Beyond Regulatory Compliance

Incentives to improve the environmental performance of IPPC installations
(ENV.C.4/SER/2005/0034r)
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EXECUTIVE SUMMARY

The IPPC Directive aims at minimising pollution and other environmental impacts from various industrial sources throughout the European Union. Operators of industrial installations covered by the IPPC Directive are required to obtain a permit from the authorities in the EU countries. New installations, and existing installations which are subject to “substantial changes”, have been required to meet the requirements of the IPPC Directive since 30 October 1999. Other existing installations must be brought into compliance by 30 October 2007. This is the key deadline for the full implementation of the IPPC Directive for existing installations.

Additional incentives or instruments, like taxes or voluntary programs, could be used to encourage firms to go beyond (IPPC) permit requirements and to enhance the dynamic nature of the BAT concept. Instruments to achieve environmental objectives are rarely used as ‘stand alone’ measures. Often a mix of instruments such as taxes and regulatory relief, in combination with the more traditional ‘command and control’ approach, is used to regulate industries. In the EC countries the industries need licenses or permits to operate. The permits specify the upper limits on the amount of polluting emissions. Voluntary programs, charges and taxes are aimed, certainly from the point of view of the authorities, to achieve performance better than these upper limits set in the permit.

The main aim of this study is to identify and assess tools or instruments that encourage IPPC firms to change their behavior and to innovate and perform beyond regulatory compliance (BRC). The main research questions that have been extracted from this are:

1. Which measures, tools etc. create incentives for companies to perform BRC?
2. In which context were these measures and tools successful (or not)?
3. What are the main incentives for companies to go BRC?
4. What is the effectiveness of the measures concerned?
5. What is their interaction with the IPPC Directive?

The specific relationship with the IPPC Directive and the hands-on experiences with the instruments within the environmental permitting context have not been addressed in many research projects and literature. Looking into some specific instruments now has assessed the context, incentives, effectiveness and fit with the IPPC directive. The specific instruments that have been studied included:

1. Environmental charge on NOx emissions in Sweden.
2. Performance Track in the US.
3. Green network in Denmark.
4. Solvent tax in Switzerland and France.
6. Looking at four major emerging technology developments.

Incentives to improve environmental performance BRC

Incentives such as public recognition or regulatory flexibility, which give more freedom to the company to decide about measures, and in particular economic drivers such as cost reduction and compensation, are really necessary for the ‘real’ participation of companies. Only then improved performance and even performance beyond the regulatory limits sometimes be can found. For example the Dutch covenants, for

\footnote{Voluntary approaches for environmental policy, OECD 2003.}
the Chemical, Steel, Paper & Pulp and other sectors, often have stricter targets than those set in the permits in order to achieve major reduction steps. Not all of these environmental targets are met by the industry. The industrial associations conducting the negotiations with the authorities agreed upon a more flexible approach. These companies use this flexibility to make their own more suitable environmental plans, sometimes including R&D for innovative measures. The Cyclone Converter Furnace development is an example of this. You could say that this ‘carrot’ (i.e. flexibility) for the companies was needed for the covenants to succeed. Subsidy is another ‘carrot’ that can be mentioned which is also part of a relatively commonly used policy package. Subsidies can stimulate the development of innovative technologies and can make polluters voluntarily abate their emissions. Although it must be said that the subsidy in itself is not always ‘carrot’ enough to be decisive for companies to start new developments such as emerging technologies like the developments of the Integrated Gasification Combined Cycle (IGCC) in the energy industry, and the Cyclone Converter Furnace (CCF) development in the steel industry. Additional external incentives, such as public pressure, and internal incentives, such as top management engagement, often appear to be necessary for that.

Exemption from taxes and refunding of environmental charges proves in some cases, for instance in countries such as Sweden and Switzerland, to give incentives for environmental improvements, beyond what is required in the permit, and give the companies more financial resources to undertake research and development for innovations. At the same time it must be said that this tax advantage was in many situations just one of the incentives for the companies’ ‘good’ environmental behavior. The threat of (future) regulations and other cost considerations (prices of fuels and raw materials) often seem to play at least an equally important role.

The primary incentives for setting up the Energy Efficiency programs in different countries are both economic and environmental factors. The reduction of Greenhouse gases is a particularly significant factor, as these are high on the political agenda in the EC countries. Prompted by stimulation measures and agreements with (most often) the governments, energy-consuming companies have developed methods, organizational as well as technical, to reduce energy consumption. In some cases this government intervention is more regulation oriented such as in Slovenia, in other cases it is more voluntary based such as the benchmarking initiative in the Netherlands. In both situations examples can be demonstrated of companies that are taking measures that are beyond the average of the sector.

Private companies, authorities and public partners can work together in networks to achieve higher sustainability in the fields of environment, social commitment and occupational health and safety. The participation in networks can be seen as a driver for companies to join environmental improvement programs. The key words for such networks are voluntary agreement, dialogue, sharing facilities and commitment. The extent to which the network is voluntary, is setting targets and is inspecting compliance to its criteria for participation, will impact the results achieved with it. Both the Green Network in Denmark and the Performance Track program in the U.S. are putting a lot of emphasis on the companies’ environmental management system (EMS). As a result of this the EMS of these companies are well organized. The level of organizational innovations is relatively high for these companies. However the technical level of environmental improvements slightly lags behind this. In many cases the technical efforts of the companies significantly decrease when the relative ‘low hanging fruit’ has been picked. Due to the well-organized EMS continuous environmental improvement, often just step by step, is generally guaranteed.
Correlation with the IPPC Directive and conditions to be effective

The complementary character of the tax instruments appears to fit well to national and international regulations such as the IPPC directive. In some cases such as the NOx charge in Sweden the organizational structure is set up fully independently from the competent authorities. The system appears to operate very well in parallel. It is thought to be crucial though to have sufficient environmental expertise available in the tax organization to achieve optimal functioning of the system. With regard to this the different tax systems in Sweden, Swiss and France can be compared. In the former two countries, in contrast to France, where the customs are involved, all or most of the parties involved with the financial instruments have a lot of specific environmental expertise. This is thought to be essential for the smooth working of their particular systems.

In the Netherlands the government has decided to achieve its goals via instruments such as the energy efficiency initiatives in cooperation with the industry rather than implementing laws describing specific measures. In principle this works well and also fits well with the IPPC directive. Voluntary instruments that are not linked in any way to environmental regulation appear to give too much freedom to the companies and will in general not lead to significant environmental improvements, but rather result in small improvements and to measures that sometimes could be seen as beyond regulatory compliance (BRC).

The IPPC Directive is based on several principles, such as prevention of environmental pollution and/or pollution control based upon application of best available technologies (BAT), an integrated approach, flexibility, and public participation. For all of the instruments as described in the case studies no real barriers to the operation of complementary tools were found. Although some small conflicts were mentioned such as the different (inter-) national environmental reporting requirements and the complexity and interference of different (energy) regulations, not one of them is really obstructive to one of the IPPC principles. Some instruments however appeared to fit better to the main IPPC principles (networking programs are fitting very well with the integrated approach) than others (energy efficiency, taxes and charge instruments). However, the latter instruments seemed to result in more significant environmental impacts, in many cases beyond regulatory compliance.
1 INTRODUCTION

1.1 Background

The European Union has a set of common rules for permitting and controlling industrial installations in the IPPC Directive of 1996. In essence, the IPPC Directive is about minimising pollution and other environmental impacts from various industrial sources throughout the European Union. Operators of industrial installations covered by Annex I of the IPPC Directive are required to obtain a permit from the authorities in the EU countries.

New installations, and existing installations which are subject to "substantial changes", have been required to meet the requirements of the IPPC Directive since 30 October 1999. Other existing installations must be brought into compliance by 30 October 2007. This is the key deadline for the full implementation of the Directive for existing installations. The IPPC Directive is based on several principles, namely (1) an integrated approach, (2) best available techniques, (3) flexibility.

1. The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. The purpose of the Directive is to ensure a high level of protection of the environment taken as a whole.

2. The permit conditions including emission limit values (ELVs) must be based on Best Available Techniques (BAT), as defined in the IPPC Directive.

3. The IPPC Directive contains elements of flexibility by allowing the licensing authorities, in determining permit conditions, to take into account the technical characteristics of the installation, its geographical location and the local environmental conditions.

The IPPC Directive is based on a dynamic concept in view of the definition of BAT, where BAT can change over time due to new technological developments and their introduction into the market. However, in practice, once an IPPC permit has been issued, and depending on the approach taken by the relevant competent authority, some operators may take a minimal and static approach to ensuring that the conditions of the permit are complied with in a strict sense. In encouraging firms to go beyond such regulatory (i.e. IPPC or other environmental legislation) requirements and to enhance the dynamic nature of the BAT concept (thereby also supporting innovative environmental technologies) additional incentives or instruments could be used. The main aim of this specific project is to identify and assess tools or instruments that encourage IPPC firms to change their behavior and to innovate and perform beyond regulatory compliance.

This project is part of the review of the IPPC Directive launched by the Commission. For more information about the review and the other projects, see http://forum.europa.eu.int/Public/irc/env/ippc_rev/library. The report does not necessarily represent the views of the Commission.
1.2 Objective, scope and approach of the Beyond Regulatory Compliance study

The primary objective of this project is to assess measures that have been or could be taken to encourage or assist companies that operate IPPC installations to go beyond regulatory compliance, as laid down in their permits and, thereby to improve their environmental performance. This includes assessment of the influencing factors that drive companies’ behaviour towards improved environmental performance compared to permit conditions and how different tools act on these factors.

The main objective of this study is to present and assess the current instruments being used in this context. The outcome of the project could be used by the Commission as well as Member States and other stakeholders. It should provide a broad picture of instruments being used to encourage operators towards improved environmental performance. This project should be seen as an information exchange and the sharing of experiences on such practices. It will inform in a broad sense the IPPC review process.

The expression “beyond regulatory compliance” (BRC) should be seen in this light and is interpreted as follows:

**Performing BRC is seen as taking steps to reduce emissions or other environmental impacts such as energy use and prevention of waste, within the context of a dynamic BAT concept and beyond what is necessary to comply with permit conditions or some other legal obligations.**

Ways or means for industries to perform BRC are for example developing and/or using innovative techniques or so-called Emerging Technologies (ET), or carrying out improvement activities through participation in voluntary programs. Authorities, but sometimes also industry (sectors), use different tools and instruments to promote performance BRC. These instruments can be voluntary or more regulatory/legislative orientated. Financial instruments like subsidies can also be used to stimulate industries to develop innovative technologies in order to improve their environmental performance beyond what is required in the permit.

It is acknowledged that it is not always straightforward to assess if a company is performing BRC or that it is just keeping some operational safety margins to the required permit levels. What is important is to share information on instruments and incentives for companies that drive (IPPC) companies to innovative activities and/or new investments for further improvement of their environmental performance. In other studies such as the REMAS a more statistical elaboration and analysis have been conducted. Here a more quantified base provides evidence that adoption of accredited environmental management systems (EMAS and ISO14001) by IPPC companies (cement, (in)organic chemicals, LCP, paper & pulp) lead to an overall improvement in operator performance and environmental outcomes. In this BRC study no statistical analysis will be done. The findings from literature and interviews will be presented as general indications.

The main activities of the BRC project have been a desk study, including an in-depth literature study, and conducting case studies, including interviews, focusing on potential BRC tools for IPPC companies.

Against this background the main research questions of the BRC project are:

1. Which measures, tools etc. create incentives for companies to perform BRC?
2. In which context were these measures and tools successful (or not)?
3. What are the main incentives for companies to go BRC?
4. What is the effectiveness of the measures concerned?
5. What is their interaction with the IPPC Directive?

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2 REMAS, analysis of initial sample data for the UK, R. Salmons, Environment Group Policy Studies Institute, Oct. 2004
6. Is the IPPC Directive considered as a barrier to such measures and, if so, how could it be improved if necessary?

It is explicitly not the objective of the project to:

• Propose initiatives to require companies to perform BRC;
• Propose to amend the IPPC Directive to tighten its legally required standards.

The main activities of the BRC project have been a desk study, including an in-depth literature study, and conducting studies, including interviews, focusing on potential BRC tools for IPPC companies.

1.3 Reading guide

The influencing factors that drive companies’ behavior, which lead to innovations and make companies perform BRC is discussed in chapter 2. A short overview of the most common and applied instruments, tools, programs, and plans to promote performance BRC and the use of innovative technologies are given in chapter 3. In chapter 4 six case studies looking at six different concrete instruments are discussed in more detail in order to give real-life examples of good and bad practices of company’s performance beyond what is or should be necessary according to their IPPC-permit. One of these case studies will focus on emerging technologies (ET). In chapter 5 the findings in this study are discussed and main conclusions will be drawn.
2 INFLUENCES ON COMPANIES BEHAVIOR

2.1 Introduction

This chapter presents a discussion of influences on companies' behavior, which may lead them to innovate and/or perform BRC, and on which BRC tools may therefore seek to act. We offer a conceptual framework, which is leading for the further analysis of instruments leading to BRC performance and/or innovative development. This conceptual framework is based on literature review.

2.2 Conceptual framework

Improvements in environmental performance are affected by the mindset and behavior of the industries concerned. These factors can be influenced through incentives, drivers and removing barriers that have an effect on industries’ environmental decision-making. Incentives and drivers can be translated in specific measures, tools or instruments. The company has a central position in all this (figure 1).

Fig 1. Influencing the mindset and behavior of operators of IPPC installations that could result in performance BRC.

The effect of specific instruments however is depending upon a broad pallet of internal and external factors. An instrument will be effective when influencing these factors in such manner that the outcome of the adaptation and implementation of that specific instrument consists of – possibly among other positive outcomes – improved environmental performance.

3 Note: in this study instruments, tools and measures are used as within one category and can be replaced by each other.
Relevant factors for influencing mindset and behavior of operators are for example cost cutting, market share, commitment of employees, image/reputation. Environment as such is sometimes no or a minor factor in some industries’ decision-making. Influencing the industries’ behavior in order to achieve (continuous) improvement of environmental performance, drivers and motivations to go BRC have to be assessed.

Incentives or motivations are related to external and internal drivers and barriers. Culture, top-level management commitment, norms and ethics are examples of internal drivers or barriers, influencing the outcome of the interaction of a specific instrument. External drivers and barriers are legislation/regulation, administrative frameworks, the role of NGO’s or other stakeholders such as governments, international agreements, etc. All these factors have to be taken into account in assessing the effectiveness of certain instruments. They play a major role as well in the identification and selection of instruments that are – in a particular situation – able to relate to drivers and take away barriers.

A remark has to be made: as many instruments have the effect of promoting both compliance with regulations, compliance beyond regulations and possibly innovation, the discussion of the instruments and their influence in this report may address all aspects, although primarily focussed on performance beyond regulatory compliance. In the specific case of innovation, one of the major drivers has been shown to be regulation, but it should be clear that this is not the focus of the study which is instruments that promote performance beyond regulation, therefore, per definition, not including regulation.

2.3 Incentives

Regulated enterprises have a diversity of motivations and incentives for environmental innovation and performance BRC such as market factors, cost savings, new technologies, external pressures, environmental campaigns, internal pressures and company policy. In addition, innovative attitude can be stimulated through regulations. It cannot be assumed that deterrence (command and control) is the principal weapon available to regulators and policy makers. Other motivational drivers are equally important. These include costs and profits, the effects of negative publicity, informal sanctions and shaming, incentives provided by various third parties, the significance for private enterprises of maintaining legitimacy (license to operate) and the necessity to maintain co-operation and trust etc.4

However the main incentives for companies, especially for small and medium enterprises (SMEs)5, could still be considered cost reduction and economics. These are for example the pressure to maintain liquidity, the emphasis on short-term profit, and the pressure resulting from economic marginality as specifically products on a saturated market have only small margins between production costs and market price.

Market and image incentives are also important for environmental innovation. These are more relevant for large enterprises because the task of regulating large enterprises is very different from that of controlling the behaviour of SMEs. Many large companies are reputation sensitive.

5 SMEs belong to a category of companies that is often difficult to influence and are for this reason important for this study.
They have become aware that damage to their corporate image caused by poor environmental performance can undermine their share value, prejudice their standing with governments and thereby threaten investment opportunities, bring unwanted attention from regulators, and risk the appeal of environmental groups and local communities (example: disposal of Brent Spar by Shell\(^6\)). In contrast also positive public recognition is an important driver for companies for good performance. Examples of these will be given later on in the report.

Inputs and outputs from (other) firms across other industries can influence innovation. In many sectors there are possibilities of commercial power along the supply chain that can be directed in the interest of environmental protection. Larger enterprises, in particular, may be able to impose product and process preferences on other enterprises, using their market power to influence the behaviour of upstream suppliers and downstream buyers. Supply chain pressure thus offers a valuable means of influencing the environmental behaviour of especially small and medium sized enterprises (SMEs).

The POPA\(^7\) study\(^8\) looks into drivers, barriers and policy contexts for cleaner technologies in the sectors transport, agriculture, energy and industry. The following categories – adopted from an OECD study of B. Long\(^9\) in 1997 – are given:

- Information-based tools such as awards/recognition; public information and education; life-cycle analysis; environmental accounting and reporting; eco-audit and management; product labelling; right to know; negotiated environmental agreement; and regulatory reform.
- Incentive-based instruments are liability rules; public procurement rules; pro-environmental rules; subsidy removal; marketable permits; eco-taxes and tax reforms.
- Direct regulation are environmental impact assessment; trade restrictions; ambient, emissions and technical standards; licensing and permitting; and (purchase) obligations or bans.

Next to these tools the POPA study identified the determinants of industry’s innovation; such as perceived environmental risk; perceived economical risk; perceived market pressure; perceived community pressure; perceived regulatory pressure; technical capabilities; organisational learning; strategic alliances; and networks of collaboration. For example the adoption of new technologies by firms, is – not surprisingly - dependent upon their profitability. Frequently cited benefits of adopting new technologies are savings of raw materials and energy, higher quality of products, increased capacity and efficiency gains. Regarding market pulls, consumers with high environmental awareness and the need to look for niche markets are driving forces for innovations. Stakeholders, inside or outside the firm, can create a pull for innovation as well; likewise top-level management is important in setting a context of sustainable entrepreneurship.

Drivers of change in European industries are of relevance for the context within which industries operate and eventually adopt new technologies. Relevant developments are amongst others globalisation and increasingly competitive business environment, sustainability and environmental issues, societal values and public acceptance of technology, and the regulatory environment and the system of European governance.

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\(^6\) Shell proposed to sink the oil platform into the sea, instead of dismantling the platform and transporting the remainders – waste – to the shore. Environmental groups rose against this plan, as they perceived sinking a less environmental friendly alternative. Shell finally adjusted it’s plans, pressed by this groups and protecting its image.

\(^7\) Acronym for Policy pathways to promote the development and adoption of cleaner technologies

\(^8\) Source: POPA documents on ec.europa.eu/research

\(^9\) B.L. Long, Environmental regulation: The third generation
Different instruments are influencing these determinants and contexts positively or adversely. The POPA study concluded that instruments have each their natural lifespan and place in the innovation cycle; and therefore various combinations of instruments will have to be put in place depending upon actors, markets, technologies and country contexts.

**Box 1. Example of innovation due to public procurement initiatives:**

A study of the Fraunhofer Institute\(^\text{10}\) analysed existing rules and current practices of public innovation procurement in the 15 EU-Member States, Australia, Canada, Norway and USA. Nine examples of good practices for concrete procurement activities are given, such as lightning system in Hamburg (DE), regional transport system in Zaanstreek (NL) and energy saving procurement in Italy. Especially the latter indicates the mechanisms influencing energy production plants (LCP) in optimising energy consumption and resource management.

In July 2002 the first national frame contract for provision of heating services to a large number of public buildings was signed for a period of 5 years. According to the companies involved the frame contract triggered innovations for modernisation of the (LCP) plant in order to comply with the requirements of the contract and national legislation. In addition, the contract stimulated the companies to search for technological innovations to further improve the performance of the plants, such as low temperature plants and incorporation of burn control, thermo-regulation control and wireless control features. Main overall results of this procurement contract were savings of energy expenditures, modernisation of heating plants, pulling down CO₂ emissions, and acquisition of market leader position.

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\(^{10}\) Fraunhofer Institute for Systems and Innovation Research; Innovation and Public Procurement: Review of Issues at Stake, 2006.
3 INSTRUMENTS & PROGRAMS

3.1 Introduction

Within a broader policy context, the European Union's focus has been on sustainable development since 1993 with the entry into force of the EU Treaty. This Treaty added the concept of "sustainable growth respecting the environment" to the European Community's tasks and wrote the precautionary principle into the article on which environment policy is founded. In 1997 the Amsterdam Treaty strengthened the EC's involvement in sustainable development, stating sustainable development as one of the Union's tasks and as an overarching objective of EU policies. In 2001, at the Gothenburg Summit, EU leaders launched the first EU Strategy on Sustainable Development. Beside the Gothenburg European Council, EU's Sixth Environment Action Programme (6EAP) and the Environmental Technology Action Plan (ETAP)\(^\text{11}\), provide a policy framework for the development and dissemination of new environmental technologies. Regulations, e.g. the IPPC Directive and REACH, are complemented by market-based and voluntary instruments on a European or national level, like the greenhouse gas trading scheme, green taxes, environmental management systems and eco-labeling.

A review of studies\(^\text{12}\) conducted in US, Australia, and Europe have been looking at policies that have been or could be used to improve environmental performance of larger and smaller industries. The main conclusions from those studies are summarized as follows.

Internal and external drivers are the most important influences in environmental decision-making. External drivers are civil society (NGOs, consumers et cetera), business-to-business relations (suppliers and customers) and financial stakeholders (shareholders, investors). Internal drivers on the other hand are top-level commitment, economics, individual ethics and company culture (see also 2.3.).

From the studies reviewed the conclusion is drawn that there is evidence to suggest that government initiatives, mandatory disclosure and industry partnerships are particularly effective at influencing environmental performance. Examples of these voluntary approaches are Environmental Management Systems (EMS), voluntary agreements (VA) or policy mixes. An Environmental Management System – as categorized by these researchers as a voluntary instrument – tends to focus more on improved management processes rather than environmental performance; but helping firms manage their efforts in reaching their environmental targets as well. The effectiveness of voluntary agreements is – not surprisingly - reliant on the stringency of the targets. The researchers conclude that thorough and in-depth studies are needed to effectively design and implement policies or policy mixes influencing environmental decision-making. In particular, they emphasize the need to look further into influencing the internal drivers of industries and corporate cultures.

Various economic instruments can be related to environmental performance improvement as well, such as emissions trading, environmental taxes, charges and deposit refund schemes, environmental tax and fiscal reform, subsidies, support schemes and green purchasing, and liability and compensation. Fiscal instruments like environmental taxes have the advantage that, as they lead to internalization of external costs in prices, there is always an incentive for operators to reduce emissions even beyond binding emission limit values (BRC).

\(^{11}\) Sources: COM (2004) 38 final and National ETAP Roadmap The Netherlands
\(^{12}\) Sources: Improving business environmental performance; Corporate incentives and drivers in environmental decision making, Arthur D Little, Defra, 2006
Therefore the regulatory approach of IPPC and the use of taxes and charges can be complementary. Another favorable argument pro financial instruments is that companies often have more knowledge and know-how than the authorities, and therefore are in a better position to identify cost effective measures to reduce emissions.

3.1.1 Categories of instruments for innovation and performance BRC

The JRC and DG Enterprise study on innovation\(^\text{13}\), ‘How should we study the relationship between environmental regulation and innovation’ (May 2000), concludes that between countries there exist differences in terms of the availability, acceptability and use of policy instruments for achieving politically or administratively determined environmental goals. These differences are likely to have implications for the nature, source and timing of technological responses (innovations). When looking at the different instruments the following categories can be determined:

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<th>Direct regulation</th>
<th>Economic/financial instruments</th>
<th>Communicative and voluntary instruments</th>
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<tr>
<td>- product standards</td>
<td>- pollution (effluent) taxes</td>
<td>- information provision/publicity</td>
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<td>- pre-market approval</td>
<td>- product charges</td>
<td>- covenants (environmental agreements)</td>
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<td>- product bans</td>
<td>- emissions trading</td>
<td>- technology compacts</td>
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<td>- process performance standards</td>
<td>- environmental subsidies</td>
<td>- network creation</td>
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<tr>
<td>- technology specifications</td>
<td>- deposit-refund systems</td>
<td>- environmental management systems</td>
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<tr>
<td>- environmental management requirements</td>
<td>- producer responsibility</td>
<td>- environmental labels</td>
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<td>- take back requirements</td>
<td>- environmental liability</td>
<td>- environmental marketing</td>
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Based upon OECD (1989, 1997b) and Kemp (1997)

Regulation

It is also stated in the report that most studies reveal the basically positive effects that regulations have on the development of environmentally relevant innovation activities. The achievement of these effects depends on the appropriate regulation intensity, and on an effective implementation and monitoring of the directives, which has to fit the techno-economic context, and tip the balance of economic decision-making in order to have a decisive and beneficial effect. In general stakeholders see regulation as the most direct and significant incentive for companies to improve their environmental performance.

