
Average number of general primary measures per plant					
Expert system	0.8	0.6	0.6	0.2	0.
Automatic quality control	1.0	0.7	0.6	0.2	0.3
Precalciner	0.5	0.9	0:0	0.8	0.3
Modern clinker cooler	0.5	0.3	0.4	0.2	0
New or modernised mill	0.6	0.3	0.6	0.8	1
Raw material storage closed	0.8	0.3	0.2	0.2	0.3
Clinker closed	0.9	0.7	0.6	0.6	1
Paving, fugitive dust	1.0	0.7	0.4	0.2	0.3
Optimal fuel feeding	0.1	0	0	0.2	0.3
Optimal burning process	0.3	0	0	0.2	0.5
Continuous measurement	1.0	0.7	0.4	0.8	0.3
Average number of general primary measures per plant	**7.5**	**5.2**	**3.8**	**4.4**	**4.3**
Average number of NO_x primary measures per plant					
MSC	0.3	0.1	0	0	0
Low-NO_x burner/ flame cooler	0.9	0.6	0.6	0.6	0.8
Sum of NO_x primary measures	**1.2**	**0.7**	**0.6**	**0.6**	**0.8**
Sum of total primary measures per plant	**8.7**	**5.9**	**4.4**	**5.0**	**5.1**
Average number of secondary measures per plant					
SNCR	0.4	0	0	0	0
Absorbent addition	0.5	0.1	0	0	0
Wet scrubber	0	0	0	0.2	0
Sum of secondary measures per plant	**0.9**	**0.1**	**0**	**0.2**	**0**
Sum of all measures per plant	**9.6**	**6.0**	**4.4**	**5.2**	**5.1**
Number of plants	8	7	5	5	4

By far the greatest number of measures per plant have been installed in plants in Germany followed by Italy, the UK and Poland. Spanish plants have the lowest number per plant, even lower than their counterparts in Poland. The same sequence can also be observed when primary and secondary measures are distinguished.

NUMBER OF BAT-ASSOCIATED MEASURES IMPLEMENTED, WITH REGARD TO BAT CLASSIFICATION IN THE DRY PROCESS

Table 21 shows that there is only a small difference in the number of BAT implemented by 'BAT' and 'middle' performers as distinguished by their emissions.

Table 21. Average number of BAT-associated measures per plant (implemented within the last 10 years) classified according to BAT emission performance of plants.

Average number of BAT-associated measures	BAT performers	Middle performers	Poor performers
Sum of general primary measures per plant	6.7	6.2	4.0
Sum of NO_x primary measures per plant	0.6	0.8	0.8
Sum of total primary measures per plant	7.3	7.0	4.8
Sum of secondary measures per plant	0.7	0.5	0.1
Sum of all measures per plant	8.0	7.5	4.9
Number of plants	3	13	13

IMPLEMENTATION OF BAT IN THE SEMI-DRY/SEMI-WET TECHNOLOGY SAMPLE PLANTS

The 'BAT' performance of plants using the semi-dry/semi-wet process was classified in the same way: according to their emission levels with respect to NO_x, SO_2 and dust. These plants, on average, have poorer environmental performance, although they have fewer problems with NO_x.

Table 22. Number of plants in each environmental category in the Semi-Dry/Semi-Wet Process.

Countries	BAT	Middle	Poor	All plants
Germany	1	1	1	3
Italy	0	2	1	3
UK	0	0	3	3
Total	1	3	5	9

Table 22 above shows that only a single German plant qualifies as a ‘BAT’ plant. This plant has not invested in secondary measures to control NO_x emissions but has invested in primary measures.

EXPECTED ECONOMIC EFFECTS OF INDIVIDUAL BAT.

The BREF provides an overview of the impact of primary and secondary techniques on efficiency, emissions, the required investments and operating costs for NO_x, SO_2 and dust (see Table 23). Secondary BAT investments are in most cases of an end-of-pipe nature and increase operating costs.

The findings of the study confirm the data in the table. There is a wide variation in the capital and operating costs for each item of investment. The investment costs depend on the general condition of the existing equipment and whether and what additional items have to be implemented to achieve the most efficient use of the new investment.

Table 23. Pollution reduction techniques for the cement industry and their environmental and economic effects

NO_x Reduction Techniques	**Kiln systems applicability**	**Reduction efficiency**	**Reported emissions mg/m^3 [1]**	**kg/tonne [2]**	**Reported costs [3, 7] Investment**	**Operating**
Flame cooling	All	0-50 %			0.0 -0.2	0.0-0.5
Low-NO_x burner	All	0-30 %	400-	0.8-	0.15-0.8	0
Staged combustion	Precalciner				0.1-2	0
	Preheater	10-50 %	<500-1000	<1.0-2.0	1-4	0
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]
SO_2 reduction techniques						
Absorbent addition	All	60-80%	400	0.8	0.2-0.3	0.1-0.4
Dry scrubber	Dry	< 90%	<400	<0.8	11	1.4-1.6
Wet scrubber	All	>90%	<200	<0.4	6-10	0.5-1
Activated carbon	Dry	< 95%	<50	<0.1	15 [6]	no info.
Dust reduction techniques						
Electrostatic precipitators	All kiln systems clinker coolers cement mills		5-50 5-50 5-50	0.01-0.1 0.01-0.1 0.01-0.1	2.1-4.6 0.8-1.2 0.8-1.2	0.1-0.2 0.09-0.18 0.09-0.18
Fabric filters	All kiln systems clinker coolers cement mills		5-50 5-50 5-50	0.01-0.1 0.01-0.1 0.01-0.1	2.1-4.3 1.0-1.4 0.3-0.5	0.15-0.35 0.1-0.15 0.03-0.04
Fugitive dust abatement	All plants		-	-	-	-

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) for NO_x and SO_2: investment cost in 10^6 euros and operating cost in euros/tonne of clinker, normally referring to a kiln
capacity of 3000 tonnes 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 tonnes 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
6) this cost also includes an SNCR process, referring to a kiln capacity of 2000 tonnes clinker/day and initial emission of 50-600 mg SO_2/m^3
7) for dust: 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 tonnes clinker per day and initial emission up to 500 g dust/m^3
source: BREF (March 2000)

Most of the general primary measures trigger reductions both in production costs (often through lower energy and electricity consumption) and in air emissions, enough to justify the investment costs (see Table 24).

Table 24. General primary measures for the cement industry and their environmental and economic impact.

General primary measures	**Unit production costs**	**Air emissions**	**Clinker quality**
Process control optimisation	Decreased	Decreased	Improved
Modern, gravimetric solid fuel feed system	Decreased	Decreased	Improved
Preheating and precalcination to the extent possible	Decreased	Decreased	Improved
Modern clinker coolers	Decreased		Improved
Heat recovery from waste gases	Decreased	Decreased	Improved
Power management systems	Decreased	Decreased	Improved
High energy efficiency of electrical equipment	Decreased	Decreased	Improved
Use of raw materials and fuels with low contents of pollution	Mostly increased	Decreased	Mostly improved

Source: own observations and BREF (March 2000)

FUTURE BAT INVESTMENTS AND THEIR EFFECTS

Dry technology

Sample plants were asked about their investment plans. Most plants were concerned about a required reduction of NO_x, particularly if the emission level is set at 500 mg/m^3. The second main concern is with dust reduction measures. The following tables show that a variety of measures are planned for the reduction of emissions generally. SNCR and wet scrubbers are end-of-pipe measures and are expected to have a negative impact on profitability. See Table 25 for the expected effect of BAT investments on the economic performance of sample plants using dry technology and Table 26 for plants using semi-dry/semi-wet technology.