The other instruments identified, i.e. economic instruments and communicative and voluntary instruments, influence innovation as well as performance with or beyond regulatory compliance.

\(^{13}\) European Commission JRC-IPTS and Enterprise DG, How should we study the relationship between environmental regulation and innovation’ (May 2000)
Box 2. Examples from the BEST study:\textsuperscript{14}

The Lisbon Strategy's focus is at improving industries’ competitiveness, ensuring economic growth, jobs and environment. With this strategy Member States (and the European Union) are required to search for opportunities to “cut red tape”, i.e. reduce administrative burden, and improve regulation. DG Enterprise and the BEST Expert Group started in 2004 a study to identify best practices of simplification of regulation, which resulted in a report presenting 33 recommendations for Member States and the Commission on taking forward simplification actions; and 76 examples of concrete actions taken to streamline and simplify regulation. The examples given are categorised as follows: simplification of permit schemes; simplification of monitoring or reporting; simplification of inspection; use of information technology tools and electronic systems; risk-based and incentive driven approaches; and compliance assistance and support mechanisms. As best practices are often focussing on regulations, only a few examples are most relevant for this study; i.e. OPRA in UK and Ireland; water tax reform in Belgium (Flanders); and EMAS regulatory relief in Portugal. OPRA is described in more detail in paragraph 3.8; and the water tax reform is a financial instrument and a further explanation of this and financial instruments in general is given in paragraph 3.5. Finally, the EMAS regulatory relief is a combination of instruments as identified in this study, being regulatory relief and environmental management systems (see par.3.7.).

Economic instruments

Some economists argue that economic instruments are usually more cost-effective than direct regulation, in large part because they give companies more flexibility as to how they achieve resource productivity and prevent pollution. Moreover, as the World Business Council for Sustainable Development (WBCSD) asserts, ‘they provide continued incentives to producers to conserve resources, prevent pollution and step up technological and organisational innovation (and) are the most direct way of changing producer and consumer behaviour toward more efficient use’.

Some important categories of economic instruments are:
1) The use of price signals in the shape of taxes or charges;
2) Property rights in the form of tradable permits.
3) Supply side instruments in terms of subsidies\textsuperscript{15}.

Communication and voluntary instruments

An increasingly important alternative or complement to conventional regulation is what is becoming known as informational ‘regulation’. This has been defined as ‘regulation\textsuperscript{16} which provides to affected stakeholders information on the operations of regulated entities, usually with the expectation that such stakeholders will then exert pressure on those entities to comply with regulation in a manner which serves the interest of stakeholder’. This approach relies upon economic markets and public opinion as the mechanisms to bring about improved performance. Informational regulation is targeted almost exclusively at large enterprises, and in particular at public companies and those who are reputation sensitive, because it is essentially these type of enterprise, which are most capable of being rewarded or punished by consumers, investors, communities, financial institutions and insurers on the basis of environmental\textsuperscript{17}. Another instrument type that can be used next to regulation is voluntary initiative, such as covenants and environmental management systems.

\textsuperscript{14} Source: ec.europa.eu/enterprise.environment. BEST is an acronym for Business Environment Simplification Task force
\textsuperscript{15} Beyond, compliance: next generation environmental regulation, Australian institute of criminology, September 2002
\textsuperscript{16} “Regulation” in this case should be interpreted as a policy instrument, and not a regulation based instrument.
\textsuperscript{17} Ibid 15
3.1.2 Context factors

It is important to know that not all instruments will be appropriate in all circumstances or to all industries. Effective regulatory design involves tailoring a particular combination of policy instruments to particular circumstances. It will be necessary to consider amongst others:

- whether or not the industry has a high profile (since this may determine the degree to which SMEs might be susceptible to public/consumer pressure);
- the level of sophistication in the industry (since this is likely to indicate its capacity to adopt complex EMSs, and the need for education and training);
- the degree of uniformity in size and management practices of an industry (the greater the diversity, the greater the need to develop different strategies for different sub categories);
- whether or not there is a well organised industry association, or such an association can be established (which will be necessary but not sufficient to determine its capacity to adopt self regulation);
- the presence of readily identifiable third parties with commercial power (raising the possibility of nurturing or stimulating regulatory surrogates and establishing a supply chain approach);
- whether the environmental issues are disparate and numerous, or focussed and limited in number (in the case of the latter, regulators may achieve a bigger bang for regulatory buck)
- the prevailing culture of the industry, and its potential receptivity to different types of approaches.\(^\text{18}\)

In the following sections a selection of types of main instruments and environmental programs, that can be considered as a mix of instruments, to improve environmental performance is described in more detail. Every section consists of a description of the instrument (or mix of instruments), experiences with the instrument, countries and industries that are familiar with the instrument, and its environmental impact. A categorization of the instruments (or mix of instruments) could be the voluntary character of it. Some instruments or programs, such as the Responsible Care program, are by their nature strictly voluntary as others are a combination of voluntary participation and companies permit requirements (some environmental agreements). Other instruments can be categorized as financial instruments or use publicity. Some instruments such as regulatory flexibility is very related to regulations and the permit requirements. However it cannot be denied that it also comprises a voluntary element. Comments and remarks on the specific instrument related to performance BRC and the potential fit with the principal IPPC requirements have been made in the different sections. Some examples of different countries and industries are mentioned and a few examples will be discussed in more detail.

3.2 Environmental agreements

General description

Voluntary environmental agreements

It should be mentioned that environmental agreements are not really always voluntary. The industry concerned voluntarily enters into the scheme, but once they have done so, they are bound to it. Some "voluntary" schemes are only voluntary in the sense that the industry can either "voluntarily" take part or be regulated instead.

\(^{18}\) Ibid 15
Voluntary Environmental agreements (VEAs) address environmental issues based on sharing responsibility and cooperation; key elements of VEAs are stakeholder involvement, objective-setting, implementation and verification. Other terms used for VEAs are voluntary measures, self-declarations, commitments, covenants and negotiated environmental agreements (NEAs)\(^{19}\).

The OECD classification\(^{20}\) distinguishes between instruments according to parties involved:
- unilateral commitments made by polluters;
- agreements achieved through direct bargaining between polluters and pollutees;
- environmental agreements (NEAs) negotiated between industry and public authorities;
- voluntary programmes developed by public authorities (e.g. environmental agencies) in which individual firms are invited to participate.

The type of voluntary agreement most frequently used has the following characteristics: it is a collective agreement between a public authority and an industrial sector focusing on one particular industrial pollution concern and including a collective quantified pollution target to be met by the firms of the industry\(^{21}\). NEAs can be defined as commitments undertaken by firms and sectors that are the result of negotiation with public authorities and/or that are explicitly recognized by the authorities. Environmental issues that are covered by VEAs are – amongst others - emissions to air (e.g. SO\(_2\), CO\(_2\) and NO\(_x\)), waste, emissions to water, energy use and efficiency.

**Countries and examples**\(^{22}\)
Examples of the use of VEAs focusing on emissions to air can be found in the Netherlands and Finland. In the Netherlands so-called long-term agreements (LTAs) are used in relation to SO\(_2\) and NO\(_x\) emissions. Finland’s VEA is related to emissions of CFCs. In Norway the aluminum industries signed a covenant on greenhouse gas emission. Examples of VEAs on waste can be found in Germany (batteries) and in Belgium. The Portuguese paper and pulp industries take part in a VEA on emissions to water. Finally, VEAs on energy use and energy efficiency have been launched in a wide range of countries.

In the Netherlands policy is focused on target groups, mainly industry. For each of these target groups, the Dutch government has stated integral reduction goals for 8 environmental “themes”. The reduction goals had to be reached in 2000 or have to be reached in 2010. To meet the goals for e.g. the industry, a selection was made of 11 sectors of industry. This selection has been based on the environmental impact of and the number of companies in these sectors. The Dutch government and the organisations representing the selected industrial sectors have agreed to meet the integral reduction goals. These agreements (covenants) are written down in a declaration of intent. Parts of these agreements are goals for emission reduction, the so-called Integral Environmental Task (in Dutch: IMT). Based on the integral reduction goals for the industry, an IMT is determined for every selected industrial branch. In chapter 4 (page 94) an example of this can be found (paragraph of CCF development).

**Long term agreements on energy efficiency and energy benchmarking covenants**
Typically “energy VEAs” are so called long-term agreements (LTAs) and benchmarking covenants; the latter are used in the Netherlands, Belgium and Denmark. LTAs are used for example in France, Finland and UK. Energy benchmarking builds on the principle of economic comparisons of industries and provides a mechanism to compare for instance the specific energy consumption (SEC) of companies.

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\(^{19}\) Source: “Voluntary Environmental Agreements”, by P. ten Brink (ed), March 2002.  
Comparable companies e.g. from one industrial branch relate their yearly energy consumption to their product output figures or other suitable indicators. This produces a SEC value, which can be compared. Companies with very high values then can then identify possibilities to lower their energy consumption and saving money by doing so. In the Netherlands, industries involved in an energy benchmark covenant have to submit energy consumption plans to the environmental authority. These plans, consisting of energy consumption reduction measures for the forthcoming four years, will be part of the environmental permit; and therefore regulatory requirements to be in compliance with.

The SAVE Programme of the European Commission, DG Energy and Transport, on implementation of long term agreements in industries analyses crucial elements for successful implementation of this instrument at national level. Key implementation elements defined in that project are:

- (early) involvement of relevant key actors;
- target setting (quantitative targets like in DK, F, NL, and UK, or qualitative targets like in SF, or both in DK);
- accompanying measures like an audit scheme;
- offers such as financial incentives, benchmarking tools, links to permits and tax exemptions, and sanctions like exclusion from the LTA scheme;
- monitoring and evaluation
- integration into the existing policy mix, including national strategies on climate change.

In addition, a study of the United States Government identifies critical factors for a successful implementation of long-term agreements and for the achievement of significant energy savings. The most effective agreements are those that – amongst others – are legally binding (once a company has committed to the agreement, it is obliged to the agreed effort and targets), set realistic targets, include sufficient government support, and include real threat of increased government regulation or energy/GHG taxes if targets are not achieved.

**Performance BRC and link to IPPC**

As the nature of environmental agreements is in principle voluntary and as target setting within these instruments is often ambitious these instruments could be seen as contributing to innovation and encouraging companies to perform BRC. However, this general remark needs to be balanced with more specific case by case assessment of the specific instruments considered in order to analyze whether such environmental agreements lead to actual performance going beyond regulatory compliance, and how their existence influences application of IPPC.

Some of the environmental agreements, such as benchmark covenant on energy, are more thematically oriented; other environmental agreements, such as covenants that require an integrated environmental plan, have a more integrated approach. Seeing the integrated prevention and control as the environment as a whole as the key objective of the IPPC directive it could be questioned if the more thematically oriented approaches of environmental agreements are not (potentially) in conflict with the objective of the IPPC. Risk of cross media effects will probably be less if the environmental agreement is - like the IPPC – set up as an integrated instrument that e.g. will not allow higher emissions to air in reducing energy consumption. The risk of conflicts appears to be lower with the more integrated variants of environmental agreements.

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23 Source: Starzer, O., Towards Kyoto – Implementation of long term agreements in industry, 2001
3.3 Environmental programs: Corporate Social Responsibility and Responsible Care

In a sense Corporate Social Responsibility (CSR) and Responsible Care (RC) could be seen as a particular form of a VEA. However CSR and RC could also be seen as concepts or programs under which a variety of instruments can be applied such as EMS. These programs could be considered as more broad frameworks for companies, which they can use for different kind of voluntary initiatives. These programs are discussed below.

Corporate Social Responsibility

The concept of Corporate Social Responsibility (CSR) has been described by the European Commission in its Green Paper “Promoting a European Framework for Corporate Social Responsibility”26. The Green paper defines CSR as “a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis”. The main features of CSR are behavior by businesses over and above legal requirements, voluntarily adopted, linkage to sustainable development and integration of economic, social and environmental impacts.

To mobilize the resources and the capacities of European enterprises and to make Europe a center of excellence with regard to CSR, the European Commission has announced its backing of a “European Alliance for CSR”27. The new Alliance has an open nature and European enterprises are invited to voluntary express their support. The Alliance is not a legal instrument to be signed by enterprises. It is a political umbrella for new or existing CSR initiatives by large companies, SMEs (small and medium enterprises) and their stakeholders. It should lead to new partnerships and new opportunities for stakeholders in their efforts to exercise CSR.

The benefits of CSR are specific and depending on the specific situation of a company. It is also not always easy to be quantified, however some companies say that the additional value of CSR clearly can be found in the yearly financial figures.28

The OECD developed Guidelines for Multinational Enterprises, including tools and approaches, encouraging enterprises to improve internal environmental management practices and to seek continuous environmental improvement. Examples of tools and instruments that are promoted within CSR are environmental management systems, public information and stakeholder consultation (e.g. global reporting initiative), life-cycle assessment, and continuous improvement in environmental performance. So CSR in this perspective can be seen as a network of business members sharing visions and committing to sustainable goals (often multinational enterprises) facilitating amongst others innovative developments and sharing and discussing best practices. In the EVER study the potential integration between EMAS and the different elements of CSR are reviewed29. Different industrial sectors diverge in application of integrate management systems. It appears however that companies operating in the chemical branch and waste management are more tending to integrate issues such as health, safety and environmental management. Large companies and stakeholders see a link between EMAS and other CSR aspects as potentially fruitful.

27 Source: EC, Brussels, March 2006, IP/06/358
28 Quote of Mr Hummels, CEO of DSM, in Chemical Magazine, March 2006.
29 Source: EC, Brussels, EVER Report: Options and recommendations for the EMAS and Eco-label revision process, December 2005
Countries and examples
All 30 OECD countries, and nine non-member countries (Argentina, Brazil, Chile, Estonia, Israel, Latvia, Lithuania, Romania and Slovenia) take part in the promotion and implementation of CSR. The UK for example encourages companies to adopt and report on CSR through best practice guidance, regulation and fiscal incentives. A best practice for instance could comprise a good application of environmental training as part of EMS (by a CSR member) clearly resulting in environmental improvement in a specific field.

Responsible Care
Responsible care is a voluntary global initiative of the chemical industry, aimed at continuous improvement in the areas of environmental protection, safety and product stewardship and occupational health and safety. The Responsible Care initiative is specified by the OECD as a sector-specific environmental management system (EMS).

Growing interest in sustainable development is influencing the progress of the Responsible Care initiative and many in the industry feel that the aims of the program should be expanded to reflect this. Developments of business networks like the World Business Council for Sustainable Development (WBCSD) are driving forces behind this. Innovations and sustainable development illustrated by big known companies have proven commitment to this RC program. Emission reduction measures are focused on emissions to air and to water, and wastes to land. The chemical branch organization for the chemical industry in the Netherlands (VNCI) for instance are organizing meetings in order to promote sustainable activities to their members. All kind of topics and sustainable developments are discussed such as environmental management systems and certification and product stewardship. The companies may decide to use the given guidelines and information to improve their environmental performance.

Examples
According to CEFIC’s Responsible Care reporting, examples of air emissions reductions achieved for the chemical industry in Europe (1999–2004) are the following: 19% of non-methane volatile organic compounds; 16% of nitrogen oxides; 34% of sulfur dioxides; 9% of greenhouse gases. Examples of water emission reduction are 24% of chemical oxygen demand; 22% of nitrogen and 47% of phosphorus.

Performance BRC and link to IPPC
The main characteristic of CSR and Responsible Care (RC) is a voluntary participation of companies whose goal is to improve their environmental and sustainable performance and who agree that corporate responsibility calls for voluntary initiative beyond legal requirements.

At first glance initiatives that result from RC and CSR would not in principle conflict with the IPPC directive as all (IPPC/RC/CSR) aim at integral environmental improvements, and thus in fact might be rather complementary.

30 Source: OECD website, and Guidelines
31 Source: OECD, Environment and the OECD Guidelines for Multinational Enterprises: Corporate Tools and Approaches, 2005
33 it is not certain if emission reductions are BRC; the figures show however significant impact achieved by the industry
34 http://www.csreurope.org
Particularly the principle mentioned in article 3 of the IPPC in which an operator has to take all possible preventive measures in order to improve environmental performance seems to fit well. However it is too early to put forward any general statement about this now. Further research looking at a number of specific examples and situations will be necessary. It is noted that in particular the chemical industry is active in taking all kind of different initiatives in the RC/CSR field.

3.4 Environmental Management Systems and certification

It is acknowledged that EMS and EMAS have been already frequently mentioned before in the report, mostly in combination with another instrument. The main focus in this paragraph however will be on EMS itself.

**General description**

The broad aim of environmental management systems (EMS) is to help an organization achieve its environmental goals through consistent control of its operations. An EMS is not based on the adoption of uniform standards, but leaves it to the organizations themselves to set their own ambitions, goals and capacities. In order to define goals, industries often use the EMS Plan-Do-Check-Improve Method starting with an initial environmental review, defining the policy, developing an action plan, auditing the EMS and finally conducting a review.

In practice two types of EMS categories can be defined: “externally certified” and “performance-driven” EMS. A new type of EMS is the so-called sector-specific EMS like the responsible care (RC) initiative in the chemical sector and the UNEP Finance initiative in the financial sector. Examples of externally certified EMS are ISO 14001 and the European Union’s Eco-Management and Audit Scheme (EMAS). Requirements to be met are: environmental review of activities; establishment of an environmental management system; environmental audit; and verification of these steps and products with an accredited verifier.

ISO 14001 is developed under the auspices of the International Organisation for Standardisation (ISO), and is the main international standard for design and content of an EMS. The ISO standard sets tools for developing, implementing, maintaining and evaluating environmental policies and objectives. EMAS is based on the international standard EN ISO 14001:1996 but goes further in two respects, i.e. the provision of an environmental performance statement and the publication of the environmental review, EMS, audit procedure and environmental performance statement. EMAS provides the strictest requirements of all EMS and therefore requires more efforts from organizations to meet them.

Performance-based EMS is tailored to fit the particular operational requirements of the implementing company. ISO 14001 often acts as the foundation for a performance-driven EMS, however is not certified by an external body.

An example from the BEST study: in Portugal an initiative had been set up to benefit EMAS registered organisations in terms of regulatory relief. In 1999 the Portuguese Government signed so called Environmental Continuous Improvement Contracts with the cement sector and the glass-packaging sector. The aim of these contracts was to develop a set of actions for continuous improvement in environmental performance by the companies, and encourage industries to implement EMAS systems.

35 Source: OECD, Environment and the OECD Guidelines for Multinational Enterprises: Corporate tools and approaches, 2005
36 Source: ec.europa.eu/enterprise.environment/
The results achieved through these contracts were improvements in eco-efficiency, reduction of water and energy consumption, implementation and certification of environmental management systems and reduction of noise and emissions into the air.

**EMAS and IPPC**

Potential benefits stemming from implementation of EMAS are numerous, e.g. sustainable use of resources, reduced risk of non-compliance with environmental legislation, better public image. In addition, implementing an EMS, in particular EMAS, makes it easier to comply with the requirements of the IPPC Directive, for example when it comes to preparing applications and monitoring reports (so-called regulatory facilitation). Some European countries have introduced forms of so-called regulatory relief for companies with a certified EMS. The majority of them have introduced special incentives to promote EMS, in particular EMAS and to recognize their benefits. In these countries inspections can be less frequent (see also 3.7), as can permit reviews, and reporting requirements can be less onerous for IPPC installations. However, Member States cannot exempt companies with an EMS from their obligations under the Directive.

As implementation of EMAS entails important investments and input of personnel, external incentives are provided within different Member States. A specific type of external incentive is regulatory relief and/or flexibility. Promotional incentives, like public procurement, support funding, and technical and information support, are instruments within the second group of external incentives. Numerous Member States provide financial support to EMAS-organizations by giving a bonus on investment costs (see 3.5).

**Performance BRC**

Most Best Available Technique (BAT) Reference documents (BREFs) contain conclusions on the use of EMS (however not on certification) as an aspect of BAT. A standard text on EMS is included in the BAT conclusion of the BREFs. It is however up to the competent authority to determine specific permit conditions based on BAT, including possible permit conditions regarding EMS. Depending on the permit conditions organizations will implement EMS, either externally validated or not.

In the REMAS study it was concluded that some IPPC companies achieved higher levels of operator performance and environmental outcomes due to adoption of accredited environmental management systems. Traditional environmental regulation and environmental permits address particular environmental impacts of an activity such as point sources of pollution. EMS on the other hand broader focuses also on indirect environmental impacts, such as product design, transportation and natural resource consumption. As EMS therefore encompass wider organizational activities like supply chain management and financial investments, this instrument can facilitate the organization to go beyond regulatory requirements and bring wider environmental benefits.

In the EVER study it was found that adoption of EMAS has consequences in terms of innovation capabilities and skills. The changes would have been primarily organizational and low tech. More radical innovations should be observed in the medium long term, due to a better cooperation and communication with the product chain and the investments of high value machinery.

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37 Source: EC, Brussels, Draft report on incentives provided by Member States to EMAS-registered organizations, 2006
38 Source: EC, Brussels, EVER Report: Options and recommendations for the EMAS and Eco-label revision process, December 2005
39 Source: Howes, C. (ed.), Environmental management systems and regulatory compliance
3.5 Financial instruments: environmental taxes, charges and subsidies

**General description**

Policy instruments that rely for their effect on financial incentives rather than regulation are called economic instruments\(^{40}\). The OECD defines economic instruments as "instruments that effect costs and benefits of alternative actions open to economic agents, with the effect of influencing behavior in a way that is favorable to the environment"\(^{41}\). The OECD (1989) survey distinguishes five categories of economic instruments: 1) taxes and charges, 2) subsidies, 3) deposit-refund systems, 4) market-creation, and 5) financial enforcement incentives\(^{42}\).

Fiscal instruments such as taxes are used for influencing production processes (e.g. taxation of raw materials, or polluting emissions) as well as on consumers (e.g. taxation of petrol or pesticides). Taxes have the advantage that they encourage industries to develop or introduce cleaner production techniques; leaving enterprises the freedom to decide whether they pay taxes or invest in cleaner production technology. An environmental tax is determined according to its tax base, which is the product, activity or substance that the tax rate is based on\(^{43}\).

A subsidy is defined by the European system of accounts (ESA 1995)\(^ {44}\) as ‘current unrequited payments from government to producers with the objective of influencing their levels of production, their prices or the remuneration of the factors of production’. Subsidies can be paid to industries in the form of grants, soft loans or tax allowances. The advantage of using subsidies is the direct motivation of industries to act more environmental-friendly, for example as they receive grants for implementing emission reduction measurements. Granting subsidies however have to comply with strict EU regulations, in order to avoid state aid.

A deposit-refund system\(^ {45}\) is a surcharge on the price of potentially polluting products. In a deposit refund system, consumers pay deposits that are added to the price and receive refunds when they return the used products. This instrument combines taxes and subsidies to prevent litter and promote material recovery\(^ {46}\).

Governments can create a market to use the environment by issuing tradable pollution permits. A recent EU-wide implemented example is the EU emission-trading scheme (see paragraph 3.6 as well). Individuals or companies have to pay pollution charges either directly to the government or they have to apply (and pay) for pollution permits. These permits – or rights – can be traded on an (inter)national market.

Finally, financial enforcement incentives drive industries to comply with regulation in order to avoid financial penalties. As this type of instrument is not of relevance for this study, and as taxes and charges best fit within the framework of this research the focus of this paragraph and the case studies is on taxes and charges. The EEA study\(^ {47}\) evaluated the following environmental taxes: cost-covering charges, incentive taxes and fiscal environmental taxes.

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\(^{40}\) Source: EEA, Environmental taxes, 1996

\(^{41}\) Source: Schanzenbacher, B., Economic incentives as policy instruments for environmental management and sustainable development.

\(^{42}\) Ibid 41

\(^{43}\) Source: Statistics Sweden, Environmental subsidies – a review of subsidies in Sweden, 2003

\(^{44}\) Ibid 41


\(^{46}\) Source: Numata, D., Economic analysis of deposit-refund systems with measures for mitigating negative impacts on suppliers, 2004

\(^{47}\) Ibid 40
Cost-covering charges are payments for the use of the environment; examples of cost-covering charges are user charges or earmarked charges. In the case of user charges a charge is paid for a specific environmental service, e.g. treating wastewater or disposing of waste (service related charge). Revenues of earmarked charges on the other hand are spent on related environmental purposes (charge is considered more product related), but not in the form of a specific service to the charge-payer. An example is the Swedish battery charge. These variants of cost-covering charges have less impact on innovations than for example incentive taxes. Revenues of incentive taxes are often used to further encourage behavior change via grants or tax incentives. Examples are the Swedish tax on NOx and the German toxic waste charge.

Environmental taxes designed mainly to raise significant revenues are called fiscal environmental taxes. Revenues of this type of taxes are used to finance budget deficits, or shift taxes away from high income taxes, or high non-wage labour taxes, towards taxes on consumption of resources and environmental pollution. These taxes often consist of energy taxes and taxes on waste, and wastewater. Examples of environmental taxes are the CO2 taxes in Sweden and Norway.

The EEA report concluded that as far as environmental effects were concerned, incentive charges and fiscal environmental taxes on air quality in Sweden, and on water pollution charge in the Netherlands did work well. Tax differentiation schemes for fuels had also been particularly successful.

Another example from the BEST study is found in Belgium. Larger water users (more than 500 m³) in Belgium (Flanders) have to pay a water treatment tax. Within the first tax scheme, taxes were collected annually by the Flemish Environment Agency (VMM–Vlaamse Milieumaatschappij). Under the new system, the public drinking water suppliers are made liable for the cost of treatment of water they supply. Therefore the suppliers charge the end users specific costs per m³ water. Business can deduct the full amount paid on water treatment tax through their taxable income.

**Performance BRC, link to IPPC and examples**

As the Commission noted in its 2003 Communication on progress in implementing the IPPC Directive, fiscal instruments have the advantage that, as they lead to an inclusion of external costs in prices of products, there is always an incentive for operators to reduce emissions even beyond binding emission limit values. Thus the regulatory approach of IPPC and the use of taxes and charges could as such be seen as complementary instruments. Taxes are often aimed at a particular issue such as NOx, CO2 or toxic waste and are as such not taking into account possible cross media effects. The impact of these measures on the IPPC integrated approach needs to be further assessed.

While Member States have made extensive use of taxes and charges on emissions, there has been little development in this area at EU level due to the requirement for unanimity on taxation issues among Member States. Member States can also grant State aids to enterprises for environmental purposes, in particular for investment to go beyond Community standards. The Community guidelines on State aid for environmental protection defines the scope for such measures with a view to both environmental and competition policy objectives. Where the use of best available techniques is required under the IPPC Directive, these are regarded as ‘Community standards’.

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48 Ibid 38
49 Ibid 14, 37
The implementation of the voluntary EU Eco-management and Audit Scheme (EMAS) is facilitated by Member States through support funds. As EMS (see paragraph 3.4) promote environmental improvements – sometimes beyond regulatory compliance (BRC) – these support funds can be seen as a (derived) example of financial stimulus for industries to go beyond regulatory (BRC) compliance. Support funding on EMAS is practice in most of the EU countries.

Another, EMAS-related, example of a financial instrument is reduced inspection or supervisory fees. Up to 50 % discount on the cost of permit application and ongoing inspection fees is given to EMAS sites in Finland, Spain, Norway and German Länder of Bavaria and Saxony50.

3.6 Emission trading

Emission trading is an instrument that could cover greenhouse gas emissions such as CO₂ and other emissions like NOₓ. Examples of emissions trading can be found in Member States, and in the US and Asian countries as well.

In the context of the review of the IPPC Directive, another parallel project on the streamlining of the IPPC Directive with other EU legislation addressed on the interaction between emission trading of NOₓ and SO₂ and existing legislation (for more information, see: http://forum.europa.eu.int/Public irc/env/ippc_rev/library?l=/streamlining_study&vm=detailed&sb=Title.

The results of that study will provide relevant information on the instrument of emission trading. Therefore the Commission has decided that emission trading, as an instrument would not be specifically addressed in the project "Beyond regulatory compliance”.

3.7 Regulatory flexibility: differentiation in permits, inspections and enforcement

General description
Within quite some Member States regulatory flexibility is used, mostly in combination with EMAS51. Regulatory flexibility includes regulatory relief (such as less inspections for good performing companies) as well as substitution of certain obligations, and is defined as differentiation in implementation of legal requirements without changes in the main framework of environmental legislation as such. Deregulation on the other hand does involve changes of legislation itself. The main objectives of regulatory flexibility are simplification and reduction of the regulatory framework; removal of procedural impediments and reduction of administrative burden (see reports on the EU BEST project)52.

Flexibility in regulations and permits can be characterized in three main categories:

- as a factor in risk assessment, with effects on site inspection frequencies (UK, DE, NO, PT, NL, A, F), insurance (CZ), governmental fees (UK) and penalties (AT);
- as a substitute for certain legal requirements such as periodical reporting (to a certain extent in DE, AT, IT, ES, SE, NL, UK, LU);
- as a condition enabling for a longer duration of environmental permits (LU, SL, DE, IT).

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50 Dahlström, K. (ed.), Environmental management systems and company performance: assessing the case for extending risk-based regulation
51 Source: EC, Brussels, EVER, Evaluation of EMAS and Eco-label for their revision; Report 1: Options and recommendations for the revision process, December 2005
52 europa.eu.int/comm./enterprise/environment/index_home/best_project
Examples: environmental permitting, IPPC and EMAS

Some relevant examples in relation to the IPPC requirements are known from Luxembourg and Slovakia. In Luxembourg EMAS companies can obtain fast track permits as well as longer duration permits. Another example is Slovakia; in Slovakia under the IPPC Directive the permit period for EMAS-registered organizations is extended from 8 to 10 years.

A specific kind of environmental license has been developed in the Netherlands (for IPPC and non-IPPC companies), the outline license, specifically for EMAS-registered and ISO-certified organizations. This type of licensing focuses on the main emissions of the installations as a whole, setting a maximum year-load as the bottom-line to be respected, but leaving it to the organizations themselves to decide upon how to comply with these limits. Advantage of this type of license is the flexibility on measurements to be taken by the organization and the shorter procedure time for a new license. Simplified application and/or permitting procedures for EMAS-registered organizations are also known from Austria, Denmark, Italy, Finland and Belgium (Wallonia).

Environmental inspections, IPPC and BRC

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) prepared in 1997 a paper called Minimum Criteria for Inspections. The European Parliament and Council used this paper and adopted a Recommendation on Minimum Criteria for Environmental Inspections (RMCEI). Concerning frequency of Inspections, the IMPEL paper suggests that Member States should set baseline frequencies for each category of installation, taking into account requirements of EU Directives like the IPPC (article 9.5 of the Directive), appropriate national regulations and the need to use resources efficiently and effectively. Therefore authorities should develop assessment and scoring systems to determine inspection frequencies, related to criteria such as the previous environmental performance of the operator, any previous prosecutions, orders or administrative fines, EMAS and ISO14001.

Using this proposed format for defining and planning inspections stimulates industries to improve their performance, limit their environmental impact and strive for high levels of compliance and continuous improvement (sometimes BRC). On the other hand, several studies have until now not proved that the EMAS scheme provides full and continuous compliance of the organization with every applicable legal requirements. Therefore, according to these studies, reducing inspections on EMAS registered organizations could be doubtful, or should be carefully assessed in view of ensuring an appropriate compliance check of installations. However other studies, such as the REMAS study, conclude more positive on regulatory flexibility in relation to EMAS registered companies.

Some IPPC operators consider the burden of being subject to intensive inspections with frequent intervals, and resulting in maybe requirements of providing information to the authorities as significant. Especially for SMEs this burden can be very large, compared to what can be achieved in environmental benefits. Therefore it could be seen as an advantage for some installations and for the authorities, if there is some kind of differentiation in the inspections and enforcements. This effectiveness of such instruments needs to be further assessed.

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53 Source: EC, Brussels, Draft report regarding incentives provided to EMAS-registered organizations, 2006
Examples

Some examples of Member States that adjust inspections (frequencies) in relation to EMAS are United Kingdom, Germany, Norway, Portugal and the Netherlands. In England and Wales the Operator Performance and Risk Appraisal (OPRA) is used to plan compliance assessment activities related to ISO 14001 and EMAS (see also 3.4. and 3.8.). Most of the German Bundesländer regulates enforcement activities on EMAS-registered organizations by provisions based on Environmental Pacts, so called Umweltpakte. These pacts are ventures between the Government and the industry with the aim of improving the environmental protection. In Portugal there is an agreement between the EMAS competent body and the General Inspectorate for the Environment on less frequent inspections.

3.8 Publicity and environmental classification

Several studies and analyses have pointed to the argument that for IPPC companies, (negative) publicity was an important incentive to change their behavior, sometimes even leading them to participate in voluntary programs and possibly perform BRC. In the past many initiatives with publicity/classification tools have been carried out in the field of environment and occupational, health and safety. Although these were not always too successful, the growing power of the public and NGOs, in computer literate, highly educated countries with political expectations of high standards of environmental protection should not be underestimated. That is the political arena in which companies operate now, and they will tend to respond to it.

The Environment Agency (in England and Wales) published an annual report (SPOTLIGHT on business), which looks at operator performance of environmental sectors. It names, shames and fames certain companies based on the highest fines given by the courts and those companies, which repeatedly offend. A league table is published of the ten worst offenders, but this is based on fines rather than specific environmental performance. The same information is also provided on the Internet. The information to make this league is collected by the EP OPRA approach. Both EP OPRA and SPOTLIGHT are described below.

EP OPRA

In the UK, England and Wales introduced the Environmental Protection Operator and Pollution Risk Appraisal (EP OPRA) approach for environmental enforcement. In its essence, it is a common approach for regulation of various regulatory regimes. The EP OPRA provides a risk profile that enables the authorities to decide how much effort should be put in place for the regulation of a site. To make this profile, a risk assessment is made based on five attributes: complexity of the site, the emissions, the location, the operator performance and the compliance rating. This compliance rating indicates how compliant a company is with its permit. This is calculated by using the Compliance Classification Scheme (CCS).

This takes the following factors into account:
- Non-compliance with permit/license requirements
- Potential impact on the environment as a result of non compliance
- Additional compliance assessment effort required to deal with permit/license breaches

The compliance rating is determined after issuing the permit.

Based on this data and the experiences of the past, an EP OPRA banded profile is produced for each of the five attributes. There are five bands, indicated by ‘A’ till ‘E’, with profile ‘A’ indicating that a lower regulatory oversight is sufficient, while profile ‘E’ requires a more stringent oversight.

The scores in each of the five attributes are converted to an overall score that indicates the risk posed by the facility and to set associated fees and charges for applications and subsistence. The Compliance rating is not used to set the application fees, as this parameter is included to make is easier to adjust and determine regulatory oversight of the company.

As the banded profile determines the regulatory oversight of a company, it is quite important that both the company and regulator agree on this. If a company is dissatisfied with their profile, there are multiple steps for the companies to take to discuss the indicated profile.

**SPOTLIGHT**

The data that is gathered through EP OPRA is reported in the Spotlight on business report of the Environment Agency of the UK. Spotlight reports annually the performance of the industry as a whole. The spotlight report is also available on the website of the Environment Agency.

Moreover the report shows in more detail the performance of the industries divided in 11 sectors, like Chemicals, Food and Drink, Metals and Waste. The information is made available by an annual report. The annual report shows the 10 larges cumulative fines, naming the involved company and presenting the fines. Furthermore for each sector the companies that have received a fine of £5,000 or more are presented in tables, including the type of offence and if the offence is repeated. It is also indicated if the director is personally prosecuted. Per sector case studies are given of very good performing companies and very bad performing companies. For the good cases it is shown that lighter regulation is possible, decreasing the effort needed by the industry.

In the Spotlight report the emphasis is given on non-compliant companies. Although there are some companies included that show major improvements in their environmental performance or have a very good performance, no list of the best performing companies is included.

A study in 2000 surveyed 100 Agency officers to see their opinions on the name and shame strategy. The survey found that 49% of Agency officers felt that adverse publicity was the most important consequence of prosecution, compared with 20% who felt that the fine was most important. This distinction was more pronounced by those officers who regulate the large-scale chemical industries.

The Agency considers that companies at the top of the list in practice try anything to get themselves off or down and nearly always improve their environmental performance. Although the tables receive some national exposure their biggest success is at local level where companies are named and shamed in local newspapers and have pressure put on them by the local community. On the positive side for industry the Agency also “names” companies which have shown good or improved performance over the year. Industry, and in particular larger companies who are more likely to be fined often have heavily criticized the league table approach adopted by the Environment Agency.

It can be taken from this example that although companies in general tried to improve environmental performance in order to get off the list of worse performers, to get on a list of well performers or to reduce the inspection frequency there is not much evidence that this resulted for some companies in performance BRC, although examples of companies that were awarded due to good environmental performance are available (see 4.6, example of Slovenia).

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57 Personal Communication – Board Member Environment Agency
Besides in some cases it was decided not to link the name and shame tables with the inspection regime due to difficulties to draw the line in terms of presenting classification results in terms of sector and size of the company.
4 CASE STUDIES

4.1 Introduction

The instruments presented and described in the previous chapter are widely known and implemented. The specific relation with the IPPC Directive and the hands-on experiences with the instruments within the environmental permitting (IPPC) context however are not addressed in many research projects and literature. By conducting case studies more in-depth knowledge has been gathered for selected cases, i.e. instruments used for specific industries within a certain country.

The selection of case studies is based upon the following criteria: type of incentive; potential to encourage BRC; countries involved; industrial sector involved; relation with IPPC; experiences with the instrument; and availability of information of the instrument. Applying these criteria upon the various examples available lead to the following selection of case studies, which are presented in more detail in the following sections:

1. Environmental charge on NOx emissions in Sweden.
2. Performance Track in the US.
3. Green network in Denmark.
4. Solvent tax in Switzerland and France.

In addition, a sixth case study is focusing on some emerging technologies identified in BREFs (Best Available Techniques Reference documents) and the contexts within which these innovations have been (un)sucessfully implemented.

In the following sections for each case study a general description of the specific instrument; its implementation; the effectiveness; and the (dis)advantages are given. Effectiveness of an instrument is defined as achieving the policy instrument’s goal, which in most cases will be the improvement of environmental performance (preferably on a cost-effective way).

The contexts within which the instrument is implemented and possible relations with the IPPC Directive are addressed as well, as these identify the applicability of the instrument in other industrial and/or governmental contexts.
4.2 Case study 1: environmental charge on NO\textsubscript{x} emissions in Sweden

4.2.1 General description of instrument and background

\textit{Background}

In 1985 the Swedish Parliament decided that emissions of NO\textsubscript{x} should be reduced significantly in order to reduce the acidification, which was a major problem in Sweden. Since 1992 Sweden imposes an environmental charge on NO\textsubscript{x} emissions from large combustion plants and other plants that produce and require energy for their processes such as the Pulp and Paper, the Wood, Chemical, Metal, Food and Waste industry. The intention of the charge was (and is) to achieve a more rapid reduction in emissions of NO\textsubscript{x} than was considered possible by relying on the administrative guidelines, individual permitting or general regulations, at that time. Before it was decided on introducing the charge a large investigation was carried out. Calculations of the reduction of NO\textsubscript{x} emission were made\textsuperscript{58}.

Monitoring (NO\textsubscript{x}) emissions require relatively heavy equipment investments. The charge was therefore initially confined to the larger combustion plants producing at least 50 GWh of useful energy per year per boiler. Due to the effectiveness in emission reduction and reduced monitoring costs the system was first extended to boilers producing 40 GWh/year (1996) and later on (1997) also extended to boilers producing at least 25 GWh useful energy per year. Today about 260 plants i.e. 400 boilers are subject to the charge.

\textit{Charge & refund system and Swedish Environmental Protection Agency (SEPA)}

The revenue of the charge charge was/is returned to plants in proportion to their energy production. This financial instrument has its legal base through the NO\textsubscript{x} Act, which was adopted in 1990. According to the NO\textsubscript{x} act today the charge has to be paid for NO\textsubscript{x} -emissions from boilers, stationary combustion engines and gas turbines with a useful energy (i.e. energy output from the boiler; the energy can be electricity, steam, hot water or hot oil.) production of at least 25 GWh per year. Almost all production units targeted by the NO\textsubscript{x} act are boilers. Until now no process emissions have been included as these are difficult to compare (i.e. benchmark) with each other. However the SEPA is still thinking about expanding the system, which can be done by including other industries, other emissions sources and/or lower the capacity threshold.

The NO\textsubscript{x} charge is based on actual recorded emissions. It is imposed irrespective of the fuel used and is levied at a rate of SEK 40 (about 4 euro) per kg of NO\textsubscript{x}\textsuperscript{59}. The Swedish EPA is the taxation authority for the NO\textsubscript{x} charge. The SEPA can be seen as an in principal independent advisory agency for amongst others the Ministry of Environment and the permitting authorities, which are the 21 counties and the 5 Environmental State Courts. Charged companies must register with the SEPA by submitting a return for boilers subject to the charge. The return includes the amount of NO\textsubscript{x} emitted and the useful energy produced. The SEPA checks these returns and a net payment or refund is calculated for each company. Companies operating boilers with high emissions relative to their energy output are net payers and the most energy efficient companies are receivers. The invoicing and payments are done on a regular i.e. yearly base as is shown in figure 2.

Total cost for the administration in 2005 was 4 555 000 SEK (about 0,7 % of the charge). There are no figures for the administration costs for the companies available.

\textsuperscript{58} Uncertainty existed, because a lot of facts were not known.

\textsuperscript{59} Information facts Swedish EPA, March 2006.
Monitoring
The equipment for continuous monitoring of NO$_x$ is checked once a year by an accredited inspector to ensure that the system meets the quality standards as required by the SEPA. The charge is applied to measured emissions, or to assumed emission levels, which are quite conservative (taken with a safe margin). Therefore emission measurements are generally preferred. For a large part of the boilers the flue gas flow is calculated from the fuel data, fuel consumption and oxygen or carbon dioxide concentration in the stack. For a minor part the flue gas characteristics are determined by direct measurements. For the calculations of revenues it is also necessary to monitor the amount of useful energy produced.

The monitoring costs are very different between the boilers. The equipment usually costs about 30,000 euro and could be up to 1,000,000 euro\textsuperscript{60}. Typical operating and maintenance costs are about 15,000 euro.

![Figure 2. Yearly cycle of invoicing and refunding NO$_x$ charge charge by the Swedish EPA.](image)

4.2.2 Justification of selection

The main criteria for selecting the NO$_x$ charge in Sweden as a case study are the positive results that are claimed with this instrument at different industrial (IPPC) sectors (LCP and Pulp and Paper industry). The tax system is an example of a financial instrument, with a long history from the early nineties on. Therefore, sufficient information and experienced contacts appeared to be available for carrying out a more in-depth study.

\textsuperscript{60} Source: SEPA, 2006
4.2.3 Interviews

From 2nd until the 4th of October 2006 the following interviews were conducted with relevant stakeholders of the NOx charge system in Sweden.

During the interviews discussions were held about the background, the legal context and boundary conditions, advantages and disadvantages of the NOx charge system during the last 15 years. Also the fit within the IPPC was assessed. In the next paragraphs the highlights of these discussions are summarized. All of this information is derived from the discussions with the interviewees (table 1).

<table>
<thead>
<tr>
<th>Name of interviewee</th>
<th>Occupation</th>
<th>Involvement with NOx charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. B. Borgstrom</td>
<td>Chief of inspection and enforcement team</td>
<td>Involved at inspection and enforcement of IPPC companies that are under the NOx charge</td>
</tr>
<tr>
<td>Mrs. H. Sjögren</td>
<td>Member of inspection and enforcement team</td>
<td>Involved at inspection and enforcement of IPPC companies that are under the NOx charge system.</td>
</tr>
<tr>
<td>Mr. Per Örvind and Mrs K. Ferbeek</td>
<td>Environmental coordinator and respectively process engineer of Söderenergi</td>
<td>Söderenergi at Södertälje is a large combustion plant (LCP) producing heat and power from biofuels and waste and is falling under the NOx charge.</td>
</tr>
<tr>
<td>Mrs. A.M. Carlsson</td>
<td>Leader of Strategy, Energy and Environment department at AFconsult</td>
<td>Working for many Pulp and Paper companies in and outside of Sweden. Many clients are under the NOx charge system.</td>
</tr>
<tr>
<td>Mr. Tage Sundblom</td>
<td>Chief of Environment, Recycle plant and Energy Technical controller</td>
<td>The Holmen Pulp and Paper plant at Hallstavik is falling under the NOx charge system. This plant is a net receiver, which is an exception for the P&amp;P sector.</td>
</tr>
<tr>
<td>Mr. P. Sjögren</td>
<td>Technical controller</td>
<td></td>
</tr>
<tr>
<td>Mrs. E.Slina Hedin</td>
<td>Quality and Environment coordinator</td>
<td></td>
</tr>
<tr>
<td>Mr. T. Kindblom</td>
<td>Project leader monitoring</td>
<td></td>
</tr>
<tr>
<td>Mr. Erik Nystrom</td>
<td>IPPC expert of the SEPA and AG-member</td>
<td>Involved at the set up of the P&amp;P BREF and well aware of the interaction of the interaction between NOx charge and the (IPPC) permitting conditions.</td>
</tr>
<tr>
<td>Mr. J.O. Arvidsson</td>
<td>Technical judge at the Environmental State Court in Stockholm</td>
<td>The Environmental Courts are the permitting authorities for the biggest (A) IPPC companies in Sweden.</td>
</tr>
</tbody>
</table>

Table 1. Interview with stakeholders NOx charge system.

4.2.4 Effectiveness, advantages and drawbacks of instrument

Since the Swedish parliament passed legislation introducing the NOx charge from 1990 the specific emissions dropped significantly. The specific emissions have decreased by about 56 % from 1990 to 2005. It was concluded that 50% of the specific emission reduction that was achieved between 1990 and 1992 was due to the introduction of the NOx charge (figure 3).

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61 Part of this was before the introduction of the IPPC directive; however it is still interesting which drivers led to this positive environmental impact.
It is however not possible to really prove that the reduction is only due to the NOx-charge, even if it is most likely. In figure 3 the effect of changing the charge, to 40 respectively to 25 GWh, from 1996 and 1997 is clearly visible (figure first rises and then drops again).

Although many stakeholders, industry as well as authorities, are very positive about the charge and are convinced of its effectiveness (in reaching the environmental target) also a number critical notes were mentioned several times. The main and most frequently stated comment, both by industry as well as by the authorities, was about the benchmark comparing different industry sectors falling under the system. Some industries would benefit more than others because of more favorable process conditions characterizing the nature of these processes. The Heat and Power industry for example would have an advantage because of their primary business goals (energy production) and stable stationary operating conditions.

![Figure 3. NOx drop since introduction of charge system.](image)

Industries like the wood and waste industry, which primary goals are not energy production and which are subject to many process fluctuations (batch processes) do not have this advantage. Partly as result of this some industries are in general net receivers while the other industries are frequent net payers of the NOx charge system (fig. 4). In 2005 there were 165 net payers total (103 478 352 SEK) and 98 net receivers (total 100 093 598 SEK).
### Table 2. Overview of emissions, energy used and fees paid by participating companies.