Table 25. Impact of future BAT investment on business performance in the dry process.

	Type of BAT	No. of plants	Effect on business
NO_x reduction measures	Exchange of burner	2	Slightly negative
	Flame cooling	1	Neutral
	Expert system	2	Beneficial
	Alternative fuels	3	Beneficial
	Precalciner and alternative fuels	2	Beneficial
	SNCR	5	Negative
SO_2 reduction measures	Wet scrubber	1	Negative
Dust	Bag filters	1	Higher operation costs
	EP	1	Negative but necessary
Optimisation of process	Expert system	2	Beneficial
	Improved process	1	Beneficial
	Change in transport system	2	Beneficial

Table 26. Impact of future BAT investment on business performance in the semi-dry/semi-wet process.

	Type of BAT	No. of plants	Effect on business
NOx reduction measures	Exchange of burner	2	Neutral
	Expert system	2	Beneficial
	Alternative fuels	2	Beneficial
	SNCR	1	Negative
Dust	EP	1	Negative but necessary
Optimisation of process	Expert system	2	Beneficial
	Process improvement	3	Beneficial
	Energy management system	1	Beneficial
	New mill	1	Beneficial
	New kiln	1	Beneficial

IMPACT OF BAT ON THE COMPETITIVENESS OF PLANTS WITHIN THE EU

Dry technology

On average, the German and Italian sample plants have strong environmental performance and have implemented more BAT measures than their counterparts in the UK or Spain. German plants have remained profitable despite higher environmental costs and relatively poor productivity resulting from slack demand. Similarly, Italian plants operate at satisfactory levels of economic performance.

IMPACT OF NO_x REDUCTION MEASURES

While only three plants reach BAT (conforming with the BAT-associated emission levels for NO_x, SO_2 and dust), none of these uses secondary measures to control NO_x.

However, German plants are required to reduce NO_x emissions below 800 mg/m^3; 40% of them use SNCR to achieve this. This leads to an increase in operating costs of 0.3-0.5 euros per tonne and investment of 0.5-1.5 million euros. In addition, strict SO_2 legislation requires absorbent additions in 50% of German and 10% of Italian sample plants. The operating costs for these measures are 0.1 to 0.4 euros per tonne with an investment of 0.2-0.3 million euros.

These additional costs explain why German and Italian plants stress that environmental costs are a major competitive disadvantage. But despite these costs, German and Italian plants are as profitable as their counterparts in the other Member States studied. They also continue to invest. The environmental cost disadvantage is in part balanced by the use of alternative fuels: all German and 30% of Italian plants used alternative fuels, thereby reducing fuel costs. In addition, German and Italian plants have invested more in BAT-associated primary measures and have low fuel and electricity consumption per tonne of cement.

Semi-dry/semi-wet technology

Sample plants using the semi-dry/semi-wet technology have implemented no secondary measures. German and, to a lesser extent, Italian plants have implemented primary measures, while UK plants, the third country compared in this part of the analysis, have implemented the fewest initiatives.

With the implementation of IPPC many of the semi-dry/semi-wet plants will also have to consider secondary measures. For some plants this will be either costly or technically difficult and closure will be expected.

ENVIRONMENTAL INITIATIVES AND COSTS IN POLAND

While environmental regulations in states adjacent to the EU are less stringent, in Poland modernisation programmes and the expectation of EU membership (and therefore the need to comply with the IPPC Directive) has led to much investment by (usually foreign owned) cement companies. Plants have introduced more primary measures than their counterparts in Spain. Secondary measures for dust reduction are accepted as standard requirements. These investments have been made despite competitive pressures from lower-cost producers behind the Polish eastern border. Secondary measures for NO_x and SO_2 have not yet been implemented in Poland. There are, however, few problems with SO_2. Where plants do not invest in NO_x reduction measures, they will enjoy a cost advantage over their EU counterparts. The competitive advantage is small, however, given transport costs to the EU.

Threat of imports from non-European countries

Of much concern to EU producers are cheap imports from South-East Asia, Africa and non-adjacent Eastern European countries. Managers claimed that for this reason they cannot afford secondary measures. However, the implementation of secondary measures has been cost neutral for those European plants investing in primary measures and using the cheaper alternative fuels.

FACTORS INFLUENCING BAT PERFORMANCE

The analysis shows that certain factors influence the implementation of BAT measures (see Table 27). Certain equipment and methods lead to or facilitate BAT implementation or performance. The factors favouring the implementation of BAT are listed below:

1. Stricter national regulations lead to an early installation of BAT-related investments.
2. New plants and modernised plants are built with many BAT-associated primary measures and adhere to BAT-associated dust reduction standards.
3. Investment costs per tonne for BAT measures are lower for large than for small units.
4. Precalciners lead to lower emissions and are considered standard technology for new dry-process plants.
5. Multi-stage-combustion optimises the input of energy into the kiln.
6. New investment in equipment and processes for improvement and modernisation also improves economic as well as environmental performance.
7. Continuous measuring of emissions leads to:
    a) more optimal burning and reduced emissions
    b) faster and more frequent response to process irregularities and therefore reduced emission levels.
8. Continuous improvement leads to better control and optimisation of processes and reduction of emissions.
9. Expert systems lead similarly to continuous improvement and better control and optimisation of processes.
10. International ownership is associated with modernisation of processes and BAT-related measures (except where these are required by regulation).
11. Better skills are required for process control and lead to a reduction of emissions.
12. Alternative fuels are an offsetting cost advantage.

Table 27. Factors influencing BAT performance

Favouring	**Neutral**
Stricter national regulations	Labour productivity
New plant	Price/cost relationship; sales per head
Large kilns	EMAS/ ISO 14000
Precalciners	Age of kiln
Multi-stage combustion	Location
High annual investments	
Continuous measuring	
Continuous improvement	
Expert systems	
International ownership	
Skills	
Alternative fuels	

The following factors, which were expected to influence the implementation of BAT, were found to be neutral

1. Labour productivity levels
2. Price/cost, sales/head and profitability
3. EMAS and ISO 14000
4. Age of kilns if continuously updated and well maintained
5. The location of plants within Member States

Factors that hindered implementation of BAT were in general the opposite of the favouring factors. Three factors are of particular importance. One is small kiln size, because environmental costs tend to be inversely related to size in this industry. The second is a lack of modernisation of plant and equipment. Where these two factors co-exist, implementation of BAT is likely to lead to closure. The third is technology; for example, for long and lepol kilns.

CONCLUSIONS

Analysis of cement plants using dry technology shows that those that have already implemented BAT are economically viable (although there is no example of a plant that has reached the NO_x level of 500 mg/m^3 using SNCR). Sample plants using semi-wet/semi-dry technology face costly or technically difficult investments in secondary measures. The wet process is very energy-intensive and is no longer an economical production method. Wet technology plants face closure irrespective of their environmental performance.