<table>
<thead>
<tr>
<th>Year</th>
<th>Companies</th>
<th>Production units</th>
<th>NO$_X$ emission</th>
<th>Usefull energy</th>
<th>specific emission av NO$_X$</th>
<th>Specific number</th>
<th>Total fee</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[number]</td>
<td>[number]</td>
<td>[ton]</td>
<td>[GWh]</td>
<td>[kg/MWh$_{nyttig}$]</td>
<td>[mg/MJ$_{tillförd}$]</td>
<td>Miljoner kr</td>
</tr>
<tr>
<td>1992</td>
<td>124</td>
<td>181</td>
<td>15 305</td>
<td>37 465</td>
<td>0,409</td>
<td>99</td>
<td>16,17</td>
</tr>
<tr>
<td>1993</td>
<td>131</td>
<td>189</td>
<td>13 333</td>
<td>41 158</td>
<td>0,324</td>
<td>78</td>
<td>12,58</td>
</tr>
<tr>
<td>1994</td>
<td>131</td>
<td>202</td>
<td>13 025</td>
<td>45 193</td>
<td>0,288</td>
<td>70</td>
<td>11,35</td>
</tr>
<tr>
<td>1995</td>
<td>136</td>
<td>210</td>
<td>12 517</td>
<td>46 627</td>
<td>0,268</td>
<td>65</td>
<td>10,69</td>
</tr>
<tr>
<td>1996</td>
<td>177</td>
<td>274</td>
<td>16 083</td>
<td>57 150</td>
<td>0,281</td>
<td>68</td>
<td>11,26</td>
</tr>
<tr>
<td>1997</td>
<td>250</td>
<td>371</td>
<td>15 107</td>
<td>54 911</td>
<td>0,275</td>
<td>66</td>
<td>10,77</td>
</tr>
<tr>
<td>1998</td>
<td>252</td>
<td>374</td>
<td>14 617</td>
<td>56 367</td>
<td>0,259</td>
<td>63</td>
<td>10,14</td>
</tr>
<tr>
<td>1999</td>
<td>248</td>
<td>375</td>
<td>14 050</td>
<td>54 921</td>
<td>0,256</td>
<td>62</td>
<td>10,09</td>
</tr>
<tr>
<td>2000</td>
<td>241</td>
<td>363</td>
<td>12 765</td>
<td>51 399</td>
<td>0,248</td>
<td>60</td>
<td>9,64</td>
</tr>
<tr>
<td>2001</td>
<td>252</td>
<td>393</td>
<td>14 160</td>
<td>58 142</td>
<td>0,244</td>
<td>63</td>
<td>9,55</td>
</tr>
<tr>
<td>2002</td>
<td>256</td>
<td>393</td>
<td>14 730</td>
<td>61 014</td>
<td>0,241</td>
<td>62</td>
<td>9,51</td>
</tr>
<tr>
<td>2003</td>
<td>266</td>
<td>414</td>
<td>15 836</td>
<td>66 136</td>
<td>0,239</td>
<td>61</td>
<td>9,45</td>
</tr>
<tr>
<td>2004</td>
<td>264</td>
<td>405</td>
<td>14 930</td>
<td>65 758</td>
<td>0,227</td>
<td>58</td>
<td>8,94</td>
</tr>
<tr>
<td>2005</td>
<td>263</td>
<td>411</td>
<td>14 371</td>
<td>64 812</td>
<td>0,222</td>
<td>57</td>
<td>8,68</td>
</tr>
</tbody>
</table>

Figure 4. Net payers and receivers of the NO$_X$ charge system.

For boilers subject to the charge in 2004, 58 percent had taken some kind of (primary and/or secondary) abatement measure. Many of these included trimming measures (optimize combustion efficiency) that practical implied zero costs. Another remarkable (secondary) measurement that could be attributed to the NO$_X$ charge was the use of selective non-catalytic reduction (SNCR) as flue gas cleaning.
This was not used at all before the introduction of the charge in Sweden. The more costly flue gas cleaning by selective catalytic reduction (SCR) is done so far by 3 percent (11) of the boilers. With SCR relatively very high reduction levels can be achieved. An overview of NOx reducing measures is given in table 3.

Table 3. Type of NOx reducing measures per sector for boilers subject to the charge in 2004.

<table>
<thead>
<tr>
<th>Type of NOx reducing measures per sector</th>
<th>Energy</th>
<th>Pulp &amp; Paper</th>
<th>Waste combustion</th>
<th>Wood Industry</th>
<th>All sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNCR/SCR</td>
<td>28%</td>
<td>22%</td>
<td>77%</td>
<td>0%</td>
<td>29%</td>
</tr>
<tr>
<td>Flue gas recirculation</td>
<td>22%</td>
<td>22%</td>
<td>45%</td>
<td>36%</td>
<td>25%</td>
</tr>
<tr>
<td>Other combustion measures</td>
<td>20%</td>
<td>35%</td>
<td>12%</td>
<td>5%</td>
<td>21%</td>
</tr>
<tr>
<td>No measure</td>
<td>44%</td>
<td>38%</td>
<td>16%</td>
<td>58%</td>
<td>42%</td>
</tr>
</tbody>
</table>

A remarkable fact is that the waste combustion sector relatively has taken a lot of measures but is (in general) not belonging to the net receivers (figure 4). It is stated that the NOx charge system was the main reason for companies to implement the abatement measures during the 1990s. Knowledge of abatement measures for NOx has definitely improved since the introduction of the charge.

Finally another comment that was mentioned was about the relative low NOx contribution of the participating companies in the charge system compared to the total NOx emission in Sweden.

Examples
The cost effectiveness of environmental measures taken by operators in the NOx charge system has been analyzed in a study by Isaksson. In the study, abatement measures of 114 combustion plants were analysed in the period from 1990-1996. The main conclusion of the study is that the plants that were analysed were triggered by the NOx charge to take measures and that most of these measures could be taken at low or zero cost, i.e. the 'low hanging fruit' such as different trimming and fine tuning activities of the combustion process. In this BRC study two examples of industries will be highlighted. One of the examples is about a large combustion plant (LCP) and the other represents the Pulp and Paper industry. Although it is not easy to verify if the measures described below were taken at low or zero cost they appeared to be cost-effective and sometimes innovative, and often leading to a significant drop in emissions. The NOx charge was said to be a main driver for these measures.

Söderenergi AB (LCP)
Söderenergi AB is an energy company that was set up for generating heat for district heating and is owned by 3 municipalities. The construction of district heating systems in the southern part of Stockholm area and in Södertalje beginning in the 1960s was meant to achieve an efficient, dependable and environmentally acceptable means of heating.

Söderenergi supplies heat to about 70,000 households, industrial plants and offices. During a normal year, the four boiler stations generate around 1.8 TWh of thermal energy. Around two third of the heat is used for space heating and one third is used for heating domestic water. During the 1990s Söderenergi switched from coal and oil to firing mainly with biofuels and waste materials derived- and recycled fuels.

63 SCR uses a catalytic ceramic plate
64 Ibid 60
65 “Abatement costs in response to the Swedish charge on nitrogen oxide emissions”, Lena Höglund Isaksson, 2005
Söderenergi set strict fuel quality demands. It controls the supplier’s incoming material, environmental permits, the supplier’s facilities, equipment and operational routines. All deliveries of fuel are also controlled according to Swedish or ISO-standards and samples are sent to an independent laboratory for analysis. Söderenergi is working in compliance with and is certified according to ISO 14001. Söderenergi has been a pioneer in the field of fuel quality and the Swedish EPA now recommends that other district heating plants should adopt a similar model for assuring the quality of their fuels. The Söderenergi plant was right from the start equipped with advanced flue-gas treatment and was most modern of its type in Sweden. Taking into account the greenhouse effects peat and tall oil were gradually introduced at the plant from 1992. Recycling and avoidance of the use of finite fuel materials became increasingly important political issues.

Söderenergi is still continuously improving process operations in order to reduce environmental burdens. A number of innovative and improvement activities have been carried out recently. Amongst these are replacing oil fired burners by vegetable oil fuel and recycle product from the pulp and paper industry, reducing NOx levels by reconsidering combustion chamber design, injection location of ammonia (NH3), using low NOx burners, and improving SNCR66 concept in combination with reversed osmosis (i.e. waste water treatment). Incentives for improvement that are mentioned are a combination of regulation requirements (including European directives such as WID and LCP), NOx refunding, energy efficiency and cost cutting (high oil prices). Yearly an innovation (research) budget of 0.25 million euro is available. One of the main criteria for research project approval is a ROI67 of 3-5 years.

At this moment the IPPC installations of Söderenergi are among the top 20 of the list of more than 400 installations participating in the NOx charge system. The companies are also mentioning this list as a motivation for continuous improvements and being one of the top companies. Very low NOx levels have been achieved, while permit requirements here are about 90 MJ/mg. Normally the company is a net receiver from the NOx charge system. Only from 2000-2002 the company was a net payer due to emission problems after rebuilding one of their boilers. The company was a net receiver in 2005. The total amount of useful energy for the boilers included in the charge was: 1 379 612 MWh. The total amount of NOx for the boilers was: 280 891 kg. This resulted net in 733 335 SEK (net receiver).

Holmen Paper Hallstavik

Holmen Paper is a big European manufacturer and developer of wood-containing printing paper. The products are primarily used in newspapers, magazines, etc. The production capacity in Hallstavik is almost 0.8 million tons per year and about 900 employees are working for the company at this site. There is another production site in Sweden and a daughter company is situated in Spain. In Hallstavik 4 lines of production exist. The county is the competent authority for the company. The company claims to take the environment into the most careful consideration in every phase of production, including de-inking, taking care of recycled products, energy efficiency and managing waste water.

The installations of Holmen Paper are in the top of the list of the installations subjected to the NOx charge. This member of the Swedish Pulp and Paper industry is a net receiver, which is an exception in this industrial sector (see figure 4).

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66 SNCR is selective non-catalytic reduction; i.e. reducing NOx by injecting NH3 in the flue gas stream.
67 Return of investment (ROI)
One of their boilers (80 MWth) managed to accomplish very low NOx emissions (15 mg/MJ), even far beyond the permit requirement (75 mg/MJ), due to optimizing the wastewater treatment system together with applying SNCR. Innovations are organized in the company amongst others by introducing an idea box that can be used by the operating staff to put forward their ideas about improvement. Yearly a budget of around 20 to 30 thousand euros is available for working out some of the ideas. The environmental targets that are set by the top management and their commitment are considered crucial for the environmental performance of the company.

Incentives that were mentioned as relevant by the company were customer requirements regarding emissions per ton of paper, social responsibility, and the (regulatory) margin available for increasing production without passing the emission limit values (ELV). Internal environmental goals were set sometimes 20% below ELV of the current company permit (figure 5.). Although it is acknowledged that operators sometimes keep some safety margins to the required permit levels this example shows a more determined attitude of the operator improving his environmental performance.

Figure 5. NOx emitted to the atmosphere (upper figure) and nitrogen emission to water (lower figure) for large boiler. The red line is the ELV in the permit and the dotted line is environmental target set by the company (was given only for water).

Note that the permit conditions apply for the sum (of emissions) of the installations per site as the NOx charge is focusing on emission per installation.
4.2.5 Conditions to be effective

The centralized approach of the organization of the NO\textsubscript{x} charge working independently from the competent (often) regional authorities dealing with the environmental (IPPC) permits is said to be one of the key issues of the success of the system. Together with the fact and the trust of the companies confident that the funds are returned to them makes the system work efficient and almost without problems.

Although there is some criticism that some companies are more benefiting from the system than others, the national culture of high environmental awareness of Swedish companies together with a relatively flexible cooperation between authorities and companies based on a mutual trust still makes the system work quite smoothly. The system is characterized for instance by a high degree of self-monitoring done by the companies. This is a desirable situation that certainly does not exist in every European country.

Despite the proper working of the NO\textsubscript{x} charge system in general, it appears not to be easy to expand it to a larger number of industries. Difficulties in benchmarking criteria between different industries hamper the progress of enlarging the charge system to other industrial sectors.

4.2.6 Interaction with IPPC

In Sweden there are around 1200 IPPC companies of which the A-category includes the biggest plants (about 500). The Regional Environmental State Courts are the competent authorities for this category. In Sweden the IPPC companies are asked to submit an IPPC statement including their level of performance regarding BAT, waste, energy, accidents and decommissioning.

The NO\textsubscript{x}-charge has no effect on the way IPPC inspections and enforcement is carried out. The NO\textsubscript{x}-charge is a separate system. There is in principle no relation between them.

There is a risk of other emissions increasing when measures are taken to reduce NO\textsubscript{x} emissions to the atmosphere. Modifications of combustion techniques in the combustion chamber of the boiler may lead to less complete combustion and increased levels of harmful pollutants such as carbon monoxide, volatile organic carbons (VOC) and polycyclic aromatic hydrocarbons (PAH). Also flue gas treatment using urea may in some circumstances lead to emissions of N\textsubscript{2}O. This nitrous oxide is not desired as it is a very stable greenhouse gas and is also playing a role in impacting the ozone layer. Finally ammonia emissions, resulting from using ammonia for NO\textsubscript{x} reduction, may occur in flue gases, wastewater or it may condensate in the fly ash. Although minimization of these pollutants is always required current assessments of these emissions (with the exception of N\textsubscript{2}O) point out their relative insignificance. In 2000 the Swedish EPA investigated the emissions of NH\textsubscript{3} and N\textsubscript{2}O from combustion plants using SNCR/SCR\textsuperscript{69}. The permit requirements regarding these emissions must be met at any time. Stricter N\textsubscript{2}O limits are expected to be introduced in the near future (driving force is reduction of greenhouse gases). These could lead to compliance problems (i.e. IPPC permitting versus NO\textsubscript{x} charge) according to the industry.

Another concern that was frequently mentioned was about the interaction between monitoring and reporting format requirements according to the different European directives (in particular WID, LCP) and the NO\textsubscript{x} charge system. For the NO\textsubscript{x} charge more accurate monitoring is required due to the cost aspect, and there are some different reporting requirements than under the LCP and WI Directives.

\textsuperscript{69} The results can be found in the SEPA report “The Swedish charge on nitrogen oxides – Cost-effective emission reduction”, p.15/16, December 2000.
Reporting about the NO\textsubscript{x} charge is not digital. Harmonizing the reporting formats (by the national authorities) should be done in the near future to relief the efforts of the companies as much as possible. A final concern mentioned was about the monitoring standards. Due to the very low NO\textsubscript{x} levels and the required accuracy with respect to the payments per kg NO\textsubscript{x}, companies deviated from standards as prescribed by some European directives (LCP and WID). The last mentioned standards need less accuracy as they are aiming only at monitoring compliance to ELVs, which is a different goal, compared to the NO\textsubscript{x} charge\textsuperscript{70}. Other aspects of the IPPC like energy efficiency, and reuse of waste appear to fit well within the NO\textsubscript{x} charge system.

An overview of the main characteristics, on a fact sheet, of the NO\textsubscript{x} charge system can be found in appendix 1.

\textsuperscript{70} A higher accuracy is needed at the NO\textsubscript{x} charge monitoring as payments are involved. For monitoring ELV you just want to know if you are above or below the ELV.
4.3 Case study 2: Performance Track in the US

4.3.1 General description of instrument

The US National Environmental Performance Track ("Performance Track") program\(^{71}\) is a voluntary partnership program that recognizes and rewards facilities that demonstrate environmental performance beyond current requirements. Performance Track was launched by EPA, the US Environmental Protection Agency, in 2002 and expands the existing regulatory system by creating incentives for facilities to achieve environmental results beyond those required by US law. Key elements of the Performance Track program are the implementation of environmental management systems (EMS) and commitments towards environmental improvements and communication to the local community.

Public or private US facilities of any type, size, complexity level, or economic sector, can participate in Performance Track. To qualify, applicants must:
- Have implemented an independently assessed environmental management system (EMS)
- Have a record of sustained compliance with environmental laws and regulations,
- Commit to achieving measurable environmental results that go beyond compliance,
- And provide information to the local community on their environmental activities.

To be admitted to Performance Track an EMS of a facility must include the following elements:
- Policy,
- Planning,
- Implementation and Operation,
- Checking and Corrective action,
- Management Review.

The independent assessment of the EMS must satisfy criteria defined by EPA. The assessment must cover all of the EMS elements and be consistent with the EMS provisions (EPA's Performance Site Visit Protocol). The person or team conducting the assessment should meet certain requirements on experience and training (as a Performance Track Site Visit Leader) and should not be connected to the facility or company of which the EMS is being assessed. An ISO 14001 certification of the EMS fulfills these requirements for example (but ISO 14001 certification is not required to qualify).

A requirement to be admitted to the program is that a facility must have a record of sustained compliance with environmental laws and regulations. EPA screens all applications on criminal and civil activity and rejects facilities, which are convicted or where an ongoing criminal investigation/prosecution is being undertaken for environmentally related violations of criminal laws involving the corporation or a corporate officer within the past 5 years. For civil activity, the ground for rejection is three or more significant violations at the facility in the past 3 years. In addition, EPA may also consider whether there are significant problems or a pattern of non-compliance in an applicant's overall civil or criminal compliance history.

\(^{71}\) EPA provides a detailed description of the program on the Performance Track website: [www.epa.gov/performancetrack](http://www.epa.gov/performancetrack)
A facility must be able to demonstrate a specific environmental performance and commit itself to continue improvement. To demonstrate earlier performance, a facility is requested to select at least two environmental aspects and to describe the improvements in its performance during the last two years. In making future commitments, facilities are to select at least four environmental aspects drawn from two or more categories. The categories are listed in the Environmental Performance Table (EPT), which contains a set of environmental indicators and measurement units that Performance Track applicants and members must use for creating environmental performance commitments. EPA states that EPT's content and format is based on various US and international reporting guidelines and standards. The categories are:

**Reductions in or improvements on:**
- Material Procurement
- Suppliers environmental performance
- Material Use
- Water Use
- Energy Use
- Land and Habitat
- Air Emissions
- Discharges to water
- Waste
- Noise
- Vibration
- Products

The improvements will have to represent actions taken by a facility that go beyond existing legal obligations. Members report their environmental achievements annually and have to declare that the commitments and improvements made are not subject to any current legal requirements. For each achievement the facility has to indicate whether they are or are not undertaken under Federal, State, Tribal or Local regulatory requirements. If there are regulatory requirements for the indicator, the facility is asked to list those, including the quantitative limits and compliance deadlines that apply and to explain how the commitment exceeds the requirements.

Another requirement for membership of Performance Track concerns commitment to public communication and performance reporting. In its application, each facility is to describe its activities and plans in three areas:
- Identifying and responding to community concerns;
- Informing the community about important matters that affect it;
- Reporting on the facility’s EMS and other performance commitments.

Members are subject to the same legal requirements as other regulated facilities. However in some cases, EPA and states have reduced routine reporting or have given some flexibility to program members in how they meet regulatory requirements.

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72 Reporting guidelines and standards quoted by EPA are the Global Reporting Initiative's (GRI) 2002 Sustainability Reporting Guidelines, the Facility Reporting Project's (FRP) Draft Reporting Framework, and the International Organization for Standardization’s ISO 14001.
To encourage facilities to join Performance Track and to achieve continuous environmental improvement, EPA provides benefits for membership in a variety of ways:

- **Publicity (recognition)** – EPA recognizes member facilities locally and nationally through letters to elected officials, trade journal articles, press releases, case studies, P-Track News, member listings on its website, and Performance Track Awards.

- **Networking** – EPA provides networking opportunities through Annual Member Events, regional roundtables, teleseminars, EPA meetings, joint workshops with Performance Track partners, and meetings of the Performance Track Participants’ Association.

- **Regulatory and Administrative Incentives** – EPA works with states and other stakeholders to provide specific regulatory and administrative benefits, such as reduced self-reporting and low-priority status for routine federal inspections, that are designed to reduce a facility’s transaction costs without causing harm to the environment.

- **Services** – EPA encourages Performance Track facilities to take advantage of services such as the Green Suppliers Network Review, which helps manufacturers and suppliers save money and improve environmental performance, or the Performance Track Mentoring Program, which matches Performance Track members or potential members with top-performing facilities currently in the program.

- **Green Investing** – Leading financial advisory firms use Performance Track data in their research methods. This practice can benefit top-performing, publicly traded companies, making them more attractive to investors and increasing brand recognition.

The organization of the performance track has its own costs. To illustrate this a global elaboration of the organization structure and costs are given below.

The Performance Track team consists of:

- Program staff at EPA Headquarters;
- Regional Coordinators at each of the EPA regions;
- State Performance Track Representatives from state-level environmental agencies;
- Performance Track Network Partners; and
- The Performance Track Information Center

EPA’s annual budget for Performance Track is about $37 million, which is funded by the states. Performance Track is operated by a core staff in EPA’s Office of Policy, Economics, and Innovation, and by Performance Track coordinators in each of the Agency’s 10 regional offices. EPA’s staff works with state environmental agencies to review applications for the program, conduct site visits at member facilities, promote Performance Track and similar state performance-based programs, and develop program policy. EPA coordinates with states in development and implementation of complementary performance-based programs on state level.

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4.3.2 Justification of selection

Selecting performance track in the United States enables a more in-depth study on successful integral instruments and initiatives outside the European Union. The initiative is known for its impact on environmental performance, and could be an interesting example for IPPC installations. One of the main drivers for industries to join the initiative is the (positive) impact on their image.

4.3.3 Effectiveness, advantages and drawbacks of instrument

Currently about 400 facilities participate as members in Performance Track. Members are found in the following sectors:
- Arts, Recreation, and Entertainment (28 Facilities)
- Chemical Products (48 Facilities)
- Electronic and Electrical Equipment (49 Facilities)
- Energy, Utilities, and Sanitary Services (14 Facilities)
- Machinery Equipment (9 Facilities)
- Medical Equipment and Supplies (23 Facilities)
- Metal Products (20 Facilities)
- Mining and Construction (6 Facilities)
- Miscellaneous Manufacturing (9 Facilities)
- Miscellaneous Non-manufacturing (31 Facilities)
- Pharmaceutical Products (30 Facilities)
- Research and Education (18 Facilities)
- Rubber and Plastics Products (26 Facilities)
- Textile Products (5 Facilities)
- Transportation Equipment and Supplies (28 Facilities)
- Wholesale, Retail, and Shipping (6 Facilities)
- Wood Products, Paper, and Printing (33 Facilities)

While the program is running for five years and considered to be the flagship of EPA, the number of participating facilities seems on the low side. The 400 facilities cover less than 1% of the total inspection scope of EPA. An explanation can possibly be the legal consequences of having an (poorly) implemented EMS in the US. Reservations of facilities to implement an EMS could possibly be found in legal arguments, as enhanced tort liability or even enhanced criminal liability. An EMS can play a role in liability discussions when after an incident it appears that risks were already known and addressed in the EMS but no adequate measures were taken. This seems however a specific US law based argument and may not so much be applicable to the situation in Europe. These liability aspects will likely less affect a similar system in Europe.

The Performance Track facilities report annually and publicly on their results and environmental improvement activities undertaken. In addition to monitoring the environmental performance of the program through reviews of the annual reports, EPA conducts site visits with a limited number of facilities (up to 20 each year). Facilities are hereby asked to provide information that supports their participation in Performance Track, including their EMS, information about progress on performance commitments, and community communication.

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The protocol with the questions that are typically asked during a site visit is available online as “The Performance Track Site Visit Protocol”76: EPA provides the inspected facilities also with an assessment of its performance relative to other facilities in the program, and can suggest opportunities for improvements or partnerships with other technical assistance providers. Till now, EPA has removed a total of 49 facilities from the Performance Track program: 34 facilities during their membership (22 for reasons related to a deficient EMS and 12 for failing to submit Annual Performance Reports). An additional 15 facilities were not accepted during renewal (8 for non-compliance, 4 for insufficient environmental commitments, 1 due to a deficient EMS, and 2 for other reasons). Also 18 percent of the members whose three-year terms expired in 2005 submitted no application to renew their membership.