A number of factors were identified that affect the ease and cost of the take-up of BAT. These include the degree of previous regulation, modernity, technology, size, skills and form of ownership. In addition, those plants that have implemented secondary measures (especially in Germany) were favoured by an above-average use of cost-reducing primary measures and the use of cheaper alternative fuels. Given this array of advantages associated with BAT implementation, the impact of BAT on the industry will depend on how IPPC is implemented in Member States.

Time for planning investments is important not only because current investment is long-lived but also because the plants that already lag behind require more time to fulfil environmental requirements. Implementation and sequencing of environmental improvements should also consider the possibility of minimizing total environmental costs through use of primary measures and alternative fuels.

THE NON-FERROUS METALS STUDY

INTRODUCTION

At least 42 non-ferrous metals plus ferro-alloys and carbon and graphite are produced in the EU and are used in a variety of applications in the metallurgical, chemical, construction, transport and electricity generation/transmission industries.

Non-ferrous metals are produced from a variety of primary and secondary raw materials. Primary raw materials are derived from ores that are mined and then further treated before they are metallurgically processed to produce crude metal. The treatment of ores is normally carried out close to the mines. Secondary raw materials are indigenous scrap and residues, which may also undergo some pre-treatment to remove coating materials.

In Europe, ore deposits containing metals in viable concentrations have been progressively depleted and few indigenous sources remain. Most concentrates are therefore imported from a variety of sources worldwide.

Recycling constitutes an important component of the raw material supplies of a number of metals. Copper, aluminium, lead, zinc, precious metals and refractory metals, among others, can be recovered from their products or residues and can be returned to the production process without loss of quality in recycling. Overall, secondary raw materials account for a high proportion of the production, thus reducing the consumption of raw materials and energy.

The product of the industry is either refined metal or what is known as "semis" or semi-manufactured material, i.e. metal and metal alloy cast ingots or wrought shapes, extruded shapes, foil, sheet, strip, rod etc.

The structure of the industry varies metal by metal. No companies produce all non-ferrous metals although there are a few pan-European companies producing several metals, e.g. copper, lead, zinc, cadmium.

THE SECTORS STUDIED

The study focuses on five products and the impact of BAT on plants producing those products:

1. Production of copper cathodes from primary raw materials. There are 4 primary smelters in the EU and all were studied. This sector competes directly with smelters that operate on a worldwide basis.

2. Production of copper from secondary raw materials. There are 6 secondary smelters in the EU and 4 were studied. This sector again operates against strong international competition.

3. Production of aluminium ingots from secondary raw materials. There are 80 secondary smelters in the EU and 13 were studied. This sector also operates against strong international competition.

4. Production of lead ingots from secondary raw materials. There are 30 secondary smelters in the EU and 6 were studied. The market for lead is now very closely linked to lead-acid battery demand.

5. The recovery of salt slag and the production of Waelz oxide. There are 17 plants in the EU and 11 were studied. These sectors have developed as a waste treatment facility for parts of the non-ferrous metals industry. Waelz oxide is a crude form of zinc oxide produced by the treatment of electric arc furnace dust from the steel industry. It is an important route for the recycling of secondary zinc and represents the largest source. Other sources of secondary zinc are normally recycling by galvanizers or small plants designed for the treatment of zinc residues.

IPPC REQUIREMENTS

The BAT requirements for the non-ferrous metals industry can be summarised by a number of common requirements: storage and handling of all materials; pre-treatment of materials; process control; management and supervision of all of the stages; the production process used; the collection of fumes and gases (prevention of fugitive emissions); the air abatement plant used; water and effluent; residues and waste and energy efficiency/recovery.

These ten BAT factors that apply to the industry in general are summarised in Table 28.

Table 28. BAT factors, investment cost and impact.

BAT factor	Example	Investment cost €	Economic characteristic	Impact cost (–ve)/benefit (+ve)
1–Storage & handling	Enclosure	100000 to 200000	Prevents up to 5% loss of raw material	Negative to neutral
2-Pretreatment	Swarf centrifuging	120000	10% increase in throughput	Positive
3–Process control	Interactive system	100000	10% increase in productivity	Positive
4–Management and supervision	Environmental system	50000	Productivity increase	Positive
5–Metallurgical process	Metal pumping system	300000	10% increase in yield	Positive
6–Fume collection - Enclosure - Hooding - Moltentransfers	Increased fan capacity	50000	Ongoing operating cost	Negative
	Furnace enclosure	200000	Dust recovered	Negative
	Intelligent dampers	50000	Dust recovered	Neutral
	Launder system	100000	Dust recovered	Neutral
7–New or upgraded abatement of - Dust - SO_2 - VOC	Change of EP to fabric filter	1000000	Ongoing operating cost	Negative
	Modern bags	100000	6-month payback	Positive
	Scrubber	1000000	Ongoing operating cost	Negative
	Afterburner	500000	Ongoing operating cost	Negative
8–Wastewater treatment	Change of reagent to NaHS	50000	Equal operating cost	Neutral
9–Process residues	Greater mixing in furnace	20000	Residue reduced to 30%	Positive
10–Energy - Efficiency - Recovery - O_2	Oxy-fuel burners	50000	Reduction in gas volume and 30% increase in capacity	Positive

Note: The BAT factors are frequently inter-dependent.

FOCUS ON FUGITIVE EMISSIONS

The relatively good standard of existing air and water abatement systems means that extensive investment in new or replacement abatement installations is not a priority for most plants in the industry. More importantly, there are significant variations in the effectiveness of fume capture and the extent of fugitive emissions in the sector. Fugitive emissions often represent the major environmental impact as well as a health and safety issue. Implementation of IPPC and the implementation of BAT are therefore likely to focus on controlling the process well and making incremental changes in gas extraction systems. Improvements in fume capture might need higher capacity fans or better control of the gas volumes caused by process surges.

The main effect of IPPC in this sector will be to reduce air emissions from non-captured or fugitive sources.

Several of the BAT factors focus on the "front end" of the process. The techniques are aimed at improving material storage and handling and increasing efficiency by reducing process variations and therefore the potential for fugitive emissions. Such techniques can also improve productivity performance.