<table>
<thead>
<tr>
<th>Box 3. Brief overview of US regulatory environmental framework for facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the U.S. there are several federal laws that regulate industrial emissions, as in the EU where there are several directives that need to be considered when regulating industrial emissions. Key federal laws that regulate industrial emissions are the Clean Air Act, the Clean Water Act and the Resource Conservation and Recovery Act and which require separate permits.</td>
</tr>
<tr>
<td>The difference of the US approach with IPPC is that the U.S. federal laws cover different media, for instance the Clean Air Act covers air emissions, and the Clean Water Act covers water emissions, while in the EU the IPPC Directive sets common rules on permitting for industrial installations.</td>
</tr>
<tr>
<td>Experimental integrated media permits have been recommended by EPA for certain facilities and have been implemented by some states. Under the IPPC, permits must be based on the concept of Best Available Techniques (or BAT), which is defined in Article 2 of the Directive. In the U.S. permits must be based on different operational requirements, e.g. BACT (Best Available Control Technology), RACT (Reasonable Available Control Technology) or NSPS (NSPS, emission standards based on Best Demonstrated Technology that is economically feasible)</td>
</tr>
</tbody>
</table>

The collectively achieved environmental (beyond regulatory compliance) improvement of all Performance Track members is reported in the EPA Annual (Fourth Progress) Report 200677. The report includes collected data on environmental achievements of all Performance Track members over 2004 and lists 938 reported progress result on facilities’ commitments (table 4).
### Table 4. Performance Track Members’ BRC compliance results in 2004\(^78\)

<table>
<thead>
<tr>
<th>Category and Indicator</th>
<th>Improvements made in 2004 (1)</th>
<th>Avoidance (2)</th>
<th>Units</th>
<th>Number of results (3)</th>
<th>Number of normalized improvements (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material Procurement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers’ hazardous materials use</td>
<td>0.03</td>
<td>0.03</td>
<td>tons</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Suppliers’ packaging use</td>
<td>12</td>
<td>18</td>
<td>tons</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Material Use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers’ hazardous materials use</td>
<td>(125,468)(5)</td>
<td>3,763</td>
<td>tons</td>
<td>49</td>
<td>36</td>
</tr>
<tr>
<td>Suppliers’ packaging use</td>
<td>30</td>
<td>28</td>
<td>tons</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Water Use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total water use</td>
<td>527,936,376</td>
<td>4,305,206,523</td>
<td>gallons</td>
<td>108</td>
<td>80</td>
</tr>
<tr>
<td>Transportation energy use</td>
<td>21,925,739</td>
<td>18,935,094</td>
<td>MMBtus</td>
<td>147</td>
<td>96</td>
</tr>
<tr>
<td>Land &amp; Habitat conservation</td>
<td>43,362</td>
<td>27,752</td>
<td>gallons</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Air Emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenhouse gases</td>
<td>3,933</td>
<td>66,147</td>
<td>MTCO2E</td>
<td>37</td>
<td>28</td>
</tr>
<tr>
<td>Volatile organic compounds (VOCs)</td>
<td>(36)</td>
<td>253</td>
<td>tons</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx)</td>
<td>1,862</td>
<td>2,038</td>
<td>tons</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Sulfur oxides (SOx)</td>
<td>1,440</td>
<td>1,196</td>
<td>tons</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>84</td>
<td>173</td>
<td>tons</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.08</td>
<td>0.08</td>
<td>tons</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Air toxics</td>
<td>63</td>
<td>97</td>
<td>tons</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Ozone depleting gases (ODGs)</td>
<td>0.65</td>
<td>0.62</td>
<td>tons</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Discharges to Water</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharges of BOD, COD, TSS, nutrients, sediments to water</td>
<td>7,390</td>
<td>14,154</td>
<td>tons</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Discharges of toxics to water</td>
<td>129</td>
<td>224</td>
<td>tons</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td><strong>Waste</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-hazardous waste generation</td>
<td>(21,745)</td>
<td>180</td>
<td>tons</td>
<td>180</td>
<td>116</td>
</tr>
<tr>
<td>Hazardous waste generation</td>
<td>791</td>
<td>114</td>
<td>tons</td>
<td>114</td>
<td>71</td>
</tr>
<tr>
<td>Noise</td>
<td>10</td>
<td>4</td>
<td>dBA</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected lifetime waste (to air, water, land) from product use</td>
<td>20</td>
<td>1</td>
<td>tons</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Waste to air, water, land from disposal</td>
<td>140</td>
<td>2</td>
<td>tons</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

\(^78\) reproduced from the EPA Annual, Fourth Progress Report 2006
1. Improvements represent the difference between 2003 and 2004 actual quantities.

2. "Avoidance" is the difference between the actual 2004 level of environmental performance and that which would have resulted if the facilities had not implemented any improvements, i.e., if they had not achieved any improvements in eco-efficiency. It is calculated by multiplying the 2003 level of environmental performance by a factor that represents the change in economic activity between 2003 and 2004, and then by subtracting the actual level of performance in 2004.

3. These numbers represent the number of commitment results included in the analysis, rather than the total number of commitments under the particular indicator. Some members’ results are not included in the analysis because their 2004 Annual Performance Reports were not completed by the cut-off date. Other results were excluded from the calculations due to missing or nonstandard data.

4. These numbers represent the number of results of an improvement in eco-efficiency. A lack of improvement can mean the facility’s performance either remained unchanged for the year or declined in terms of efficiency.

5. Numbers in parentheses indicate an overall increase irrespective of production. Numbers in the avoidance column indicate improvements in efficiency.

6. CFC-11=trichlorofluoromethane (CCl3F); MMBtus=million British thermal units; MTCO2E=metric tons of carbon dioxide equivalent; BOD=biochemical oxygen demand; COD=chemical oxygen demand; TSS=total suspended solids; dBA=decibels (acoustic).

The achievements in the table (columns 2 and 3) are the result of beyond regulatory compliance actions. It is not possible to assess the significance and importance related to the environmental pressure of all US facilities. The number of facilities participating is about 1% of the total inspection scope of EPA so the impact of the scheme on total US environmental performance is expected to be limited.

The total number of results is lower than expected, considering the number of facilities in 2004 (expected to be somewhere around 300 to 350) since major facilities have to commit to at least four environmental improvements, the number of results should be around at least 1200 - 1400. Small (SME) facilities however, are asked to demonstrate two future commitments rather than the four required by major facilities. EPA also states that some members’ results are not included in the analysis because their 2004 Annual Performance Reports were not completed by the cut-off date. Other results were excluded from the calculations due to missing or non-standard data.

A closer look at the performance of a few members

EPA provides public access to the achievements of the members of Performance Track. The application forms and the annual reports of all participating facilities are available from the EPA Performance Track website. To get an insight in Performance Track on facility level, three different, randomly chosen, facilities were reviewed:
- Monsanto Company, Muscatine, Iowa Plant
- New Hampshire Ball Bearings
- City of Manassas Maintenance Garage

Regarding the IPPC directive in relation to these facilities, the Monsanto Plant is a large chemical manufacturing plant and to be regarded as an IPPC Annex I facility79. The New Hampshire Ball Bearings is a metal working facility and can also be possibly regarded as an Annex I facility80, however this can not be concluded from the application and reports since both application and annual reports do not list technical information on processes.

79 Source: IPPC, Annex I, 4.4. Chemical installations for the production of basic plant health products and of biocides
80 Source: IPPC, Annex I, 2.6. Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m³
The activities of City of Manassas Maintenance Garage, which is to be considered as an SME, are not covered under IPPC and therefore not to be compared with an IPPC facility. The Manassas Maintenance Garage is only reviewed here to get an impression on how Performance Track handles both large industrial facilities as small SME’s.

Monsanto’s Muscatine (Iowa) plant manufactures herbicide technical ingredients and formulates and packages herbicides into liquid, encapsulated and granular finished products.

**The Muscatine plant**
The Muscatine plant applied for Performance Track in 2000 and has been a member since 2001. In the application the plant selected two past achievements on environmental improvement. Reductions claimed in the last two years were 40% on total energy use and 60% for total water use. Both reductions, related to the quantity of product manufactured, were achieved by an improvement in the manufacturing process and not further specified in the application. In the application commitments for the next three years were made on four environmental aspects from the environmental performance table (and which were marked as significant for the EMS of the plant):
- Reduction of total energy use
- Reduction of total water use
- Reduction of total solid waste
- Reduction of BOD discharges to water

The application includes furthermore some elements of the EMS system as the guiding principles, the audit management systems, a pollution prevention program and the planned public communication efforts.

The Monsanto plant has made large reductions in the eco-efficiency of the processes. The annual report of 2003 of Monsanto’s Muscatine reports improvements on eco-efficiency for these indicators that go beyond the commitments. Reported are for total energy use an improvement of 57% (commitment 33%), total water use 50% (commitment 45%), BOD discharges to water 72% (commitment 33%) and solid waste has reduced to more than 25% (commitment, absolute amount) of the baseline.

Most of these environmental improvements are however induced by process-improvements, which have no specific environmental drivers.

For 2004 an application renewal is admitted in which new commitments are made on eco-efficiency:
- Reduction of material use, especially herbicide intermediate (1%)
- Reduction of material use, specially a granular processing aid used in herbicide manufacturing (30%)
- Reduction of total (non-transportation) energy use (1%)
- Reduction of transportation energy (17%)

These current commitments seem less ambitious than the commitments from the first three-year round, which is probably an indication, that the easy to reach improvements are made in the beginning of the performance track. It could be expected that in the longer run the instrument is less effective for individual companies.

In its latest 2005 annual report the plant reports on the material use indicators an improvement of 2% caused by placing an extra reactor for increased yield, but reports for the second indicator a decrease of efficiency of 3%. For the energy indicators the non-transportation energy used reduced with 12% (commitment 1%) where the transportation energy used was reduced with 79% (commitment 17%). The recommendations from an energy audit on the plant’s compressed air system were implemented in 2004 (larger surge tank and improved controls on the air compressors) and progress was made to reduce the amount of diesel fuel used to ship waste off-site for disposal by reusing the wastewater.
The 2005 report further reports that the Muscatine plant supported educational and community involvement by:
- Hosting four groups to the Big Sand Mound and Prairie Restoration areas in 2005 (105 total).
- Delivering a presentation in Chicago at an Environmental Partnership Summit on the benefits the site has experienced as a result of the PT program.
- Attending a Restoring Greenspace Conference in New Orleans hosted by the Wildlife Habitat Council.
- The Muscatine plant Biotechnology Communications Committee made several presentations to local elementary schools on the effects of a growing population on limited natural resources.

The plant further reports to seek certification of its EMS under the Responsible Care (RC)14001 protocol in 2007. The RC 14001 certification is developed by the chemical industry and consists of an integrated management system in which both ISO 14001 and Responsible Care are combined.

**New Hampshire Ball Bearings, Inc.**

New Hampshire Ball Bearings (NHBB) in New Hampshire is a manufacturer of precision roller, machine tool, rod ends, spherical, and miniature bearing products. NHBB applied for performance track and is a member since 2001. The EMS of NHBB is ISO 14001 certified. Earlier commitments from 2001 to 2004 were to:
- Reduce total energy use.
- Reduce total materials use (oil used in the primary department).
- Reduce hazardous materials use (nitric acid for passivation).
- Total water use.

The commitments were normalized to direct labour hours. Of these commitments only a sufficient reduction of the use of Nitric Acid for passivation was achieved, other targets were not met.

Current commitments are to:
1. Reduce the generation of, and improve the management of non-hazardous waste.
2. Reduce total GHG emissions
3. Reduce total water use

Drivers for these commitments are, besides environmental concerns, most probably also savings on costs caused by water use and prevention of material use losses and waste extraction.

The amount of non-hazardous waste is reduced by 14% with better segregation of the waste stream, increased employee awareness and increasing efforts on recycling. The baseline for the performance track has been changed compared to the one provided in the renewal application (751 instead of 556 tons). An explanation is not provided.

In the application for the current performance track period NHBB does state a commitment to reduce greenhouse gas emissions. This commitment is however not quantified. The GHG inventory was not finalized at that time of application. The 2005 annual progress report states that NHBB is participating in the EPA Energy Challenge and reduced GHG emissions with 6% from 2003 to 2004.

Although NHBB installed in 2004 a recycling system (reverse osmosis) to re-use a portion of the wastewater the proposed reduction of water usage was not accomplished. An explanation for the increase in water use is given by the fact that both new and old systems were operated together.

The 2005 report further reports that NHBB supported educational and community involvement by hosting an Energy Fair in September 2005. This was done to educate the employees, members of the local community and students at the local high school about the impacts of energy use.
City of Manassas Maintenance Garage
The Manassas Maintenance Garage maintains all municipal governments’ vehicles (Approx. 500) like heavy trucks, heavy equipment, tractors, police cars, school buses, pickup, cars etc. The garage has a staff of fewer than 50 and can be considered as a SME.

In the application of 2004 the garage selected two past achievements on environmental improvement:
- Total energy reduction (current 2553 kWh, 3646 kWh in 2000) by replacing the lights in the garage with metal halide bulbs to reduce energy usage
- COD Discharges to Water, was 419,550 pounds, current it is 0 because all discharges now go to a waste water plant (Publicly-Owned Treatment Works)

Three-year commitments are made for:
- Total materials Used (solvents): from 10,000 lbs to 0 lbs: The garage will stop using chemical parts washers that produce approximately 10,000 lbs of chemical solid waste a year. It will be replaced with a contained heated aqueous solution cleaner, the solution recycles and requires replacement only about every 100 days.
- Hazardous Materials Used: a 10% reduction from 2002 (459 tons) to 2006 (413 tons); the garage will attempt to reduce vehicle fuel (gasoline) usage with policies to reduce unnecessary driving, shutting off vehicles if their drivers going to sit down for more than 10 minutes, taking less vehicles to job sites etc.

Drivers for these commitments are, besides environmental concerns, most probably also savings on costs caused by the increasing costs of fuel.

The 2005 annual performance report (year 2) of the garage states that the total use of solvents is decreased to 3000 lbs and the fuel use (reported under hazardous materials use) is decreased to 450 lbs (reduction of 2%). The garage intents to identify and respond to the community concerns by newspaper, phone number on the website, through calls to the fire department, police department, public works, City Hall etc.

Review of performance
When reviewing the actual performance made by the members we based our analysis on three, more or less randomly chosen facilities of different categories. All facilities have met the criteria for the Performance Track program, Monsanto’s Herbicide plant in Iowa, being a division of a large multinational chemical company, the New Hampshire Ball Bearings facility, a ISO 14001 certified manufacturing facility and finally the Manassas Maintenance Garage, being a public service which resembles an SME. Reviewing these three different facilities, large differences can be seen in the type of improvements and reporting.

The Monsanto plant has made large reductions in the eco-efficiency of the processes, but most of the environmental improvements are induced by process-improvements that do probably not have an environmental driver. Also the current commitments seem less ambitious than the commitments from the first thee-year round. The application of NHHB lacks a motivation for the shift in commitments and the reduction to three instead of four commitments. The annual report also misses an explanation for the altered baseline for hazardous waste. The Manassas Garage (typical for a small facility) reports only two commitments. Small (SME) facilities however, are asked to demonstrate two future commitments rather than the four required by major facilities.
As could be deduced from the table with the environmental progress results from EPA’s 2005 annual report, the number of commitments made in Performance Track does not correspond with the minimal required number of four. In the three reviewed facilities we see that Monsanto provides for four commitments, which are much alike, as being two energy indicators and two material use indicators. The NHHB facility only commits to three environmental indicators and does not motivate the lack of a fourth commitment. The Manassas Garage finally commits itself to only two environmental indicators, of which the reduction on transport fuel is basically an energy indicator but is promoted as reduction of hazardous materials. It would be useful for these specific sites to give information on the application of regulatory requirements, and how these were modified as a result of participation in Performance Track. However no ready available detailed information on this is in the progress reports.

EPA concludes in the 2005 4th Progress Report: "Membership in the program grew by 33 percent in 2005, and members reported another year of impressive voluntary environmental achievements. The results reported in 2005 (for the 2004 reporting year) highlight the complex challenges faced by facilities in meeting their Performance Track commitments when their production increases. Many of the commitments made by members, such as improvements in energy and water use, or the generation of solid waste, are tied directly to production. In most cases, Performance Track members succeeded in improving their eco-efficiency, producing less waste and fewer emissions per unit of production and thus avoiding many tons of pollution than otherwise would have occurred. ..."

An independent assessment of the Performance Track program is currently being conducted by Harvard University’s Kennedy School of Government, but results are not available yet.

**Advantages**

The environmental improvements made by the facilities in Performance Track are to be beyond regulatory compliance. The reported environmental performance would therefore not have been reached with the existing regulatory framework.

Performance Track offers advantages for the regulatory bodies:

- The policy of considering members to be a low priority for routine inspection allows EPA and states to shift inspection resources from facilities with strong compliance records to facilities that present a greater risk of non-compliance and those which are rarely, if ever, inspected.
- Promotion of implementation of EMS in industry, because potential members are obliged to implement an EMS.

As an example of a regulatory incentive EPA is developing Flexible Permitting. The term “flexible permit” is used to describe for example air permits with conditions designed to reduce the administrative “friction” – costs, time, delay, uncertainty, and risk – experienced by sources and permitting authorities when implementing a permit or making certain changes under the permit. This is accomplished by allowing a facility to make certain types of changes (e.g., modifications to a source’s method of operation, equipment, raw materials, emission factors, or monitoring parameters) without requiring additional case-by-case permitting, provided the source meets certain criteria outlined in its operating or construction permit.

**Drawbacks of instrument**

Performance Track is strongly build upon the obligation to implement an environmental management system before participating. An EMS, being a useful system, offers itself however no special guarantees when it comes to legal compliance or when it comes to emission reductions, waste prevention, external safety, or energy efficiency. The promotion of continuous improvement in an EMS also hardly refers to the speed of improvement in environmental performance.
This does not mean the same as, for instance, performance according to BAT, as the IPPC Directive demands from operators of (large) industrial installations. Besides, an EMS is for a number of industrial sectors already considered as BAT. Also, having a certified EMS and a clean compliance record in the past does not guarantee full compliance. Dutch empirical research for instance has shown that EMS (ISO 14001) certification offers no special guarantees for compliance in daily practice. The study, conducted on behalf of the Dutch Ministry of Justice, shows that 63 per cent of the companies with an ISO 14001 certified EMS violate the rules of the “Wet verontreiniging oppervlaktewateren” (Pollution of Surface Waters Act), while only 24 per cent of the companies without an EMS act in the same way. A possible explanation is that companies with an EMS are usually large and more complex organizations. The relatively low number of site visits in relation to all Performance Track facilities (20 visits a year for a total of about 400 facilities) does not ensure compliance with the members.

This concern is shared by the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) in their recent letter to EPA (Oct. 2005). The two national associations of air pollution control agencies ask EPA to improve the review on admission and compliance of the facilities. STAPPA and ALAPCO claim to have heard a number of comments from their members about Performance Track participants: “For example, members have observed, “their compliance is no better than others;” “having a violation does not result in getting kicked out;” “[all] of our performance track facilities have some kind of violation;” and “there is no full compliance evaluation (FCE) before admission to the program.” STAPPA and ALAPCO state that several states have indicated that the bar for admission is “too low” and that contrary to the membership criteria, it appears that compliance of many member facilities is not “sustained.” They urge EPA to set and enforce standards for determining the continuing compliance of member facilities, preferably through normal inspections, and promptly removing non-complying facilities from Performance Track status. The problem appears that in Performance Track there is no guarantee that participating facilities comply with legal requirements nor that facilities comply with the commitments to the programme.

Another concern about the Performance Track program is that only those facilities that will strongly benefit from this recognition will participate. Small companies do not benefit from the recognition and are less willingly to participate. As can be seen from the member directory, many of the currently participating facilities are multi facility (and even multinational) companies with a strong public image. Some of the 48 organizations, which have more than one facility in the Performance Track Program, are listed below:

- 3M Company (15 Facilities)
- Coca-Cola Company (3 Facilities)
- Du Pont de Nemours and Company, Inc. (6 Facilities)
- Fuji Hunt Photographic Chemicals, Inc. (3 Facilities)
- Hewlett Packard (4 Facilities)
- Intel Corporation (3 Facilities)
- Johnson & Johnson (36 Facilities)
- Lockheed Martin Corporation (11 Facilities)
- Monsanto Company (3 Facilities)
- Motorola, Inc. (4 Facilities)
- Pfizer, Inc. (9 Facilities)

82 Source: http://www.4cleanair.org/Performancetrack-103105.pdf
83 Source: http://www.4cleanair.org/Performancetrack-103105.pdf
This is being confirmed by a recent study on internal factors and their influence on corporate environmental decisions\textsuperscript{84}. In this study ten closely matched facilities were reviewed, five of which participated in Performance Track. The study suggests that Performance Track facilities may not systematically have better environmental performance than non-participating facilities. Interviews showed that managers in Performance Track facilities value recognition from outsiders, including the EPA, but the other benefits and goals of the program were not apparent in the comments of managers. They did not speak of Performance Track as a vehicle for improving environmental performance or enabling innovation; indeed, they largely saw it as “easy” to join because they were already doing many of the things that the program required. The matched facility interviews showed that such facilities may shun, rather than seek, recognition from outsiders, preferring to keep a low profile and achieve environmental results. The study concludes that the Performance Track program attracts those who already actively cultivate an identity of environmental responsibility and environmental leadership, who value recognition and actively seek to engage regulators and communities, and who enjoy managerial support for such efforts.

4.3.4 Conditions to be effective

It has been acknowledged that legislation is the main driving force for environmental improvement. However, the type of legislation and regulation is extremely important. While emission limit values are necessary in certain instances, legislation based solely on this concept is unlikely to encourage environmental performance beyond regulatory compliance\textsuperscript{85}. For an instrument as Performance Track to be effective in stimulating facilities in going beyond the regulatory compliance, the willingness of participation of the facilities is necessary. Since Performance Track is a voluntary program, the incentives and benefits gained must somehow outweigh the costs for the facilities of performing beyond environmental compliance. EPA rewards the Performance Track members with benefits as recognition (publicity) and by developing regulatory and administrative actions that only apply to member facilities.

In relation to the European situation an instrument as Performance Track can be applied in a similar way as in the US. The regulatory authorities will have to develop incentives for the facilities to stimulate self-control of their environmental performance. The incentives can be much like the benefits used in the Performance Track program. With such a comparable approach, the authorities can redirect their regulatory and inspection capacity towards the facilities where this capacity has most effect. If a EU-wide initiative is desired an infrastructure would need to be set up.

\textsuperscript{84} Constructing the License to Operate; Internal Factors and their Influence on Corporate Environmental Decisions, Harvard University, August 2006, source http://www.ksg.harvard.edu/m-rcbg/CSR/publications/workingpaper_27_howard-grenvilegeetal.pdf
\textsuperscript{85} Source: -Dermot Cunningham, IPPC, BAT, and voluntary agreements, Journal of Hazardous Materials, Volume 78, Issues 1-3, 3 November 2000, Pages 105-121
4.3.5 Correlation with IPPC

The IPPC Directive is based on several principles, such as an integrated approach, flexibility and public participation. In Performance Track, facilities have freedom to select only a limited number of environmental indicators on which should be reported and improvements to be made. This differs from the integrated approach in IPPC which means that permits must take into account the whole environmental performance of a facility (plant), covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.

Performance Track allows for regulatory flexibility. Member’s benefits are lower priority for routine inspections, possibility of networking with EPA officials and members of the program and reducing paperwork and reporting requirements. This seems comparable to the IPPC element of flexibility by allowing the licensing authorities, in determining permit conditions, to take into account specific technical characteristics of the installation, geographical location and the local environmental conditions.

An important part of Performance Track is community outreach (communication) of the facilities. Public participation is also included in the IPPC. It ensures that the public has a right to participate in the decision making process and to be informed of its consequences, by having access to information as permit applications and results of monitoring of emissions.

Performance Track builds on efforts at state level to promote the use of EMS in facilities, while with IPPC EMS are more and more regarded as integral part of BAT for IPPC installations. A recent study gained some insight into the existence of relationships between enterprises’ technological (and environmental) performance, IPPC and ISO 14001 certification in Slovenia. It was found that Slovene metal and chemical industrial companies, which were ISO 14001 certified enterprises, considered their EMS as a very useful tool in promoting and adopting new cleaner techniques. In addition, it was confirmed that ISO 14001 seems to be particularly important to create better conditions for the technology changes in IPPC Annex I companies.

An overview of the main characteristics, on a fact sheet, of the Performance Track program can be found in appendix 2.

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4.4 Case study 3: Green Network in Denmark

4.4.1 General description of instrument

Networks between private companies and environmental and occupational health and safety authorities (OHS) have been established in several counties and municipalities in Denmark.

The total number is about 11:

- Green Network, Vejle County
  (http://www.greennetwork.dk/)
- Netværk for Grøn Erhvervsudvikling i Storstrøms Amt
  (Network for Green Business development in Storstrøms County)
  (http://www.n-ge.dk/)
- Netværk for virksomheder med ISO 14001 eller EMAS, Bornholms Amt
  (Network for companies with ISO 14001 or EMAS), Bornholm County
  (http://www.groenerhvervsudvikling.net/nt/netvaerk.html)
- Københavns Miljønetværk
  (Copenhagen Environmental Network)
  (http://www.kbhmiljonet.dk/http://www.kbhmiljonet.dk/)
- Grønt Netværk Sønderjylland
  (Green Network South Jutland)
  (http://www.gns.dk/)
- Miljøforum Midtjylland
  (Environmental Forum Central Jutland)
  (http://www.mfaa.dk/)
- MiljøForum Fyn
  (Environmental Forum Funen)
  (http://www.mf-fyn.dk/)
- Holbaekregionens Miljøforum
  The Environmental Forum in the area of Holbaek
  (http://www.miljoforum.dk/)
- Albertslund Miljøforum
  (The Environmental Forum in Albertlund Municipality)
- Miljønetvaerk - Ribe Amt
  (Environmental Network – Ribe County)
  (http://www.milra.dk/)
- Miljøforum Nordjylland
  (Environmental Forum North Jutland)

Their *mission* is to work for environmental improvement and in the case of Green Network for sustainable development with a focus on environment, occupational safety and social responsibility. The oldest of these networks, Green Network in Vejle, will be used for illustration.

The Green Network in Southeast Jutland was established as regional, local initiative in 1994. The mayors of the county and the largest municipalities and top directors of local industry decided and backed up the establishment of the network. The other green networks in Denmark are initiated by inspiration of the Green Network but implemented in a local context. The key criteria are local engagement and back up by
the top politicians and top managers of local industry. Nationally the networks are supported as good
initiatives, but there has been no substantial financial or political support so far from central level.

The key words in this cooperation are dialogue, voluntary agreement and continuous improvement. Key
employees from the authorities are available to support the companies to go beyond national regulation
(BRC) with consultancy primary implementing the Green Network EMS. Courses, conferences and
seminars for the members also support the work. These facilities are very inexpensive for the members
and many of them find the inspiration to continue their work on sustainability in their own companies.

Today Green Network has 269 members in one of four categories87:

- **V-members**: Committed to perform continuous improvements BRC and to document this
  achievement in an environmental report (alternatively social and occupational health and safety
  report) every second year. (V = “Virksomhed” (Enterprise))
- **I-members**: Interested in following the achievements of the network and to participate in meetings
  and activities, but are not committed to BRC – some are enterprises, some are educational
  institutions, some are consultants (I=Interest)
- **O-members**: Municipalities with their publicly owned institutions (sewage treatment works,
  incinerators, hospitals, fire brigade, town halls etc.) as well as environmental regulators (O =
  offentlig” (Public))
- **K-members**: Smaller municipalities who only has the obligation to help companies to whom they
  are the competent authorities (K=commune)

More than 150 members in the network are V-members (of which 60 % is industrial production
enterprises), obliged to make sustainability reports (on environment, social engagement or occupational
health & safety) regularly. About 750 reports have been made so far, out of which 95% are environmental
reports. There are many SME’s among the V-members, but also some large enterprises (around 10 %).
The V-members present a large spectrum of different branches of industrial production, some of which are
covered by the IPPC Directive, e.g.

- Waste incineration (TAS, Kolding),
- Waste recovery (Uniscrap, H.J. Hansen),
- Glass wool and mineral wool (Isover Saint-Gobain, Rockwool),
- Metal surface treatment (Scan Bejds Steel),
- Polymers (Star Pipe, Alsom Power Flowsystems),
- Oil refining (Shell),
- Aluminum (Stena Aluminium)
- Food (Tholstrup Cheese, Tulip Food Company, Tuborg Fredericia, Coca-Cola, Gumlink, Cerealia
  Unibake, Danpo),
- Surface treatment using solvents (Smurfit Kappa, Schur Pack Denmark),
- LCPs (Elsam Kraft).

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87 [http://www.greennetwork.dk/page37.asp](http://www.greennetwork.dk/page37.asp)
The Green Network and environmental authorities support these companies in their IPPC approval procedure. However, the aim of the network for V-members is to support continuous improvements: BRC (i.e. continuous environmental improvement efforts) must be documented in the environmental report from V-members in order for the V-member enterprises to get their diplomas, and therefore – to support this effort the network has assisted in the preparation of a manual for the environmental report with the following focus points:

- environmental policy;
- collection of relevant data;
- key environmental figures;
- evaluation and prioritization of significant environmental parameters;
- goals and action plans.

The environmental enterprise reports are public and can be downloaded from the Green Network web site, or from a link to the respective companies web pages. The authority members and the Green Network secretariat\(^88\) assess the implementation of EMS and issue diplomas on that base. Diplomas can be issued for environmental, social or occupational health & safety achievements – the majority being for environmental achievements (since environment has been an issue for more than 10 years, while social engagement and occupational health & safety has only been on the agenda for a couple of years). The manual is also of great assistance, a major first step if a company wants to implement also ISO 14001 or EMAS.

The Green Network has also prepared a manual covering occupational health and safety (OH&S) and social responsibility, and it is up to each V-member to choose, whether they want to be awarded (with a diploma and a flag) for environment, OH&S and social responsibility or just one or two of the subjects. Experience shows, that as it gets more and more difficult to obtain significant environmental improvements in time, the V-members continue to make voluntary improvements regarding OH&S and social responsibility.

V-members have the right to receive assistance from the authority to perform an initial survey on environment, and continuously to have dialogue with the authority on the implementation of EMS. This aid is a part of an employment program, where unemployed people with an academic degree have the opportunity to get experience from a production company, and at the same time providing the production companies with assistance to carry out an initial survey and/or reporting according to the Green Network requirements. Apart from giving the assistance to the production companies, this often also results in the employees obtaining regular employment in the one of the production companies, where they have been assisting, or giving them so much experience, that they can obtain a job in a different production company performing the same kind of job. Especially for the SMEs support for implementation of EMS is important since SMSs often don’t have capacity on its own. For example Scan Bejds Steel, which is a metal surface treatment company with less than 10 employees, has benefited from this assistance. The burden of implementing an EMS for such a small IPPC-company is high, so the assistance to the company was welcomed very much as it relieved the cost of complying with the IPPC requirements. This kind of consulting support has assisted a lot of installations in achieving ISO 14001 and/or EMAS certificates.

\(^{88}\) The Green Network secretariat is a part of the administration of Vejle County with a separate economy. The permanent staff is 3.5 persons (2.75 academic and 0.75 technical personal).
The experience from Green Network has now spread out to several other regions in Denmark, and therefore a nationwide organization “Key2Green” has been founded to congregate experience and coordinate development relevant to environment in all these networks. Moreover Key2Green has to develop tools for gaining market benefit from sustainability work.

In the case study the effectiveness of this Green Network, the main drivers within it and the conditions for success are assessed.

4.4.2 Justification of selection

The Green Network is an example of a combination and cross-linking different tools to (potentially) obtain performance BRC, as it involves implementation of EMS, close dialogue and cooperation with authorities (differentiated inspections/enforcement) and social responsibility. In addition, selecting this example will raise possibilities to assess various sizes of industries including the SMEs involved in the case study. A comparison between the experiences within the network at SME level with those at the large industrial level provides additional, interesting information on conditions for success.

4.4.3 Interviews

From 25 until the 27th of September 2006 the following interviews were conducted with relevant stakeholders of the Green Network of the county of Vejle.

<table>
<thead>
<tr>
<th>Name of interviewee</th>
<th>Occupation</th>
<th>Involvement with Green Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr J. Christensen</td>
<td>Former chief of environmental department in Vejle</td>
<td>Closely involved at the start-up and first years of Green Network</td>
</tr>
<tr>
<td>Mrs A. Aakesson</td>
<td>Environmental manager of Isover, Vamdrup, production of Glass Wool &gt; 20 tons/day (IPPC category 3.4)</td>
<td>Member of the Green Network</td>
</tr>
<tr>
<td>Mrs T.B. Kristiansen</td>
<td>Environmental coordinator of TAS IS, Kolding, a (domestic and industrial) waste incineration site with a capacity of &gt; 10 tons/hr (Category 5 of IPPC)</td>
<td>Member of Green Network</td>
</tr>
<tr>
<td>Mr P. Wade</td>
<td>Environmental inspector of IPPC companies in the region of Vejle (South Jutland)</td>
<td>Closely involved with Green Network members, IPPC companies and SME's.</td>
</tr>
<tr>
<td>Mrs D. Bramsen Clausen</td>
<td>Coordinator of Green Network administration in Vejle</td>
<td>Since many years working for thee Green Network administration</td>
</tr>
</tbody>
</table>

Table 5. Interview with stakeholders Green Network.

During the interviews discussions were held about the background, the legal context and boundary conditions, advantages and disadvantages of the Green Network during the last 10 years. Also the fit with the IPPC was assessed. In the next paragraphs the highlights of these discussions are summarized. All of this information is derived from the discussions with the interviewees.
4.4.4 Effectiveness, advantages and drawbacks of instrument

Especially in the first 10 years of the Green network the members achieved considerable results in the field of the environment (table 6). During the last few years especially the old members have difficulties to (significantly) improve their environmental performance and are now more focusing on occupational health and safety and social responsibility issues. According to the stakeholders the main advantage of the Green Network is the low profile way of supporting and stimulating the companies to set and achieve relatively small environmental goals that go beyond what is required in the permit. The companies are convinced in more effectively achieving their environmental standards in this way. Apart from this the regional positive environmental image of the company also plays an important role. Most companies that are members and that are achieving their goals and diplomas have a Green Network flag hanging outside.

According to the municipalities (highest contributor) joining the Green Network investments are cost effective. The use of less resources by Green Network environmental authorities has been shown in a review by Danish Environmental Protection Agency about 5 years ago. Estimations of using 30-40% fewer inspection and permitting resources (achieved after several years of introduction of the GN) compared to other non-Green Network municipalities legitimate the investments in the Green Network (16% of 0.5 million-euro budget per year in total). The new allocation of these saved resources is often a political choice.

Table 6. Achievements of members of Green Network.

<table>
<thead>
<tr>
<th>Achievement</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15 % reduction in energy consumption over two years</td>
<td>Gumlink</td>
</tr>
<tr>
<td>-75 % reduction of waste water, 75 % reduction of dioxin-emissions</td>
<td>TAS, Kolding</td>
</tr>
<tr>
<td>-5 % reduction in energy consumption relative to produced amount</td>
<td>Rockwool</td>
</tr>
<tr>
<td>-95 % recycling of waste, decreased consumption of water and energy</td>
<td>Coca Cola</td>
</tr>
<tr>
<td>relative to produced amounts</td>
<td>Tholstrup Cheese</td>
</tr>
<tr>
<td>-20 % reduction of waste for incineration</td>
<td>Tuborg Fredericia</td>
</tr>
<tr>
<td>-8 % reduction in water consumption despite implementation of new water</td>
<td>Shell</td>
</tr>
<tr>
<td>consuming processes</td>
<td>Uniscrap</td>
</tr>
<tr>
<td>-50 % reduction in SO2-emissions in two years, 4 % reduction in energy</td>
<td>Elsam Kraft</td>
</tr>
<tr>
<td>consumption and 5 % decrease in water consumption</td>
<td>Saint-Gobain Isover a/s</td>
</tr>
<tr>
<td>-12 % reduction in consumption of diesel oil, 2 % reduction in waste for</td>
<td>Stena Aluminium</td>
</tr>
<tr>
<td>deposition</td>
<td>H.J. Hansen</td>
</tr>
<tr>
<td>-Demand of suppliers having implemented EMS</td>
<td></td>
</tr>
<tr>
<td>-28 % reduction of ammonia-emissions</td>
<td></td>
</tr>
<tr>
<td>-90 % reduction of waste for special deposition</td>
<td></td>
</tr>
<tr>
<td>-Reduction of oil in waste water using biological decomposition</td>
<td></td>
</tr>
</tbody>
</table>

Note: 80 % of members had achieved reductions in energy consumption, and more than 20 % actually reduced by more than 25 %.

It has been tried to attribute the environmental results to Green Network, but it appeared to be very difficult to sort out all the impacts for different reasons.

89 66% is paid by the county and 16% by the companies.
Some examples of small environmental improvements (e.g. of TAS waste incineration) beyond what was required by their permit that could be mentioned were:

- setting goals stricter then the standard such as the content of TOC (2 in stead of 3%) in slag and the emission of dust to the atmosphere (5 in stead of 10 mg/m3);
- developing a rain water collection and recycle system for cooling slag and quenching flue gas.

Main drivers for the company are said to be a good image, as 8 municipalities own the company. The company wants to be ahead of developments so as to serve as a good example to the community. A driver to make use of rainwater is of course also a financial one.

Examples of environmental improvements done by Saint-Gobain Isover a/s glass wool production that are beyond legal requirements are:

- Set up a glass collection system at other companies (using the Green Network) to reuse waste glass, which is more environmental friendly and cheaper in using energy for melting.
- Apart from reducing costs another incentive is to show energy efficient performance of the company to their customers who purchase the product for energy saving purposes. The development of energy efficiency is shown below (figure 6).

![Figure 6. Specific energy consumption][2]

The company makes efforts to achieve and maintain a high environmental performance standard. Main incentives for doing this are a combination of environmental and safety requirements (the SEVESO-II directive), the Green Network incentives and tools for environmental improvement and the environmental goals of the top management of Saint-Gobain, i.e. the mother company.

During the interviews it appeared that no real big innovative break-through was achieved, however many small environmental improvements or steps could be mentioned. It was remarkable that no one of all interviewees could mention any real disadvantage of the Green Network. A disadvantage that was not explicitly mentioned but could be regarded as such was the difficulty of maintaining the interest of ‘old members’ after several years of participating. Particularly big companies now having their own benchmark system, and or ISO14001 and EMAS did not see as much added value of Green Networks as for instance the SME’s, but they still profited on good networking meetings with colleagues and environmental inspectors. In the competition of competent employees the Green Network flag is of considerable importance in the local neighbourhood (figure 7).
4.4.5 Conditions to be effective

The far most important criterion that was mentioned for the success of the Green Network is the participation of the top management of companies and municipalities. The highest authority of Green Network is the annual general meeting, where all members are entitled to attend and to speak. Only V- and O-members have voting rights. Six of the V-member representatives are elected as members of the Board and the chairman must be a company representative. County Mayor and the municipal mayors are Board members.

Other factors that were called to be of influence of the success of the Green Network in Denmark are the cultural aspects. The informal attitude between management and employees, and the pragmatic nature of the Danish people are examples of this.

One of the conditions of importance was the local character of the networks and the common feeling of identity. Now the Networks are at the point of facing a new administrate structure in Denmark with less, but larger municipalities and regions covering a larger area. It is not clear how this will impact the effectiveness of networks, but they seem to continue. Important will be the financial back up by the new Regions and new municipalities, the maintaining interest of old members, and participation of sufficient new members (20% in a year).

4.4.6 Correlation with IPPC

One of the main objectives of the Green Network is to facilitate, stimulate and support companies with the set up and improvement of their environmental management systems. Supporting companies with IPPC permitting issues is also part of this. This seems to fit very well with some of the IPPC key elements.

The Green Network concept impacts the IPPC implementation indirectly by creating a context of voluntary but committed co-operation about good practice about environmental (and occupational health, safety and social responsibility). The (IPPC) industry joining the network as V-members must implement EMS and do open reporting according to the manual and get Green Network certification. In practice the Green Network member industries and the environment authorities changes the approach to a co-operative context in stead of a control and command context.

Figure 7. Flag Green Networks: symbol and incentive for companies to improve performance?
The Green Network has developed a manual – the strategic environmental dialogue - describing how environmental responsible industries and authorities can develop environmental inspection and development in the most effective way. Central in this concept is an annual meeting between industry and authority discussing the future for industry in relation to environment, the environmental performance of the industry, new investments and (IPPC) applications. Also results of self-monitoring and inspections are input for discussions. As a result of the meeting the environmental plan for next year will be set up by the industry. This plan includes the way to deal most effective with authority procedures in order to obtain regulatory compliance, environmental improvement and beyond regulatory compliance where practical possible and with reasonable economic costs. The result of this approach has shown that IPPC permit applications, inspection efforts and the data monitoring is done more smoothly and more effective than compared to a situation with a less pro-active attitude.

An overview of the main characteristics, on a fact sheet, of the Green Network can be found in appendix 3.

4.5 Case study 4: Solvent tax in Switzerland and France

4.5.1 General description of instrument

Introduction
Both in France and Switzerland the use of solvents and emission of volatile organic compounds (VOC), is reduced by the implementation of a tax system. In Switzerland regulation on taxes on VOC are in place 1997, related to the Swiss Environmental Law (Umweltschutzgesetzes USG). Annexes of the Fiscal Act consist of so-called substance and product positive lists. Users of VOCs as described in the Act and its Annexes have to pay a tax per kilo. Some industries or users are exempted of the tax if they reduce VOC-emissions by 30 % in 2003 and 50% in 2008 below the norms within the Swiss Ordinance on Air Pollution Control.

France introduced air pollution taxes in 1985 and environmental taxes, so called 'eco-taxes' in 1990. The revenues from this environmental tax were used by the ADEME (Agence de ‘Environnement et de la Maîtrise de l’Energie; Environmental and Energy Agency) between 1992 and 1998 for funding their work and projects on pollution and emission reduction, such as waste, air pollution, dust and odour nuisance,and polluting fuels.

Examples are known of innovative solvent reduction measures at the packaging and printing industries that were financed by the ADEME as well as the regional authority.

By the first of January 1999 the TGAP (taxe générale sur les activités polluantes; general tax on polluting activities) replaced the different environmental taxes. The TGAP revenues since then are directly paid to the general state budget, and no longer earmarked for environment related studies or projects. The competent authority for the tax system changed as well, as the Douane is the responsible authority for the TGAP. VOCs are only one type of air pollutants that are taxed, which is a part of an even broader environmental tax system.

Background of the Swiss solvent tax system
Air quality, and specifically summer smog, has been a political item in Switzerland since decades. In 1986 the Parliament (Bundesrat) aimed for a reduction of VOC emissions on the level of 1960 as a minimal level. That meant a reduction of 55 percent VOC emissions. In the report of the Parliament and cantons of
23rd June 1999 (99.077) a reduction of even 70 – 80 percent was reported to be necessary in order to achieve good air quality; i.e. 80,000 tonnes reduction annually.

The existing regulations on air quality (the Ordinance on Air Pollution Control), containing emission levels, were frequently not complied to or did not consider all relevant industries or activities. The public opinion was that with adjusting and sharpening the existing legislation would not lead to the emission reduction that was needed. Therefore a financial instrument was proposed to be set up next or in addition to the command and control method of regulation.

**Swiss environmental regulation for industries**

As Switzerland is not a member of the European Union, the IPPC Directive is not applicable. Nevertheless, many European or member state regulations and practices are regarded in the establishment of Swiss regulation and requirements. Industry activities, comparable to activities of IPPC installations, are regulated through the Environmental law (Umweltschutzgesetz). This ‘umbrella law’ is further detailed in various Ordinances, like the Ordinance on Air Pollution Control. The environmental permit consists of specific requirements for air, noise etc from the different thematic ordinances. Industries have to comply with the specific tailor made permit requirements, as well as requirements from the relevant ordinances.

**Swiss VOC tax system**


Taxes are levied on the use of products imported into Switzerland (about 90 – 95 %) or produced in Switzerland (about 5 – 10 %), as described in a so-called Positive Substances List (annex 1 VOCV) and a Positive Products List (annex 2 VOCV). Examples of substances from the first list are acetone, benzene, ethanol (except drinking or consumption use), methanol, methyl acetate and toluene; examples of the product list are colour lakes, paints, ink, perfumes, soaps and shampoos. Taxes are levied on all VOCs or VOC-containing products with a vapour pressure of at least 0.1 mbar at 20 °C or a boiling point of maximum 240 °C at 1013 mbar (atmospheric pressure).

The Federal Customs Administration (Eidgenössische Zollverwaltung) is the competent authority; assisted in inspections and enforcement by the cantons through the reviews of VOC balance sheets. The Swiss Agency for the Environment, Forests and Landscape (Bundesamt für Umwelt BAFU) is the competent authority for the distribution of the tax revenue, the review of the instrument on the air quality and reporting.

The tax rate has been introduced in two stages; i.e. from 1. January 2000 to 31 December 2002 the tax was set at 2 Swiss francs per kilogram VOC, from 1. January 2003 up to date the tax is set at 3 Swiss francs (equivalent of € 1.590) per kilogram VOC.

Exempted from the taxes are:

- mixtures and objects in which the VOC content does not exceed 3 per cent (% by mass) – reflecting possible accuracy levels of measures;
- mixtures and objects manufactured in Switzerland, which are not on the positive list of products.

---

90 Rate of September 2006.
In addition, the VOCs which are used in stationary installations and regulated by the Ordinance on Air Pollution Control of 16 December (Luftreinhalte Verordnung LRV) can be – temporarily – exempted from taxes (acc. Article 9 VOCV), if:
- until 31. December 2003 measures have resulted in a reduction of annual VOC emissions of at least 30 percent from the maximum emissions allowed;
- until 31. December 2008 measures have resulted in a reduction of annual VOC emissions of at least 50 percent from the maximum emissions allowed.

Manufacturers have to request for tax exemption themselves, and are obliged to keep account of VOC and present a VOC balance sheet to the competent authorities. Balance sheets should contain entries, stocks, outgoings, quantities contained in mixtures or objects, quantities recovered, quantities eliminated in the enterprise or through an external enterprise, or quantities transformed, and remaining emissions.

The General Director of Customs (Oberzolldirektion) may authorise persons to obtain VOC provisionally not subject to tax provided that they obtain at least 50 t per annum and commit themselves to use or treat the VOC in such a way that they are not released to the environment, or export them. The authorisation may also be granted to persons who for the most part only use styrene (at least 1 t annually) or use another substance listed in Annex 1 VOCV (at least 1 t annually and on average at most 2 percent are released to the environment). Finally, wholesale may require an authorisation for exclusion from the tax system if they have stocks of VOC of at least 50 t. Holders of an authorisation have to submit a VOC balance sheet to the cantonal authorities.

Industries reducing their emission levels of VOC below 50 % of the threshold values of the LRV, are exempted from tax (Art. 9 VOCV). Most of the industries have chosen for end-of-pipe techniques such as waste gas incineration. These industries have to make an annual VOC balance sheet; with this balance sheet the industry can indicate its 'real' emissions of VOC that are emitted (including diffuse emissions or emissions during drop out of the system). The tax paid for VOCs that have not been emitted – due to their installation – can be reclaimed with this balance sheet afterwards (once a year). Industries that are exempted of taxes in advance, are those covered by Article 21 VOCV; these industries store or use large amounts of VOC (products) and guarantee that no VOCs are emitted to the environment. An example of this is wholesale. As these industries annually use very large amounts of VOC they would have to pay (invest) millions of Swiss Francs in advance and being paid back after a year. As this obligation would lead to drop of their solvability, these industries pay part of the taxes, and a final summarisation is made at the end of the year based upon their annual balance sheet.

**Ordinance on Air Pollution Control (LRV)**

The Ordinance on Air Pollution Control (Luftreinhalte Verordnung LRV) of 16. December 1985 lies down emission levels for installations, combustion of waste, traffic etcetera. Annex 1 of the Ordinance consists of tables of emission levels for specified classes of (an)organic particles and gasses. In Annex 2 additional, lower emission levels are prescribed for specific installations such as refineries, printing industry and (vinyl) chloride producers. The competent authorities are the cantons; the cantons may sharpen the emission levels if the local situation asks for that. Measurements of emissions have to be carried out every three years.

Article 4 LRV defines best available technique (Stand der Technik) as technically and economically possible, i.e. successfully applied at other comparable installations in Switzerland or elsewhere, or successfully applied / tested in pilots and (technically) applicable at other installations. The majority of emission levels in the LRV are based upon the German TA Luft.
VOC Tax: costs and revenues

Tax revenues are distributed by the BAFU to the population of Switzerland, through the insurance premiums of the mandatory health insurance; being a cost effective method and guaranteeing that all people living in Switzerland receive (once per year) their part of the revenue. The Swiss Parliament decided to this kind of distribution, as it did not want to have another tax burden for the inhabitants.

Costs for the implementation and execution of the VOCV are estimated on 2 – 4 million Swiss Francs per year, being about 2 % of the total revenues. Administrative burden for the industries is not known; according to an industry representative it could be about 30,000 – 40,000 Swiss Francs annually for a medium sized industry.

In conjunction with the Federal Department of Finance (Eidgenössischen Finanzdepartement EFD), the Federal Department of Environment, Transport, Energy and Communication (Eidgenössische Departement für Umwelt, Verkehr, Energie und Kommunikation UVEK) regulates the compensation of the cantons for their support in enforcing the VOCV. The health insurance organisations are reimbursed for their administrative expenses by means of the interest from which they benefit; tax revenues are paid in advance to the insurers (distributions of revenues is two years after receiving the revenues). This is illustrated in figure 8.

Figure 8. Route of VOC tax revenues
Background of the French solvent tax system

The TGAP (Taxe générale sur les activités polluantes, Decree no. 98-1266 of 30 December 1998) rests on the principle of ‘polluter pays’ and is regulated in articles 266 and following of the Code de Douane (Customs Law). The tax system consists of environmental taxes on waste; emissions into the air; oils and lubricants; detergents, mining materials; anti parasite products; and classified installations. The Douane is the competent authority for these taxes, except the environmental tax for classified installations. This tax is collected and controlled through the DRIRE (Direction Régionale de l'Industrie, de la Recherche et de l'Environnement, that is the regional environmental competent authority).

The TGAP on air is focusing on four main pollutants, i.e. sulphur(di)oxide; nitrogen(di)oxide; hydrochloride; hydrocarbons and non-methane VOCs. Installations that have to pay taxes for their emissions of (one of) these pollutants into the air are summarized in the table below. The installations involved are the large (IPPC) installations.

Table 7. Taxes for emissions of pollutants into the air.