THE IMPACT OF BAT ON EXISTING PROCESSES AND COMPETITIVENESS

Method for measuring BAT

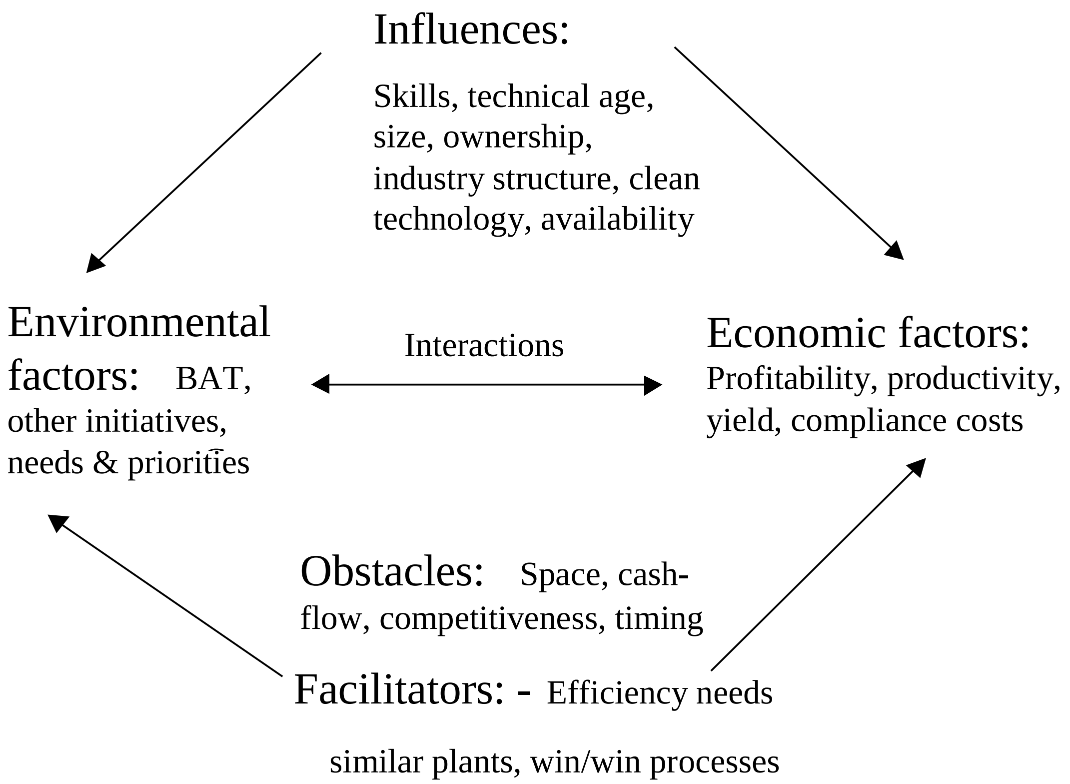
An experienced regulator who also has industrial process experience conducted interviews and made the assessment and judgements of the impact of BAT on the competitiveness of sample plants using an environmental assessment methodology and a questionnaire.

The environmental assessment procedure is based on the Operator Performance and Risk Assessment (OPRA) methodology, which has been used in the UK for more than 5 years. The scheme marks environmental standards against a number of headings, which include the BAT factors. The factors are scored out of 5. The use of BAT achieves a score of 4. Other important criteria that can influence the environmental and economic performance of a plant are also measured using this methodology and are reported as factors influencing the take-up of BAT, positively or negatively.

Factors influencing environmental and economic performance

The environmental performance of a plant is the sum of the scores on each of the BAT factors measured using the OPRA methodology. This is compared with the economic performance of the plant defined primarily as productivity performance and metal yield. A number of factors that may influence the BAT 'score', e.g. national regulation, are also measured and compared. All the factors considered in the study are shown diagrammatically in Figure 4.

Figure 4. Factors considered when measuring the environment and economic performance relationship.



Plants sampled

The sample includes primary and secondary copper plants, secondary aluminium plants, secondary lead plants and the associated processes for the recovery of salt slag and production of Waelz Oxide (crude zinc oxide). The range of sizes of sample plants is representative of the non-ferrous metals industry as a whole in the EU and, importantly, includes SMEs. See Table 29.

Table 29. Site visits for the sectors studied.

Metal Produced	No of plants in EU	No of plants visited
Primary copper	4	4
Secondary copper	6	5
Secondary aluminium	50	17
Secondary lead	30	11
Salt slag	10	7
Waelz oxide	7	4

FINDINGS ON RELATIONSHIP BETWEEN ENVIRONMENTAL AND ECONOMIC PERFORMANCE

Companies that have developed their environmental standards, have already exploited cleaner technology and have adopted effective methods for controlling the process also have a competitive advantage. The observations on site confirm that these companies not only have high environmental standards but also have higher productivity and lower energy usage. These companies are profitable and report that they foresee no problems in implementing IPPC. Figures 5 and 6 show this positive relationship. This result is not surprising, as the underlying principles of IPPC are to reduce the consumption of energy and raw materials. Increases in yield will produce more metal for a given operating cost, improve profitability and will prevent emissions of waste products to all environmental media.

Figure 5. Secondary aluminium - productivity and strength of BAT.

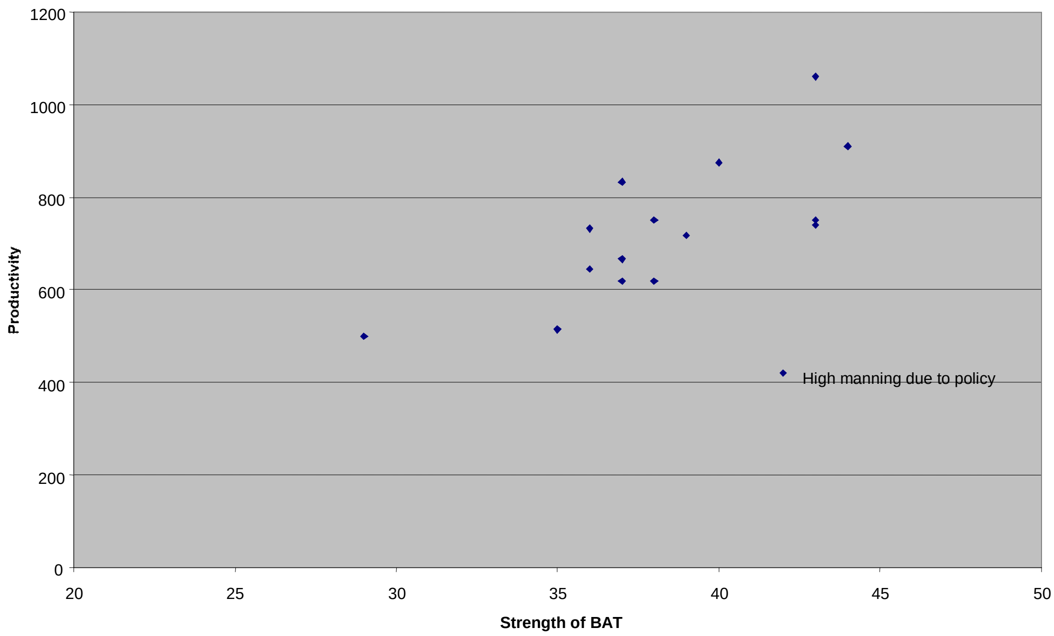
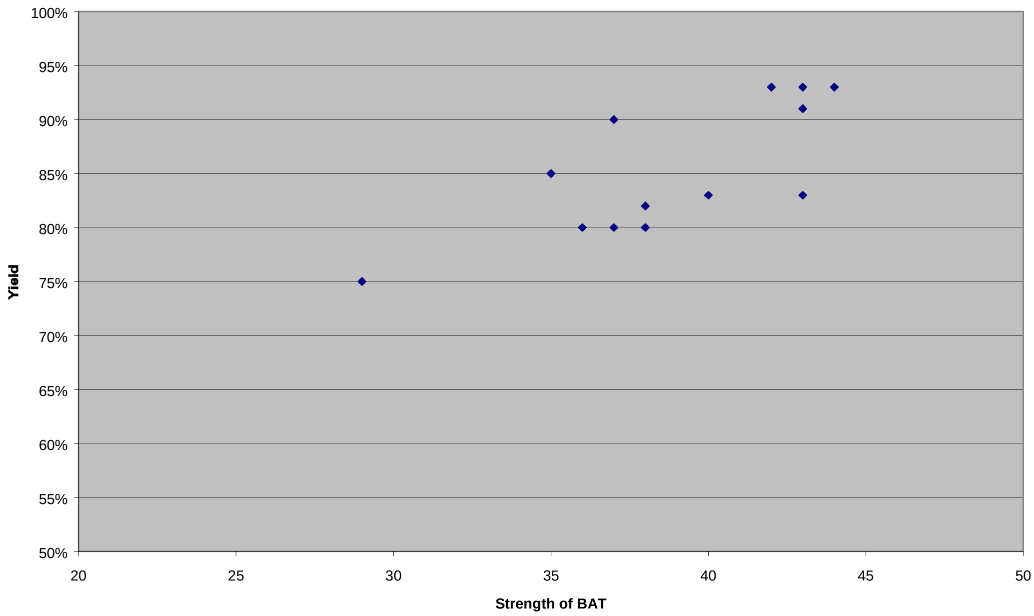