<table>
<thead>
<tr>
<th>Type of installation</th>
<th>Criteria/thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion plants</td>
<td>Power of 20 megawatt thermal</td>
</tr>
<tr>
<td>Waste incinerators</td>
<td>Capacity of 3 tonnes/hour</td>
</tr>
<tr>
<td>Other types of installations</td>
<td>Emitting substances annually:</td>
</tr>
<tr>
<td></td>
<td>- 150 tonnes SO$_2$ or</td>
</tr>
<tr>
<td></td>
<td>- 150 tonnes NO$_x$ or</td>
</tr>
<tr>
<td></td>
<td>- 150 tonnes HCl or</td>
</tr>
<tr>
<td></td>
<td>- 150 tonnes VOC</td>
</tr>
</tbody>
</table>

Table 8. The taxes to be paid for the different air pollutants (tax per tonne).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur (di)oxide</td>
<td>180 F</td>
<td>250 F</td>
<td>€ 38,11</td>
</tr>
<tr>
<td>Hydrochloride</td>
<td>180 F</td>
<td>250 F</td>
<td>€ 38,11</td>
</tr>
<tr>
<td>Nitrogen (di)oxide</td>
<td>250 F</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>-</td>
<td>375 F</td>
<td>€ 57,17</td>
</tr>
<tr>
<td>Nitrogen oxide, except nitrogen dioxide</td>
<td>-</td>
<td>300 F</td>
<td>€ 45,73</td>
</tr>
<tr>
<td>VOC</td>
<td>250 F</td>
<td>250 F</td>
<td>€ 38,11</td>
</tr>
</tbody>
</table>

Taxes are paid to the customs in Nice in advance, based upon the activities carried out during the year before. Industries can be exempted for a certain amount of the tax, if they pay this part of the VOC tax to a local organisation that is in charge of air quality monitoring in application of Directives on ambient air. The associations consist of state authorities, local authorities, industrials, NGOs and experts. Small industries can be exempted up to 100 % of their tax, with a maximum of € 152,000 annually. The larger industries – and thus payers – can be exempted above € 152,000, with a maximum of 25 % of the total annual tax. The exemption and its thresholds accounts for all air pollutants together.

Tax incomes are decreasing the last years, as emissions of air pollutants are reduced; and industries are joining local monitoring organisations more and thus are exempted from (part of) their taxes. An example is Airparif, which is monitoring the air quality in Ile de France over many years. Airparif is partially financed by the French Ministry of Ecology and Sustainable Development until 2005.
This association, as all other (37) comparable associations, are mainly financed by the Ministry of Ecology and Sustainable Development through the DRIREs, local authorities and by tax revenues from industrials. Tax revenues over 2002 - 2004 are the following (for all pollutants): € 65 mio (2002); € 63 mio (2003) and € 58 mio (2004). The ten most polluting industries are paying almost half of the total tax.

4.5.2 Justification of selection

In this case study a financial instrument will be assessed in a member state (France) in comparison to a non-EU country (Switzerland). One specific industrial sector (the printing industry) will be involved and assessed in two countries. Both countries have different systems for solvent reduction and taxation, which might result in differences in efficiency of this specific financial instrument. The advantage of assessing another financial instrument (in addition to the NO\textsubscript{x}) charge in Sweden is the possibility to compare different financial instruments and their specific strengths and weaknesses. This comparison might lead to additional information on the effectiveness of this kind of instruments, especially in relation to continuous improvement within the IPPC context.

4.5.3 Interviews

The interviews on the VOCV in Switzerland have been carried out in week 36 of 2006. The interviews on the French TGAP have been carried out in week 39 of 2006. The following table gives a short overview of the interviewees, their occupation and involvement with the instrument.

<table>
<thead>
<tr>
<th>VOCV Switzerland</th>
<th>Occupation</th>
<th>Involvement with VOCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Dr. N. Baumann</td>
<td>SOLV (Swiss Organisation for solvent usage)</td>
<td>Representing industries that are covered by solvent regulations and VOCV</td>
</tr>
<tr>
<td>Mr. H. Trauffer</td>
<td>Federal Customs Administration</td>
<td>Competent authority for VOCV</td>
</tr>
<tr>
<td>Mr. U. Mani</td>
<td>Canton Bern, Immission Department</td>
<td>Competent authority for LRV and assisting in VOVC inspection through solvent balances</td>
</tr>
<tr>
<td>Mrs. U. Finsterwald</td>
<td>BAFU (Swiss Agency for the Environment,</td>
<td>Competent authority for USG and LRV</td>
</tr>
<tr>
<td></td>
<td>Forests and Landscape)</td>
<td></td>
</tr>
<tr>
<td>Mr. J. Dauwalder</td>
<td>BAFU (Swiss Agency for the Environment,</td>
<td>Competent authority for USG and LRV</td>
</tr>
<tr>
<td></td>
<td>Forests and Landscape)</td>
<td></td>
</tr>
<tr>
<td>Mr. R. Gamma</td>
<td>SGCI (Swiss Organisation for chemical and</td>
<td>Representing chemical and pharmaceutical industries</td>
</tr>
<tr>
<td></td>
<td>pharmaceutical industries)</td>
<td></td>
</tr>
<tr>
<td>Mr. T. Wengle</td>
<td>VSLF (Swiss Organisation for paint and ink</td>
<td>Representing paint and ink industries</td>
</tr>
<tr>
<td></td>
<td>producing industries)</td>
<td></td>
</tr>
<tr>
<td>Mr. U Näf</td>
<td>Economisuisse (Swiss Umbrella Organisation)</td>
<td>Representing all industrial branche organisations</td>
</tr>
<tr>
<td>Mr. A. Ghetta</td>
<td>Alcan (Kreuzlingen)</td>
<td>Producer of packaging materials for pharmaceutical industry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TGAP France</th>
<th>Occupation</th>
<th>Involvement with TGAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mrs. S. Rocard</td>
<td>Ministry of Ecology and Sustainable Development (MEDD)</td>
<td>Competent authority on air pollution</td>
</tr>
<tr>
<td>Mrs. J. Garet</td>
<td>Ministry of Ecology and Sustainable Development (MEDD)</td>
<td>Competent authority on air pollution</td>
</tr>
</tbody>
</table>
During the interviews more detailed information on the Swiss and French experiences with taxing of solvents, the legal context and the (dis)advantages of the instrument have been discussed. In the next paragraphs main issues and conclusions, in respect to this study, are presented. Sources are both interviews and literature provided by the interviewees during the meetings.

4.5.4 Effectiveness, advantages and drawbacks of instrument

VOCV in Switzerland

The (announcement of the) introduction of the VOC tax in Switzerland lead during the years 1998 – 2001 to the implementation of twice as much emission reduction measures as compared to the years before (1990 – 1998). VOC emission levels from industries dropped significantly. In the following table VOC sources, emissions and reductions in 1998, 2001 and 2004 are presented.

Table 10. VOC emission sources and reductions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(%t)</td>
<td>(%t)</td>
<td>(%t)</td>
</tr>
<tr>
<td>VOC tax payers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Industry</td>
<td>64700</td>
<td>55200</td>
<td>36300</td>
<td>-9500</td>
<td>-15%</td>
<td>-18900</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Households</td>
<td>14100</td>
<td>13900</td>
<td>15600</td>
<td>-200</td>
<td>-1%</td>
<td>1700</td>
</tr>
<tr>
<td>Total</td>
<td>78800</td>
<td>69100</td>
<td>51900</td>
<td>-9700</td>
<td>-12 %</td>
<td>-17200</td>
</tr>
<tr>
<td>Other VOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>36100</td>
<td>28000</td>
<td>21200</td>
<td>-8100</td>
<td>-22%</td>
<td>-6800</td>
</tr>
<tr>
<td>Industry</td>
<td>22000</td>
<td>20400</td>
<td>18500</td>
<td>-1600</td>
<td>-7%</td>
<td>-1900</td>
</tr>
<tr>
<td>Agriculture</td>
<td>8700</td>
<td>8400</td>
<td>7900</td>
<td>-300</td>
<td>-3%</td>
<td>-500</td>
</tr>
<tr>
<td>Households</td>
<td>3500</td>
<td>3200</td>
<td>2800</td>
<td>-300</td>
<td>-9%</td>
<td>-400</td>
</tr>
<tr>
<td>Total</td>
<td>70300</td>
<td>60000</td>
<td>50400</td>
<td>-10300</td>
<td>-15%</td>
<td>-9600</td>
</tr>
<tr>
<td>Total VOC</td>
<td>149100</td>
<td>129100</td>
<td>102300</td>
<td>-20000</td>
<td>-13%</td>
<td>-26800</td>
</tr>
</tbody>
</table>
At industrial level VOC emissions have been reduced with 18,900 (34 \%) tons between 2001 and 2004; compared to 9,500 tons (15 \%) reduction between 1998 and 2001. The largest emission reductions are summarized in the following table; in blue the IPPC related industries are highlighted.

### Table 11. Industry sources and reduction of VOC emissions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t)</td>
<td>(t%)</td>
</tr>
<tr>
<td>Industrial use of paint</td>
<td>-3100</td>
<td>-13 %</td>
</tr>
<tr>
<td>Printing</td>
<td>-1800</td>
<td>-16 %</td>
</tr>
<tr>
<td>Metal cleaning</td>
<td>-700</td>
<td>-18 %</td>
</tr>
<tr>
<td>Wood preservation</td>
<td>-270</td>
<td>-15 %</td>
</tr>
<tr>
<td>Solvents (not industrial)</td>
<td>-200</td>
<td>-11 %</td>
</tr>
</tbody>
</table>

### Some examples of results achieved

As can be read from the tables and paragraphs above, the VOCV is involving various industries and non-industries, besides the IPPC installations. Switzerland did not implement the IPPC Directive, although using best available techniques as described in the different Bref documents in defining environmental requirements and thresholds in permits and other regulations.

Some examples\(^{91}\) of industry reactions on the introduction of the VOCV are the following:

- Aerni Fenster AG (production of windows and doors) changed part of their production process to water carried paint;
- Armacell Switzerland AG (production of isolation products) installed a waste gas treatment, reducing its VOC emissions with 33 \%;
- R. Nussbaum AG (metal treatment and painting) changed its production process as well to water carried layers;
- Petroplast AG (printing and packaging) installed a waste gas treatment (catalytic incinerator);
- Poly Laupen AG (printing industry) renewed its waste gas treatment.

\(^{91}\) Source: Bafu documents and interviews with industry.
Petroplast AG, for example, had experienced with water carried paints, but could use these paints only – due to quality loss of the prints – for some specific products. Annually 200 tonnes of solvents were 'consumed'; in 1999 a catalytic waste gas incinerator was installed anticipating the introduction of the VOCV. This installation Petroplast reduced the VOC emissions with more than 50 % and is a so-called Article 9 installation and exempted from the VOC tax. The installation needed an investment of about 1 million Swiss Francs; with a payback period of 10 years. Maintenance costs are about 100.000 Swiss Francs per year; energy is used from the local power plant. By using this installation the firm is exempted from 400.000 Swiss Francs tax. Taking the tax exemption into account as well, the payback time for this investment is even far less than 10 years, being just over three years. The installation destroys up to 17.000 m³ solvent laden air per hour. Five diesel motors with SCR-waste gas catalysts and water injection system for reduction of the particle emission, drive five generators of each 200 kW. Annually 7 million kWh are produced, covering 55 % of the total energy consumption. Heat from the local power plant is used for the processes; waste gases from the motors are used for preheating of the rooms.

Alcan, in Kreuzlingen (CH) is one of the largest producers of packaging materials for the pharmaceutical industry in the world. During the years 1990 and 1994 Alcan Kreuzlingen invested about 24 Million Swiss francs in 5 catalytic incinerators. These regenerative thermal installations are only burning solvent-laden air, and sustain auto-thermal operation where no additional fuel is required. The installations will be depreciated in twelve years; partially due to the high maintenance costs, but thanks to the reduction of energy consumption of 1.2 Million Swiss francs annually as well.

As Alcan is printing mostly on aluminium, which is not absorptive material, solvents in the inks, varnishes and adhesives are inevitable. Oxidising waste gasses fits within the EU Solvents Directive. New developments and alternatives will be UV printing and electron beam coating – described as emerging techniques in the BAT reference document on surface treatment using organic solvents. Both technologies are tested in Alcan's laboratory/testing site. A new technology that already has proven its use, and is installed at the Alcan site in Kreuzlingen, is solvent free lamination. This technology however can only be used for products that do not have to be sterilised, as water (used during sterilisation) solves some product layers.

Looking at the type and age of installations used at the printing industry in Switzerland92, the following results can be found: in 2001 52 % of the waste gas installations have been newly installed since 1999. This means that since the introduction of the VOCV – in a few years - about half of the printing industry invested in VOC emission reduction installations.

Finally, another positive side effect of the VOCV is the growing awareness of industries of their use of VOC (products), the costs of these products and the environmental impacts. This can be illustrated by the search for alternatives for organic solvents during the last years.

TGAP in France
The Citepa (Centre Interprofessionel Technique d’Etudes de la Pollution Atmosphérique, Centre on air pollution studies) supports the Ministry of Ecology and Sustainable Development in the implementation of air policy, through producing annual emissions inventories for the French government. Non Methane Volatile Organic Compounds (NMVOCs) are surveyed since 1988. The Citepa report93, last updated in April 2006, gives the following figures on air pollution (figure 10).

92 Source: Beco Berner Wirtschaft
93 Air emissions in France; mainland France, substances causing acidification, eutrophication and photochemical pollution, Citepa, April 2006.
The overall emission of VOC in 2004 was 1367 kiloton; compared to the levels in 1998 - being 2547 kt - the VOC levels decreased 46 % (1180 kt). The distribution of emissions among the sectors has changed during the last fifteen years. In 1990 transport was the main sector with 45 % of the total emissions, whereas in 2004 the industry is the main emitting sector with 30 % against 22 % of transport. When looking closer at only the industries, the following figures give a clear example of the reductions achieved in the different sectors. In energy conversion a lot progress has been made in petroleum storage and distribution, resulting in a 65 % reduction (resembles 148 kt) between 1988 and 2004. The manufacturing industries reduced their emissions of VOC through substitution of products by other products containing less or no solvents, or using end-of-pipe technologies.

![Figure 10. VOC emissions by different sectors (kton).](chart1)

![Figure 10. VOC emissions by different sectors (kton).](chart2)
Examples from industry

According to the French VOC regulation installations emitting above 30 tonnes VOC per year had to reduce their emission levels in 2004, 30% below the levels of 2000. In Ile-de-France overall VOC emissions have been reduced 17.4% between 2000 and 2004, specifically due to the 37% reduction that has been achieved by the large emitters (emitting above 30 tonnes VOC/year). The VOC emission reduction results in Ile-de-France (district of Paris, French department) are presented below (figure 11).

![VOC Emissions Ile-de-France](image)

**Figure 11. VOC emission reduction results in Ile-de-France.**

Major investments have been made in the automotive industry, e.g. Peugeot reducing the VOC emission per kg/car from 6 kg/car in 2000 to 3.7 kg/car in 2004. Another example in Ile-de-France is Griffine Enduction (coating industry) that invested more than € 2 mio in a waste gas incinerator, and reducing the VOC emissions from 1011 tonnes in 2000 to 95 tonnes in 2004.

Advantages and drawbacks of the instrument

According to the Swiss interviewees the main drawback of the VOCV was the administrative burden, at the industries as well as the authority level. Although, currently these costs are less than immediately after the introduction of the VOCV, as systems for VOC balance sheets now are being set up.

Finally, the positive effects of the VOCV, as can be read above, however can only be found at the industry level, and not at the households. The VOC emissions from households rose from 2001 – 2004. Achieving emission reduction at the household source is rather difficult, and doubts are rising whether this could be achieved through a financial instrument. An explanation could be the fact that no or little alternatives for VOC containing products are available (like perfume, soaps etc). Taxes, pricing, does not work if no alternatives are available. The French tax system on the other hand, is not involving households and is focussing on industries and transport.
Comparing both tax systems, the difference between the French and the Swiss tax levels are evident. The Swiss tax is far higher than the French tax is: i.e. € 1,5 per kilogram VOC in Switzerland versus € 38,11 per tonne VOC in France (meaning the Swiss tax a factor 40 higher than the French tax!). The incentive of the Swiss tax therefore is far more than the rather low French tax level – as is confirmed by both French industries as authorities.

One could conclude that with the same administrative effort and costs, the results – i.e. emission reduction of VOC – are higher in Switzerland than in France.

4.5.5 Conditions to be effective

The VOCV in Switzerland and the TGAP in France are both financial instruments that are used in addition to other regulations. For the industries involved this means that they have to comply with (regional) air quality regulation as well as are 'driven' by (national) financial instruments.

The Swiss government decided, despite the view of some industry branches, to have an additional instrument to the legislation in place, and not to choose for one of both instruments (regulation versus financial instrument). In the recent years, industries are therefore stimulated through two types of instruments, to reduce their VOC emissions. A combination of both instruments, as given in Article 9 VOCV, gives an extra stimulus to reduce VOC levels in waste gases. As industries that lower their VOC levels in waste gases significantly, are exempted from the taxes.

In France, both instruments are in place as well, although according to most interviewees the driver for emission reduction comes from regulation and not from the financial instrument. The major reason for this is the low tax level, being no 'hurt' for industries that are focusing far higher tax levels on waste and waste water. In addition, no extra stimulus for emission reduction is given like the Swiss exemption option for industries reducing their emission levels at least 50 % below the regulatory emission limit values.

Although not recognized by all Swiss industry branches, this combination of both instruments seems to be the most effective and powerful way to reduce VOC levels significantly. A time horizon for industries on exemption of taxes, in combination with an ambitious reduction level, is a strong stimulus to improve VOC management and waste gas treatment, and to look for other alternatives for the use of organic solvents. At the moment industry and authorities are discussing the new (text) version of the VOCV, as the exemption period as stated in Article 9 VOCV will end and industries then will have to pay for their VOC emissions. Some alternatives are discussed, like a continuation of this “exemption article” with stricter emission reduction levels. Another possibility could be adjusting (having stricter) emission levels in the LRV, and therefore higher emission reduction requirements in relation to Article 9 of the VOCV as well. As 50 % reduction, as prerequisite of Article 9 VOCV to be exempted from tax, from e.g. 150 mg/m³ emission level of the LRV would then be 50 % lower emissions than the 100 mg/m³. This would be a stimulus for industries to innovate and invest as well.

Concluded, a combination of ‘command and control’ and financial drivers seems to be most effective if an extra stimulus is incorporated in the financial and regulatory instrument like the exemption option in the Swiss VOCV, and the tax level is above a certain critical level.

Regardless the – positive - fit with the constitutional and legislative context, the implementation of a financial instrument requires an institutional context that is suited for collecting and distributing the tax revenues. As the taxes are paid for solvents imported, and restituted at the export, e.g. the customs and financial department of the ministry have to be involved in the development and implementation of an instrument of this kind.
The Swiss construction of dividing the tax revenues to the Swiss inhabitants, but using a percentage as forfeit for the administrative burden at the cantonal and the custom departments, reduces the financial impact of implementing a new instrument. The health insurance organizations receive interest during the year between receiving and paying the revenues; the interest used for costs made by them for the administrative tasks of dividing the revenues over all health insurance payers. In France, the administrative bodies are paid through the state budget, without using any additional financial support from the tax revenues. On the other hand, no other than public institutions are involved in the tax system, requiring financial compensation for administrative burden like the Swiss health insurance organizations.

Finally, having a financial public body involved in emission reduction knowledge gaps might lead to ineffective implementation of this policy. Both the French as the Swiss customs administrations are the main inspection bodies for the solvent tax, however without having any knowledge of air pollution and emission reduction measures. The effectiveness of the customs’ inspections and the identification of new taxpayers is therefore limited. In Switzerland this disadvantage is partially solved by involving the cantons in the administrative inspection of the tax declaration forms. This is however not the practice in France.

4.5.6 Correlation with IPPC

The printing industry and chemical industry, which are the focus within this case study, are both listed in Annex 1 of the IPPC Directive; as category 6.7 and category 4 respectively. Various BAT reference documents (BREF) are developed for these industry branches, like the (draft) BREF Surface treatment using organic solvents. Although Switzerland, being not an EU member, did not implement the IPPC Directive, the environmental requirements are similar to those in EU and its Member States’ regulations, e.g. by using the German TA Luft as a reference.

As the financial instrument, the VOC tax, is in addition to or combination with, environmental requirements, this would smoothly fit within the IPPC context. The results achieved so far, seem to indicate that a strong and effective combination of both instruments leads to significant reductions at the industry level. The IPPC Directive itself does not prohibit the use of additional, financial instruments; a combination as described above would therefore be introducible within the current IPPC practice.

The tax system is based upon the polluter pays principle, stimulating reduction at the source, intervention at the source or the use of end-of-pipe solutions if both other options are less feasible.

Interesting is the fact that the VOC Solvents Directive has been transposed and implemented in France having more stringent requirements than the EU Directive itself, as industries have to reach VOC emission levels in 2005 instead of 2007. According to the DRIRE most emission reductions have been achieved through the regulatory approach (VOC and environmental legislation) and not due to other mechanisms, such as the IPPC Directive and/or the TGAP. In addition, installations are allowed to emit above emission limit values, as long as the company lowers the overall amount of solvents used, e.g. by substituting some products containing solvents by more environmental friendly products. This is in compliance with the VOC Solvents Directive, although one could ask oneself if it is in line with the philosophy of the IPPC Directive.

In France the regulatory system impacting the VOC emissions is said to be the VOC and environmental legislation in place. Companies have to apply for an environmental permit, which will set VOC emission levels based upon the national legislation and relevant regional contexts. The tax is not directly related to the permit nor influencing the companies efforts in reducing VOC emissions.

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94 Conseil des Impôts; Fiscalité et environnement: Vingt-troisième rapport au Président de la République, 2005
The same goes for Switzerland, although the regulatory VOC levels might differ from the thresholds in France, that are in line with EU requirements. Companies have to apply for an environmental permit, in which specific VOC – and other air quality – levels are set. According to the VOCV companies have to pay a tax on VOC as well, unless the enterprise lowers its emissions 50 % below the – regulatory set – emission levels. The VOCV is directly linking tax payment to the emission levels, and therefore this regulatory – financial combination is stronger connected than in the French case.

An overview of the main characteristics, on a fact sheet, of the Solvent tax can be found in appendix 4.
4.6 Case study 5: Energy Efficiency in Slovenia and the Netherlands

4.6.1 General description of instrument

Background
The energy crises in 1973 and 1979 urged for a change in energy consumption; energy efficiency programmes were developed and implemented. The worldwide climate policy objectives gave a new impulse on energy consumption reduction, as energy use is linked to the use of fuels causing high emission levels of greenhouse gases. The Kyoto protocol was set up in 1997 and is ratified by most industrialized countries in the world. The Kyoto protocol contains quantitative agreements on reduction of greenhouse gas emissions. Many governments have implemented the Kyoto requirements through energy efficiency programmes such as voluntary agreements and benchmarking covenants, CO₂ tax systems and emission trading schemes.

Slovenia: various energy efficiency schemes
In Slovenia energy efficiency programmes have been set up as government decided early nineties not to invest in nuclear energy but to improve the existing energy infrastructure and promote the use of renewable energy sources. Examples of Slovenian initiatives are energy audit schemes, energy efficiency award, subsidies for feasibility studies, financial incentives for energy efficiency and renewable energy sources investments for households as well as industries.

The energy auditing programme (EAP) started in 1995. Target groups are industry, public and commercial sector and multi-apartment buildings. The programmes objectives are to promote energy efficiency investments and energy management, and to develop a market of energy services. The Ministry of Environment and Spatial Planning administer the EAP. Monitoring and evaluation of the energy audits and the programme itself are carried out –partly- by independent consultants.

The participation in the EAP is voluntary, but limited to the budget available. The minimum energy consumption of participants has to be at least 300 MWh for buildings and 500 MWh for enterprises. The maximum applicable subsidy depends upon the energy costs; i.e. up to 50 % of the energy audit costs and maximum € 8.300. The energy audit consists of the following steps; energy survey and analysis (of contracts, energy supply, main consumers, energy costs, measurements); identification of energy efficiency measures (organisational, reconstruction, best practice technologies, advanced technologies); selection of proposed energy efficiency measures; feasibility analysis of selected measures; savings calculation; investment costs determination; energy audit report and presentation of report.

During three years (1997 – 2000) a specific energy audit scheme has been set up for industries with at least € 500.000 energy costs. Industries were assisted during the audit by an independent consultant. The project consisted of an energy assessment, an energy audit, a top management meeting, a seminar for line management and after six month an assessment of the results achieved and management commitment.