Figure 6. Secondary aluminium - strength of BAT and yield.



ADDITIONAL COSTS ARISING FROM IMPLEMENTATION OF IPPC

The site visits revealed that many companies in the sector are using elements of BAT and most companies are already using satisfactory process and abatement plant. The absent BAT factors are those relating to the collection of process gases and control of the process (e.g. management and operator skills). Differential compliance costs for IPPC will generally be low because the missing factors can be corrected with minimal capital expenditure.

Table 30 lists differential costs for the uptake of IPPC that have been quoted by the companies or calculated from the costs available. The estimates are based on the environmental assessment methodology and anticipate the implementation of all of the BAT factors.

Differential impact due to IPPC	**Motivation driver and obstacles**	**Work needed**	**Effect on emissions**	**Likely project cost €**	**Effect on productivity**	**Economic effect**		**Capital and running cost.**
						Margin	**Yield**	
Improved fan capacity	Some fugitive emissions	Increase fan capacity by 25000 m^3/h	Reduction of fugitive emissions	120000 = 1.2 €/t over 5 years	No change	- 2 €/t*	No effect	1 €/t* 50 kWh
Optimisation of extraction	Small fugitive emissions	Survey and adjustment of extraction.	Reduction of fugitive emissions	Minor	No change	No change	No change	Minor effect
Optimisation of extraction	Some fugitive emissions	Survey and adjustment of extraction.	Reduction of fugitive emissions	Minor	No change	No change	No change	Minor effect
No anticipated costs	Use of all BAT factors	None	No reduction needed.	Nil	No change	No change	No change	No change 8 companies in the sample.
Improved fan capacity	High level of fugitive emissions	Increase fan capacity by 50000 m^3/h	Reduction of fugitive emissions	240000 = 0.6 €/t over 5 years	No change	- 2 €/t*	No effect	1 €/t* 100 kWh
Reduced gas volume	High level of fugitive emissions	Use of oxygen if feasible	Reduction of fugitive emissions	Minor	Increase possible	+ 2 €/t	No effect	< 1 €/t
No effect likely effects on Employment and Skills. * Based on increased electricity usage								

Table 30. Likely impact of IPPC on a selection of sample plants.

FACTORS FACILITATING IMPLEMENTATION OF BAT

Although there is a correlation between BAT, good environmental performance and productivity/yield, the result is influenced by a number of other factors that have enabled companies to achieve good economic and environmental performance. These factors are shown in Table 31. These are factors that are also shown as correlates of economic performance, see Table 32.

Table 31. Factors influencing the take-up of BAT and environmental performance.

Effect on environmental performance			
Metal sector	**Factors that help**	**Factors that are not important**	**Factors that have a negative effect**
Primary copper	Innovation in process development, Skills, Technical age.	Stringency of regulation, Size	Lack of prioritisation Timing
Secondary copper	Innovation in process development, Skills, Technical age.	Stringency of regulation, Size	Lack of prioritisation Timing
Secondary lead	Innovation in process development, Skills, Technical age	Stringency of regulation, Size	Lack of prioritisation Timing
Secondary aluminium and salt slag processing	Innovation in process development, Skills, Technical age	Stringency of regulation, Size	Lack of prioritisation Timing

Table 32. Factors influencing the competitiveness of plants.

Effect on competitiveness			
Metal sector	**Factors that help**	**Factors that are not important**	**Factors that have a negative effect**
Primary copper	Innovation in process development, Skills, Technical age, Timing of projects	Stringency of regulation, Size	Location with respect to raw material and market
Secondary copper	Innovation in process development, Skills, Technical age, Timing of projects	Stringency of regulation, Size	Location with respect to raw material and market. Policy of parent company.
Secondary lead	Innovation in process development, Technical age, Skills, Timing of projects	Stringency of regulation, Size, EMS	Location with respect to raw material and market
Secondary aluminium and salt slag processing	Innovation in process development, Technical age, Skills, Timing of projects	Stringency of regulation, Size, EMS	Location with respect to raw material and market. Strength of local customer base.

During the site visits it was apparent that a group of “front end” factors that relate to how a process is managed, developed and controlled is very important in differentiating between good and poor performers at both an economic and environmental level. These factors include the technical age of the process and a number of skill factors that include training, innovation, operator competence, management and supervision and the elements of maintenance.

There is a strong influence of *technical age* on economic and environmental performance. The successful development of furnaces and processes, which reduces *technical age,* are in turn strongly influenced by the level of innovation employed by a company.

A large number of process improvements have been made by companies using high levels of *innovation and skills* to solve problems. They improve productivity, competitiveness and environmental performance. All of the projects have used in-house skills and knowledge. Without appropriate focus the presence of these skills and knowledge alone does not necessarily improve a company's competitiveness and environmental performance.

The site visits have shown that companies with higher productivity have more elements of BAT because the processes have been optimised and are therefore well controlled. The use of analysis, blending and automatic feeding systems is common in these companies. The use of these techniques minimizes fugitive emissions.

Size of the company and ownership were found not to be important and SMEs were equally successful in environmental and economic issues. Size of the installation (throughput of metal) did, however, have a positive effect on productivity. The use of EMAS did not affect environmental performance but this may be due to the relative newness of the scheme.

Companies at risk from IPPC have fallen behind in the development of their processes and face above-average differential compliance costs. These companies have much lower productivity and efficiency than the average and have not optimised their processes.

ENVIRONMENTAL COSTS AND COMPETITIVE ADVANTAGES AND DISADVANTAGES FOR FIRMS

Companies reported their competitive advantages and disadvantages as follows:

Main advantages:

- labour quality, efficiency, process control, knowledge of process and reject rate
- price, quality of products and marketing
- transport charges and markets
- scale and raw material price
- flexibility (raw materials, products and general)
- environmental cost and image.

Main disadvantages:

- transport
- environmental cost
- raw material type and price
- products and scale
- location
- inability to use difficult raw materials.

The environmental cost disadvantage reported in 6 cases refers to existing legislation. Significantly, the companies that thought that environmental costs were a disadvantage were not using all (or even most of) the BAT factors and were less efficient performers. Companies that reported environmental costs as an advantage are using all the BAT factors.

WORLDWIDE COMPARISONS

The study also examined the costs of production and environmental performance worldwide in the production of primary copper. This shows that the EU is not at a cost disadvantage despite maintaining high environmental standards. This is a consequence of strong process development and the use of innovation at the EU sites.

METHODS FOR IMPROVING THE WORST PERFORMERS

In most cases, important environmental improvements arise primarily from the "front end" of the process, followed by the development of the process itself. Skills and the way that they are directed can be used by medium and poor performers to improve both of these elements.

In cases where under-designed gas collection is the main issue, process improvements can reduce gas volumes to a level that is acceptable, but some plants need to up-rate fan sizes and possibly the size of abatement plant.

The study has shown that SMEs are not necessarily at a disadvantage. Many SMEs have a higher degree of flexibility to adapt their processes. They also have an important degree of innovation potential when technically qualified senior management is closely involved with day-to-day operations. They may, however, suffer a disadvantage in obtaining funding for improvement work.

The improvement of skills is an area where many companies have had success by adopting established systems. Many of these improvements relate to management issues. For example, the use of a Meister (a high level supervisor of the process), the incorporation of management techniques such as Investors in People (IIP) and the implementation of Total Quality Management (TQM) have been successful.

The implementation and development of an Environmental Management System may also help in the longer term. The improvements identified by such a system can allow priorities to be set and successful projects to be planned and carried out.

Both companies and regulators can use the methodology developed for the study. Using this, they can identify the areas that need to be improved, the techniques that are available to give the improvement, the factors influencing the implementation of those techniques and the obstacles involved. The factors can then be used to establish the priorities for a particular site and a timetable for improvement can then be agreed.

CONCLUSIONS

BAT plants are plants with high environmental standards, high productivity and low energy usage. These companies are also profitable and foresee no problems arising from the implementation of IPPC Comparisons of environmental performance and costs of production worldwide in the primary copper sector show that the EU is not at a cost disadvantage despite maintaining high environmental standards.

Many companies in the sector are using elements of BAT. The absent BAT factors are those relating to the collection of process gases and control of the process. Differential compliance costs for IPPC will generally be low.

The correlation between BAT, good environmental and plant economic performance is influenced by a number of other factors that have facilitated the implementation of BAT principles.

The important factors are technical age of the process and a number of skill factors including training, innovation, operator competence, management and supervision and the elements of maintenance.

Companies at risk from IPPC have fallen behind in the development of their processes and face higher than average differential compliance costs. These companies have much lower productivity and efficiency than the average and have not optimised their processes. The study shows that in most cases environmental improvements arise primarily from the "front end" of the process, followed by development of the process itself. Skills and the way that they are directed can be used by medium and poor performers to improve both of these elements.

The methodology developed for this study can be used to identify areas where improvement is required and how it can be achieved. This will facilitate the establishment of priorities and a timetable for improvement.

THE PULP AND PAPER STUDY

INTRODUCTION

Selected products

This study investigates the impact of BAT on the competitiveness of plants producing three different but important products of the pulp and paper industry:

- kraft pulp, produced from fresh fibres,
- copy paper, produced from pulp and
- white line chipboard (WLC), produced from recycled fibres.

Globally and in Western Europe, bleached kraft pulp accounts for over 20% of all paper and board making fibre.

Wood-free uncoated paper and cartonboard are important segments of the paper and board industry. Copy paper comprises 30 % of global and 40 % of Western European production of wood-free uncoated paper, whilst WLC accounts for 40 % of global and 30 % of Western European carton board production.

Important producers

Important world producers of kraft pulp are the US, Canada, Japan, Finland, Sweden and Brazil. The main copy paper producers are the US and Japan while, in the EU, the major suppliers are Finland, Sweden and France. WLC, made from recycled fibres, is produced in a number of countries with no one country dominating the market. The most important suppliers are Japan, South Korea, Indonesia, Taiwan, Germany and Italy.

EU and international trade

A major concern is the threat of imports from countries with lower environmental stringency and environmental costs. International trade in the three selected products was as follows:

Bleached kraft pulp from North America and South America are important sources of imports to the EU while, within Europe, intra-EU trade in pulp is more important than the export of pulp internationally.

Imports of *copy paper* to the EU are from South America, Asia and the US and, while these imports are relatively small, they are increasing. Exports from the EU are also small, and expected to decrease. Within the EU, there are significant flows of trade from the Nordic countries to Central Europe and within Central Europe.

Unlike the other two products, EU exports of *WLC* are more important than imports. Most of these exports are to Asia and Australia and these flows are stable. The less significant flow to South East Asia is decreasing due to strong local competition from Indonesia, Taiwan and Korea.

The BAT studied

Table 33 shows a list of the relevant BAT for reducing emissions to water and air, used in this study. They are taken from the BAT reference document (BREF).

Table 33. BAT considered in the analysis.

	Bleached kraft pulp		White line chipboard		Paper	
	Water	**Air**	**Water**	**Air**	**Water**	**Air**
1	Dry debarking	Incineration of concentrated malodorous gases	Recycling of process water	Co-generation of heat and power	Recycling of process water	Co-generation of heat and power
2	Modified cooking	Incineration of diluted malodorous gases	White water clarification and recycling within the paper machine	Low-NO_x-technology	Control of potential disadvantages of closing the water systems	Low-NO_x technology
3	Highly efficient brown stock washing	Mitigation of TRS emissions	Counter-current flows of white water between units.	Usage of low sulphur fuel or controlling sulphur emissions	A balanced white water, filtrate and broke storage system	Usage of low sulphur fuel or controlling sulphur emissions
4	Oxygen deligni-fication	Control of SO_2 emissions from the recovery boiler	Flotation and recycling of white water from de-inking plants	Using renewable sources to reduce fossil CO_2 emissions	Reduce frequency and effects of accidental discharges	Using renewable sources to reduce fossil CO_2 emissions
5	ECF/TCF	Control of NO_x emissions from the recovery boiler	Equalisation basin and primary treatment		Reuse of clean cooling and sealing waters	
6	Reuse of conden-sates	Control of NO_x emissions from the auxiliary boiler	Aerobic biological treatment (de-inking mills)		Separate pre-treatment of coating waste waters	
7	Spill moni-toring	Control of SO_2 emissions from the auxiliary boiler	Anaerobic and aerobic biological treatment (non de-inking mills)		Substitution of potentially harmful substances	
8	Sufficient black liquor evaporation	Electrostatic precipitators	Partly recycling of biologically treated water (non de-inking mills)		Secondary/ biological treatment of waste water	
9	Reuse of cooling waters		Treating internal water circuits (biological, membrane filtration, ozonation)			
10	Primary treatment					
11	Secondary treatment					

Note. All air BAT are the same for white line chipboard and paper production. For the water BAT, clarification and recycling of process water and white water respectively are common aspects for board and paper production.

MEASUREMENT OF THE IMPACT OF BAT ON COMPETITIVENESS

Measurement of the impact of BAT on the competitiveness of plants in the three sectors is based on two approaches. The first is a micro study, which examines the impact of BAT on individual plants. The second is a macro approach, which estimates the number of mills at risk in the industry, following a strict implementation of the directive.

MICRO APPROACH

Sample mills

The target was to sample mills on the basis of their existing environmental and BAT performance. In practice, little is known about the environmental performance of individual plants, hence sampling was based on country environmental regulatory stringency, data on emissions where available, knowledge of industrial associations, help from individuals and industry directories.

Within Europe, sample companies were drawn from: Sweden, Finland, Portugal and Spain for bleached kraft pulp; France, Sweden, Portugal and Spain for paper; and Italy, Germany, Spain, Austria and Sweden for WLC. In addition, competitor mills in Canada, the US and Brazil were also sampled in the kraft pulp sector.

Emissions to water and air and the number of BAT implemented for air and water are used to classify mills into environmental performance categories (“A” strong, “B” medium and “C” weak environmental performers). Table 34 shows the number of mills sampled by environmental performance category.

Table 34. Number of mills sampled by environmental performance, product and location.

	EU			Canada	Brazil
	Pulp	Paper	WLC	Pulp	Pulp
A mills	5	3	5	1	1
B mills	5	2	5	3	2
C mills	1	-		3	-
Total number of mills	11	5	10	7	3

Impact of individual BAT on the profitability of plants

Managers were asked to report on a wide range of factors associated with the implementation and use of individual BAT, including investment and running costs, driver for the initiative, effects on processes, capacity, economic and environmental performance, training requirements etc..

Table 35 shows the impact of individual BAT on profitability. Three BAT had a negative impact on profitability (primary and secondary treatment and the mitigation of concentrated malodorous gases) at all mills. These BAT are all end-of-pipe measures and have been driven by regulation. However, there are four BAT (modified cooking, oxygen delignification, mitigation of TRS and reduction of SO_2 from the recovery boiler) that have a significantly different economic impact on A mills from the one they have on B/C mills. A major reason is probably that the implementation of these BAT was driven by regulation at the B/C firms, while A mills undertook these investments as part of the development of their mills. Consequently, the A mills managed to achieve a positive overall economic return from the investment while the B/C firms experienced a negative one.

Table 35. Impact of BAT on profitability of mills in the EU (kraft pulp).

	A mill Regulation-driven investment	**A mill Non-regulation-driven investment**	**B/C mill Regulation-driven investment**	**B/C mill Non-regulation-driven investment**
Positive impact on profitability		Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO_2 from the RB Dry debarking, Brown stock washing, Evaporation	Brown stock washing, Evaporation	Dry debarking,
Neutral impact on profitability	Control of NO_x from RB,	Reuse of condensates, Spill monitoring, Reuse of cooling waters, Electrostatic precipitators	Reuse of condensates, Spill monitoring, Control of NO_x from RB, Electrostatic precipitators	Reuse of cooling waters,
Negative impact on profitability	Primary treatment, Secondary treatment, Concentrated malodorous gases,		Primary treatment, Secondary treatment, Concentrated malodorous gases, Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO_2 from the RB	

Similarly for the producers of the other two products, WLC and copy paper, most producers report end-of-pipe BAT as having a negative impact on economic performance. For WLC, three water BAT (separation and recycling of process water, clarification and recycling of white water and counter-current flow of white water) have a negative impact on the profitability of B/C plants (in contrast to A plants). Also in paper making, two BAT (recycling of process water and reuse of clean cooling waters) have a negative impact on profitability at B/C mills and a positive impact on profitability at A mills. Hence, the experience of implementation of process integrated BAT differs between A and B/C mills.

Environmental costs and competitive advantages and disadvantages

How important is environmental cost among mills' competitive advantages and disadvantages? All mills were asked to specify their competitive advantages and disadvantages. Environmental costs were not in general considered an important competitive disadvantage.

In the production of *kraft pulp*, the most commonly stated competitive advantages were quality, variety (especially in Northern Europe) and environmental image. No A mill reported environmental costs a competitive disadvantage while one B/C mill did. Product price, cost, proximity to customers and distribution costs were the main disadvantages noted by pulp mills.

Producers of *WLC* claimed cost, quality, variety and production efficiency as important competitive advantages. In addition, two "A" mills located in Northern and Central Europe reported environmental image as a competitive advantage. While environmental cost was seen as a drawback by one of the Central European "A" mills, another claimed these costs were low and not a problem. Labour supply and marketing were noted as key disadvantages by individual mills.

In *paper making*, competitive advantages included quality, variety, efficiency and service. One "A" mill reported that environmental costs incurred in the EU might become a disadvantage in comparison to potential competitors in the US, South America and Indonesia in the future. Reported disadvantages included distribution costs, lack of economies of scale and lack of mill integration.

Competitive threats from outside the EU

Competitor pulp-producing mills in Canada and Brazil were sampled for this part of the study. Data were collected on their environmental and economic performance and compared with those of BAT producers in the EU. The key question is: Are "A" mills disadvantaged relative to their Canadian and Brazilian competitors because of differences in BAT? The findings were as follows.

CANADA

The competitive strategy among Canadian mills is very much focused on pulp characteristics. Because of the features of the wood fibres used, the pulp is of very high and competitive quality and this is an important competitive advantage. However, the cost of the wood is also high.

Mills sampled have on average a lower environmental performance than their European counterparts, especially on the water side. That is why there are more mills classified as C mills in the Canadian sample and, on average, regulatory limits and mill emissions are slightly higher than those of comparable mills in Europe. They also use fewer BAT than EU firms, especially on the air side. On the water side, modified cooking is often missing and on the air side, control of NO_x and SO_2 lag.

The mills visited have a higher technical age and lower productivity and have experienced slower growth rates than their EU counterparts. These are important reasons for a lack of competitive advantage over their EU A mill counterparts, despite their somewhat lower environmental performance.

Most BAT adopted by Canadian mills have been installed for cost reduction reasons and are accordingly being experienced beneficially by business. These BAT include efficient brown stock washing, oxygen delignification, reuse of condensates, effective spill monitoring, sufficient black liquor evaporation, reuse of cooling waters and electrostatic precipitators. ECF, on the other hand, (elemental chlorine-free bleaching) was more often regulation-driven in Canada than in Europe. Many mills felt a market pressure from paper mill customers in Europe to implement BAT environmental initiatives and their environmental performance is affected by environmental trends in EU. They also feel pressure to comply with the US cluster rules.

Canadian mills do not see the IPPC directive or the US cluster rules as an opportunity to take over markets from the EU or US. Nor did any EU mill consider Canada a potential threat as a result of the IPPC directive. This was for a mix of reasons including distance from customers, a shortfall in current environmental performance required by customers, productivity and mill age. The main economic threat is from new and large mills in Brazil, which because of their low age already have most BAT and moreover have a low production cost. This threat is considered further below.

BRAZIL

Three competitor mills were sampled in Brazil. They are large relative to their European counterparts. They are also young, follow a competitive strategy of cost-leadership and have high productivity. They have low production costs and are highly profitable. Exports are an important share of their output and the main destination for these exports is Europe.

Their main competitive advantage is the use of eucalyptus for pulp production. The trees are harvested on large plantations and wood costs are low.

Their main competitive advantages over counterparts in Portugal and Spain (who also use eucalyptus) are a higher eucalyptus quality and lower cost (due to lower wood and labour costs). With increasing replacement of long fibres by eucalyptus, they also compete with mills in the Nordic countries. Their advantage in the latter case is lower cost. Relative to Europe, their competitive disadvantage is principally their location, which results in high distribution costs and possibly a lower customer service.

Water BAT

All the mills visited have all the water BAT. Generally, the emissions of COD and AOX are low and in the same range as the very best European mills, while BOD is slightly higher than the top performers in the EU. TSS is a weak point; the level is markedly higher than the average value of their EU counterparts. On total P and total N, they have similar values to good European mills.

Almost all water BAT observed were installed at the time of expansion in the mid-nineties. Investments made in new technology most often resulted in improved process efficiency and environmental performance; the contrary was never reported. In general, the driver for improved environmental performance has not been regulation, but market pressure – mostly from Europe – combined with a desire generally to meet international regulation and eco-labels standards and, of course, to obtain cost savings. For example, the water BAT improved competitiveness, market position and public image. With the exception of end-of-pipe BAT, the introduction of BAT almost always reduced running costs and enhanced profitability.

Air BAT

On the air side, the emissions for two of the mills are low, not only in comparison to their EU competitors, but also in comparison with the BAT-associated levels in the BREF. However, one mill has high levels of all air emissions.

The number of BAT used for air emissions differs. No mill controls NO_x and one lacks control of SO_2 from the auxiliary boiler. The economic consequences of BAT used depended on whether the driver for implementation was cost reduction and/or increase in capacity (which normally resulted in reduced costs) or other drivers, which raised costs. However, changes in production cost were not significant and profitability was in no case said to be affected, neither positively nor negatively.

Total emissions
One of the mills visited has low emissions for both water and air, i.e. it reaches the BAT-associated levels in the BREF document. This is categorized as an “A” mill in the micro level study. Another mill also reaches very good (BAT standard) emissions on the water side while having high emissions on the air side. The third mill only manages medium emission levels to water while being very good on the air side. These latter two are labelled B mills. All three mills are currently expanding production and introducing new technology. Their emissions are therefore expected to decrease further in the future.

The future
The three mills have growth plans. Two are already constructing new lines while at the same time updating older lines. All new capacity will be used for market pulp and will be targeted across existing markets. The driver for the expansions has not been a cost advantage derived from differential regulatory stringency, in fact the environmental performance of these Brazillian mills is already strong. Their environmental performance is importantly influenced by customer demands, the IPPC directive, the US cluster rules, and an expectation of regulation tightening in Brazil in the future.

Characteristics and economic performance of A mills in the EU

Comparisons for each product were made between “A” and “B/C” mills in the EU. These comparisons sought to test whether the technical and economic characteristics of “A” mills differed. In kraft pulp and paper making, “A” mills in comparison with B/C mills are found to have technical and economic strengths. Important differences were as follows:

Kraft pulp:
- The majority of “A” mills in the sample are large mills.
- The average age of “A” mills is lower than that of B/C mills.

- “A” mills tend to have higher productivity.
- “A” mills have experienced higher growth rates than B and C mills.
- Most “A” mills reported that mill updating and environmental improvement were undertaken together.
- “A” mills are more actively involved in R&D and use it to undertake environmental improvements.
- “A” mills employed above-average skilled personnel.
- Production cost was not linked to environmental performance.
- “A” mills have been more strictly regulated than their B/C counterparts and this (with the anticipation of regulation) has pushed their environmental performance forward.

White line chipboard:

- “A” mills have more research and development on site than the “B” mills and they claim that R&D affects their environmental performance in a positive way.
- “A” mills had invested in BAT in more recent years than their B/C counterparts.
- Small and medium-sized mills can be found among both groups of performers, i.e. among “A” and “B” mills. Thus size does not seem to be as important for WLC mills as for pulp producers.
- There was no significant difference in the technical age between A” and “B” mills. It is possible to make the right investments on old machines in order to reduce emissions.
- There was no relationship between productivity and “A”or “B/C” status.
- Growth was not correlated with environmental performance and/or “A”,”B/C” status.
- Production costs were not related to environmental performance.

Paper:

- “A” mills have a higher productivity performance than their counterparts in the “B/C” group producing the same grade.
- Mills with high volume growth implemented more BAT and reached lower emissions than mills with stable production or little growth.
- “A” mills were shown to explicitly use R&D to solve BAT-related issues.
- The top environmental performers had a strong skill base.
- “A” mills had invested in BAT in earlier years than their B/C counterparts.
- Mill size is not related to environmental performance.

- There was no significant difference in the average age of the paper machine between “A” and “B/C” mills.
- There was no link between exports and environmental performance.
- Ownership was mixed for “A” mills. The results do not indicate a disadvantage for independent mills.
- “A” mills were found in all studied regions, while the “B/C” mills tended to be located in Central and Southern Europe.

MACRO APPROACH

For this study, the impact of BAT on the competitiveness of all EU mills in the three sectors has been estimated using a different methodology by pulp and paper consultants Jaakko Pöyry.

By using their database and in-house expert knowledge of individual mills, mills were divided into four categories according to whether they achieved above- or below-average environmental and cost performance respectively. The percentage of EU mills in each category is shown in Table 36.

Table 36. Percentage of EU mills with above or below average environmental and cost performance.

	Good economic performance & good environmental performance A	Poor economic performance & good environmental performance B	Good economic performance & poor environmental performance C	Poor economic performance & poor environmental performance D
Kraft pulp	60	25	5	10
White Line Chipboard	30	10	45	15
Copy paper	45	35	10	10

Vulnerable mills are those in Group D, with poor cost and environmental performance. While these mills can improve by moving from D to A, this group of poor economic performers will have to make substantial investments in the face of BAT and is vulnerable to closure.

Furthermore, Jaakko Pöyry estimated the competitive capacity outside the EU using the same criteria. Displacement of weak EU capacity is forecast to arise from some low-cost and strong environmental performers in Asia, Latin America and North America and there is significant competitive capacity in these regions as shown in Table 37.

Table 37. Low cost and good environmental performance capacity in competitor countries (%).

	Kraft pulp	White Line Chipboard	Copy paper
Asia	40	45	45
Latin America	30	-	40
North America	10	-	10

Finally, estimates were made of the number of mills in Europe that are endangered by the introduction of IPPC because of economic and technical weaknesses in general. Hence, while such mills predominate in column D in Table 36, they can also be located in columns A to C. The results (Table 38) show that between 15% and 20% of the total number of Western European mills are endangered.

Table 38. Percent of western European Mills endangered by IPPC.

	% mills endangered
Kraft pulp	15
White line chipboard	20
Copy paper	15

CONCLUSIONS

To summarise, while there is no evidence that BAT disadvantaged those mills that have already implemented the techniques, it does not follow that other mills can implement BAT as successfully. The economic impact of BAT on individual mills is tightly linked to the mill’s past competitive performance and technical characteristics, especially, in this study, in the kraft pulp and paper sectors. Hence, for example, mill size, age, productivity level, growth and R&D capacity have been shown to be factors which can be important in minimizing the cost of the implementation of BAT.

The characteristics of vulnerable mills have also been identified and these include mill age, size, product cost and quality, and a current environmental performance which is below average.

The findings point to the need for a prudent approach in order to retain economic viability. For example, viability is likely to be related to careful planning and timing and the need to sequence BAT implementation to make the best use of business opportunities for investment. The most successful firms are already good at this planning, while others might need help to find the optimal solution for them.