Other energy efficiency initiatives are the Fund for Energy Efficiency Investments (1997 – 2007), the Energy performance and supply contracting (from 2002 onwards) and the CO₂ voluntary agreements (2005 – 2008) in which the elaboration of an energy audit is one of the obligatory measures. The Energy Efficiency Investments fund is managed by the Commercial Bank; the incentive comes from lower interests.
The Ecological Fund is a public fund giving soft loans for investments in cogeneration, energy efficiency and renewable energy. The Slovenian government increases the basic capital of the ecological fund annually.

In 1996 a CO2 tax system has been introduced as well; the tax level rose within two years from €4 per ton CO2 at the start to €13 per ton in 1998. Industries were allowed a two third reduction of tax, until the Commission defined this to be state aid. The Slovenian government adjusted the tax system and introduced in 2003 a new system, in which tax exemption levels were reduced annually with 8%, and ending of the exemption option in 2010. In 2004/2005 the European Commission again raised questions on the (revised) tax system, and two additional schemes have been set up next to the tax system. Within these schemes, smaller industries have to sign a voluntary agreement if they want to apply for tax reduction. Larger industries, such as IPPC installations, are participating in the Emission Trading Scheme. In total 1000 companies have to pay CO2 tax; of which about 100 industries take part in the Emission Trading Scheme and about 150 industries joined the voluntary agreement. The revenues of the CO2 tax go directly to the state budget; a part of the revenues is used for the voluntary agreements.

The voluntary schemes oblige industries for example to audit energy consumption, attend annual energy efficiency events, keep energy books and report to the authorities. In addition, these industries have to set up an energy efficiency plan with measures to be taken between 2005 and 2008, in order to reach the 2.5% specific energy consumption reduction in 2009.

Finally, since ten years an energy efficiency conference Energy Days is organised, during which the most energy efficient company, manager and project are awarded. Annually about 100 energy managers are participating.

The Netherlands: energy efficiency covenants as key instrument in energy policy

The Dutch National Environmental Policy Plans of 1989 and 1990 introduced a new key instrument in environmental policy, i.e. negotiated agreements95 for pollution abatement – in Dutch called ‘covenants’. The agreements with different industrial branches set quantified emission reduction targets for the years 1995, 2000 and 2010 in relation to six environmental themes, such as the greenhouse effect and acidification.

Covenants have a status of contracts of civil law; signed by the government and branch associations. The contract serves as a framework for a series of agreements between the government and the individual firms, willing to join the scheme. Long time experience with various forms of covenants, resulted in a more uniform instrument containing matters such as the settlement of disputes, evaluation, consultation, accession et cetera. These individual contracts can engage a firm’s liability in a civil court, as most covenants with industries generally explicitly state that the agreement is governed by civil law. Therefore, the covenants can more easily be enforced. Furthermore, the covenants are tightly linked to the environmental permitting system. Industries participating in a covenant are obliged through their environmental permit to submit environmental and energy efficiency plans to the respective competent authority in which they indicate how to achieve the targets set in the covenant.

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95 Source: Börkey, P. and F. Lévêque, Voluntary approaches for environmental protection in the European Union
The Dutch benchmarking covenant\textsuperscript{96} has been signed by the Ministers of Economic Affairs and of Housing, Spatial Planning and Environment; the Inter-Provincial Consultative Forum (IPO) on behalf of the provinces; and the industry represented by VNO-NCW Confederation of Netherlands Industry and Employers and by branches from various industrial sectors and the electricity production sector. The industries involved in the benchmarking covenant are those consuming at least 0.5 Peta Joules per year. Their aim is to be among the world leaders in energy efficiency no later than 2012; making maximum efforts to consume energy more efficiently, without comprising their international competitiveness.

As the covenant is a two-sided agreement; the Dutch government – in return for the efforts and commitment of the industries – ensures that no supplementary national policy regarding CO\textsubscript{2} reduction or energy conservation is imposed on the companies that joined the covenant. In addition, no specific national energy tax will be levied and the costs arising from the obligations of the Dutch government in the field of the Joint Implementation or the trade of emission rights will not be charged directly to the participating companies. However, the general rules relating to fuel consumption, sustainable energy or energy consumption, and the energy taxes are not covered by the covenant.

Companies set their own levels to be achieved through an international benchmark; comparing the plant with plants abroad and the average energy efficiency of the best region in the world or with the best 10 percent of the globally structured installations (excluding those in the Netherlands). When defining the world leaders, account is also taken of the anticipated efficiency improvements up to 2012; and this definition is redefined every four years. After having defined the world leaders and energy levels, the industry draft an energy efficiency plan, indicating when and how they will belong to the top of the world. The plans include (cost-effective) measures; and if necessary from 2008 onwards flexible instruments such as emission trading. The competent authority evaluates the energy efficiency plan and incorporates it into the environmental permit. When redefining ‘world leadership’, the energy efficiency plan has to be reviewed as well. The (environmental) competent authority assesses the company’s energy efficiency plans, in the context of the environmental permit and the covenant. The initiatives presented in the energy efficiency plan are – if feasible – integrated in the environmental permit by the competent authority (municipality or province). Implementation period and choice of measures on energy reduction are of the company’s responsibility. Annually a report on the implementation of the agreed upon and proposed emission reduction measures is required by the competent authority.

The newly established Benchmarking Committee is responsible for the overall implementation of the Benchmarking Covenant. The Committee consists of representatives of all the participating parties. The Benchmarking Verification Bureau has been established to verify the benchmarking process; e.g. checking the definition of world leaders and the energy efficiency plan, and advising the authorities and industries.

\subsection*{4.6.2 Justification of selection}

The energy efficiency programs are specifically focusing on image and market incentives. The advantage of this case study is the broad and long experience with a broad variation of energy efficiency initiatives. Secondly, the energy efficiency programmes have been selected as some of these are examples of voluntary initiatives. And finally, the geographical spread of case studies can be covered, by selecting a new member state that has experienced this instrument since several years.

\textsuperscript{96} Source: www.benchmarking-energie.nl
Slovenia has entered the European Union in 2005; meaning that still a lot of measures have to be set in place and the legislative starting point is differing from those in the other case studies. Nevertheless, involving a new Member State within the case studies, loosening somewhat the case study selection criteria, could give relevant information on possible side (positive or negative) effects of the implementation of the IPPC Directive for the existing practice regarding energy efficiency. Comparing the Slovenian initiatives to the Dutch experiences with energy efficiency programmes will help to identify context criteria on a country level on the success and effectiveness of this instrument.

**Interviews**

The interviews on energy efficiency programmes in Slovenia have been carried out in week 38 of 2006. The following table gives a short overview of the interviewees, their occupation and involvement with the instrument.

**Table 12. Interviews in Slovenia with stakeholders energy efficiency program.**

<table>
<thead>
<tr>
<th>Name of interviewee</th>
<th>Occupation</th>
<th>Involvement with Energy efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. J. Žerjav</td>
<td>Ministry of Environment and Spatial Planning, Environmental Directorate</td>
<td>Competent authority for IPPC, LCP etc policies, AG member</td>
</tr>
<tr>
<td>Mrs. J. Leban</td>
<td>Chamber of Commerce Environmental Protection Department</td>
<td>Representing Slovenian industries on environmental issues</td>
</tr>
<tr>
<td>Mr. D. Novkoviž</td>
<td>Acroni, d.o.o.</td>
<td>Environmental and energy manager in steel industry</td>
</tr>
<tr>
<td>Mr. T. Fatur</td>
<td>Institut “Jožef Stefan”</td>
<td>Energy (research) institute</td>
</tr>
<tr>
<td>Mr. B. Kandus</td>
<td>ENEKOM</td>
<td>Energy consultancy</td>
</tr>
<tr>
<td>Mr. T. Vuk</td>
<td>Salonit Anhovo</td>
<td>Technical (incl. Energy) management in cement industry</td>
</tr>
<tr>
<td>Mr. K. Mair</td>
<td>Bavarian Environment Agency</td>
<td>Permanent team leader/expert in energy efficiency twinning project</td>
</tr>
<tr>
<td>Mr. B. Selan</td>
<td>Ministry of Environment and Spatial Planning Department for Energy Efficiency and Renewable Energy</td>
<td>Competent authority on energy policy</td>
</tr>
<tr>
<td>Mrs. M. Logar</td>
<td>Environmental Agency</td>
<td>Competent authority IPPC permits</td>
</tr>
</tbody>
</table>

During the interviews more detailed information on the Slovenian experiences with energy efficiency in broader sense, and the implementation of the IPPC in relation to energy efficiency specifically, has been discussed. In the next paragraphs main issues and conclusions, in respect to this study, are presented. In addition, the Dutch energy efficiency initiatives and their results will be described, based upon literature review. In this way a comparison of programmes and their effectiveness is provided.

**4.6.4 Effectiveness, advantages and drawbacks of instrument**

**Slovenian experiences**

The Energy Audit Programme resulted in the period 1998 – 2005 in a total of 166 energy audits, of which 68 energy audits at buildings and 98 industrial energy audits. The Ministry provided € 627,000 for subsidising the programme. The industry reduced their energy consumption about 7.3 % with a pay back period of less than 3 years. The estimated costs savings compared to the subsidy budget is 15:1. Subsidies / CO₂ reduction is 0.9 € / (t CO₂* a).
About 40 (large, IPPC) companies participated in the Energy Audit scheme. Every € 1 state budget resembled € 16 energy cost savings. The CO₂ emissions were 60 % lower compared to the levels in the early nineties. The reductions achieved, as described above, cannot be found in the overall energy consumption level of the Slovenian industries. As industry and production is growing, energy needs are rising, notwithstanding energy efficiency measures.

Figure 12. Greenhouse gas emissions energy sector.

Figure 12 above is showing the development of the total greenhouse gas emissions from the base year 1986 till the year 2004 for the energy sector, the industry, transport and district heating services.
Figure 13 gives a clear example of the effect of large industries energy consumption levels in relation to the overall energy consumption level. Energy intensive industries, some of them even raising their production levels significantly, are influencing the overall energy consumption heavily despite the implementation of various efficiency initiatives.

Examples of industries
To illustrate the effect of (the combination of) various Slovenian energy efficiency programmes two examples of industries will be highlighted. One of the examples is Acroni – a large steel plant; the other example is Salonit, which is a cement industry.

Acroni (steel production)
Acroni is a steel plant producing hot rolled strips, quarto plates and cold rolled strips and sheets, which sales about 260,000 tonnes steel per year. The most important markets are the domestic and the European markets. In achieving their goal of becoming the second-ranked supplier of stainless steel plates and achieving 30 % market share in Europe, Acroni is investing high in technology and ecology measures.

The CO₂ levels have been monitored over years, as these are a good indicator for energy consumption. Since 1986 CO₂ emissions dropped from 1,79 tonnes per year to 0,67 tonnes CO₂ in 2005; that means a reduction of 75 % (absolute) and a reduction of 63 % specific emission (relative emissions). This reduction is – partly - due to a change of the production process in which now steel is recycled instead of producing steel from minerals. But by the end of the nineties the company many improvements have been implemented to lower production costs and therewith energy consumption.

In order to comply with the strict norms on energy consumption, as required by the IPPC Directive, Acroni audited its energy consumption and production processes and started a Target Monitoring of Energy project in 2002, which additionally reduced the energy consumption. Acroni was one of the first Slovenian company where energy consumption data are integrated into the information database, and where assessments are made according to the principle of target monitoring of energy consumption. This allows planning and monitoring of realisation, as well as monitoring and managing peak consumption. By
installing the T&M system, Acroni decreased the specific energy consumption by 10 % per production unit (from 8.22 GJ/t to 7.38 GJ/t). The most significant decrease is recorded regarding the steam consumption (-49%), due to replacement of the system of building heating. The specific consumption of natural gas was reduced by approximately 10 %. However, the effect regarding electrical energy was less, i.e. 3 % reduction, which is a result of additional consumption for environmental purposes such as dedusting and waste-treatment equipment (figure 14).

Figure 14. Energy consumption of Acroni.

With the introduction of Monitoring and Targeting for Air more than 30 % energy consumption has to reduced, i.e. 25 mio.m³/year and € 150.000 cost savings). The implementation of M&T for all energetic media reduced the specific energy consumption with 10 %, i.e. 1 – 1,5 mio €.

The most important investments in ecology at the Acroni plant have been the following:

- first stage of the reconstruction of dust collection equipment € 2.5 mio
- closed cooling water system on VOD € 2.4 mio
- reconstruction of scale pits € 0.7 mio
- reduction of the use of cooling water € 2.7 mio
- second stage of reconstruction of dust collection equipment (planned) € 3.5 mio
- Planned: In ecology: reconstruction of dust collection equipment (6.0 mio €), reconstruction of scale pits (3.7 mio €), regulation of the banks of the Sava river (1.4 mio €), and reduction of the use of cooling water (1.2 mio €).
Box 4. Example of energy efficiency investments at a steel plant

In 2004 the Slovenian steel company Acroni installed a VOD (Vacuum Oxygen Decarburization). This technology is known for further refinement of stainless steel through reduction of carbon content in the iron and steel producing industries. The amount of carbon in stainless steel must be lower than that in carbon steel or lower alloy steel (i.e. steel with alloying element content below 5 %). While electric arc furnaces (EAF) are the conventional means of melting and refining stainless steel, VOD is an economical supplement, as operating time is reduced and temperatures are lower than in EAF steelmaking. Additionally, using VOD for refining stainless steel increases the availability of the EAF for melting purposes.

Molten, unrefined steel is transferred from the EAF into a separate vessel, where it is heated and stirred by an electrical current while oxygen enters from the top of the vessel. Substantial quantities of undesirable gasses escape from the steel and are drawn off by a vacuum pump. Alloys and other additives are then mixed in to refine the molten steel further.

For modernising and adapting the VOD device for processing of steel, the innovators of Acroni received the annual award for the best innovations at the national level, granted by the Slovenian Chamber of Commerce, in 2005.

Salonit (cement production)

The Slovenian cement company Salonit is targeting energy efficiency since many years. As the production of cement is a very energy consuming process – 50 % of total production costs are energy costs-, looking for energy efficiency measures is a condition for success and competitiveness. Salonit is therefore implementing energy efficiency measures, as well as looking for other fuels such as waste tires, waste oils and animal fat. In 2007 the company will use plastic chips as alternative fuel for the heating of the clinker production lines. The use of alternative fuels and the installation of a pre-heater tower led to a specific energy consumption reduction of 50 %. Investments that are planned for the short time period are the installation of a new clinker cooler with recuperation of heat and improvement of the heater for reducing NOx emissions amongst others. These improvements are incorporated in the IPPC permit; additional investments in five years will be the basis for a new IPPC permit.

The Netherlands

In 2004 186 companies joined the energy benchmarking covenant97, of which 153 industrial firms and 33 electricity producing firms. Energy consumption of the industry increased from 668 PJ/year to 708 PJ/year in 2004 (+ 6%). If no energy efficiency measures would have been implemented, the energy consumption would have been 742 PJ/year (+ 11%).

A calculation of CO2 emission reductions that could be achieved by the year 2012, based upon data from energy efficiency plans, according to the covenant, accounts for a reduction of 4.6 million tonnes CO2. Although some Dutch industries already belong to the world’s top ten, quite few of them are implementing more measures than would be necessary, in order to hold their high ranking positions.

Figure 15 gives an overview of the Energy Efficiency Index (EEI) of three industry branches over the last five years. The energy efficiency index is defined as the measured energy consumption within a certain

year divided by the reference energy consumption. The reference energy consumption is the theoretical energy consumption of the industry needed for the production levels of the monitoring year, produced with the same energy consumption per production unit in 1999. The EEI of industry improved with 4.5% since 1999.

![Figure 15. Overview of the Energy Efficiency Index (EEI) of three industry branches.](image)

Improvements made and measures implemented since 1999 resulted in a reduction of 41.7 PJ energy consumption annually; this is equal to a CO₂ emission reduction of 2.7 Mton/year. The effectiveness of the benchmarking covenant is since 2005 influenced by the introduction of the emission-trading scheme; participants of the benchmarking covenant and the emission trading scheme are no longer obliged to implement the energy efficiency measures that were planned from 1 January 2005 onwards. The companies involved in the emission trading scheme are no longer obliged to draft an energy efficiency plan, although the requirement on world top leadership still stands. The companies will continue to comply with the reporting obligation of the benchmarking covenant. Annual reports are submitted to the Dutch Verification Bureau Benchmarking, like the reports of the companies not within the trading scheme. The Dutch Emission Authority (NEA) is responsible for the inspection and enforcement of the covenant as well as the emission trading scheme.

The Dutch cement industry

The Dutch cement industry\(^98\), for example, signed the covenant in 1992, committing themselves to reduce their energy consumption by 10% by the end of 1995 based on the energy consumption level in 1989. The total energy consumption of the Dutch industry has decreased from 5.3 Peta Joule in 1989 to 3.4 PJ in 1996; i.e. a 35% reduction. Energy efficiency in 1996 improved by 18% compared to the reference year 1989. In the meantime a second covenant had been signed by the cement industry, committing themselves to an improvement of energy consumption by 21% between 1989 and 2000, based on the energy consumption level of 1989. A reduction of 15% was achieved through direct energy savings and a 6% reduction through the use of alternative fuels substituting fossil fuels in cement kilns. Through these commitments the cement industry contributed largely to the overall Dutch targets. The main reductions

\(^98\) Source: Cembureau, The European Cement Industry Voluntary initiatives to reduce CO₂ emissions – A contribution to climate change, April 2003.
have been achieved through implementation of computerized systems for dry process kilns, the use of alternative fuels in cement kilns, alternative materials in cement grinding and new technology (roller press systems) in cement grinding.

The covenant has been replaced in the beginning of 2001 by an international benchmark on energy efficiency. The Dutch cement industry is participating in this initiative as well, striving to belong to the top 10% worldwide the latest by the end of 2012. The Dutch government provides financial support to those industries engaged in energy conservation programmes and projects including those dedicated to the research and development of less energy-intensive production methods. Industries that are complying with the energy benchmarks aim and targets will not have to face any additional requirements imposed by the government.

### 4.6.5 Conditions to be effective

In general, the interviewees and literature point at the fact that the main drivers for energy efficiency are energy prices and market competition. Specifically in energy consumptive industries, such as the cement and lime industry, reduction of energy costs is one of the major tasks / objectives in order to be competitive in the relevant sector. High levels of energy consumption reduction can be found at the large industries such as cement and lime industry, where the energy price is sometimes 30 – 50 % of the production costs. Energy efficiency pays itself back very easily. This ‘mechanism’ is hardly influenced by authorities and/or policies.

The advantage of energy efficiency initiatives is, likewise to be found at financial instruments, that industries are most competent to select and implement cost effective measures. Facilitating this mechanism means therefore being flexible in permitting procedures and requirements; offering tailor-made and not in-depth defined permit requirements. In addition, often top-level commitment is said to be crucial to successful implement energy efficiency measures and achieve significant reductions.

Negotiated agreements such as the Dutch covenant have been evaluated in various studies (see for an overview and examples Börkey, P. and F. Lévêque99). The main advantage of the Dutch covenant system is the individual liability rule by linking the agreements to the environmental permit, instead of collective liability systems as known in for example Germany and France. Requirements from the agreement are permit conditions in the Netherlands as well, and control of the participating firms is therefore stronger and reaching the agreement’s goals is more efficient. In addition, the regulatory threat in the Dutch system is much more perceived, and leads to setting relatively ambitious targets in the negotiated agreements.

Relevant in implementing negotiated agreements is the choice and combination of instruments. A (negotiated) standard that is not backed by sufficiently expensive sanctions or frequent enough monitoring, may lead to non-compliance. Another, specific to agreements, disadvantage is known as the problem of free riding. All firms together have to reach specific emission reduction levels, but some individual firms might be less active participating than others. This problem applies specifically to voluntary approaches not providing for any individual sanctions, such negotiated agreements relying on collective liability.

As for economic efficiency, negotiated agreements are theoretically superior to command and control regulation, because they allow for a greater flexibility on individual emission reduction and energy efficiency targets than e.g. emission standards do.

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99 Source: Börkey, P. and F. Lévêque, Voluntary approaches for environmental protection in the European Union
Finally, stakeholders involved in negotiated agreements think that these agreements provide for some important positive side effects as they improve communication and trust, rise awareness of environmental problems and are consensus building.

4.6.6 Correlation with IPPC

Energy efficiency initiatives, like voluntary agreements and energy benchmark covenant, seem not to be in conflict with the IPPC Directive. Although some IPPC stakeholders at industrial as well as governmental level, discuss the implementation of energy issues in the IPPC permit.

An overview of the main characteristics of the Energy Efficiency can be found in appendix 5.

4.7 Case study 6: Emerging Techniques

4.7.1 Introduction

A different methodology for identifying and assessing (policy) instruments stimulating industries to go beyond what is required by permit is looking at industries that already implemented or developed an innovative, or so called, emerging technique (ET). For the project it was agreed to carry out four case studies to get detailed information on drivers and if relevant the policy instruments which play a role in the development and market introduction of the selected emerging techniques (ET). In the current BREFs a large number of emerging techniques are mentioned for reduction of emissions to air, water and soil. These emerging techniques were used as a starting point for the selection of techniques for this case study. The selection procedure and the result of the selection of ETs in a worksheet is given in appendix 6. The selected emerging techniques for pollution control on the priority list with a short description of advantages of implementation are:

1. **Integrated Gasification Combined Cycle (IGCC) with heat recovery.** Pressurised gasification in an integrated gasification combined cycle (IGCC) is one of the high efficiency techniques which could reduce emissions, including greenhouse gas CO₂, from large scale power production based on solid fuels (coal and biomass) and from waste incineration plants.

2. **Smelting reduction with Cyclone Converter Furnace (CCF) in iron and steel industry.** In the smelting reduction process, the product is liquid pig iron or (in some cases) liquid steel. In the CCF the iron ore is pre-reduced and melted. The molten mixture falls into the lower part of the vessel where reduction is completed. Both pre-reduction and final reduction takes place in one vessel. Since no coke oven plant, sinter plant or pellet plant is required a marked reduction of air emissions can be achieved. Also specific energy consumption will be lower.

3. **Adsorption of PCDD/F in sinter plants** State of the art practice in PCDD/F control in sinter plants is injection of lignite coke powder with subsequent bag filter or fine scrubber with subsequent wastewater treatment. With these techniques PCDD/Fs are concentrated in waste. In the emerging technique of adsorption PCDD/Fs are adsorbed in an entrainment adsorption process with electrostatic filtration of adsorbent and recycled to the sinter plant to be destroyed and not concentrated in waste.

4. **Inorganic binder material for core-making in smitheries and foundries.** In order to reduce the consumption of organic binding material, responsible for odour emissions (amines, pyrolysis products and smoke) in foundries, different compositions of inorganic binding materials have been developed for use in core-making. These binding materials and sand used
are reused in the core sand cycle. Amount of waste generated by core-making is reduced to a minimum by this emerging technique.

4.7.2 Emerging techniques (ET)

4.7.2.1 ET 1: Integrated Gasification Combined Cycle (IGCC)

Summary
Gasification is a process that converts solid or liquid hydrocarbons into combustible gases with low or medium caloric value. In the process of Integrated Gasification Combined Cycle power generation, fuel is reacted with air and oxygen and other gases at high temperatures, then pollutants like sulphur and dust are removed to leave a clean gas composed mainly of carbon monoxide and hydrogen. The energy released from the combustion of this gas is used in a gas turbine. The thermal exhaust from the gas turbine is used in turn to power a steam turbine, thus a single system can generate power in two cycles, which is why it is known as "combined cycle power generation." It is hoped that this method of power generation will offer a thermal efficiency of 48% for coal, compared with conventional coal-fired thermal power generation systems that can manage around 41% [Criepi, Japan]. Critical for the success of the IGCC is the maintenance of the gas turbine. The IGCC turbine’s lifetime can be limited due to erosion and high temperature corrosion caused by impaction of particles and deposition of impurities such as alkali metals in the product gas (synthesis gas) [Klein, 2002].

In the past decades the use of coal, biomass and waste in IGCC was investigated. The incentives for all IGCC developments were more (cost) efficient use of coal, biomass and/or waste to produce electricity with lesser emissions of pollutants to the environment. This incentive fully meets the intentions of the IPPC: integrated prevention of pollution and efficient use of natural resources. The IGCC technique has not yet widely been implemented because of:
- technical problems;
- lack of sufficient funding for technology development;
- non competitive electricity production costs.

R&D support was the main instrument to bring the IGCC technique to the point were it stands now. Only higher energy prices for conventional fuels and additional R&D support will promote the further implementation of IGCC.

Applied instruments to promote development of Integrated Gasification Combined Cycle
In the development of Integrated Gasification Combined Cycle technique for coal, biomass and waste (see appendix 7) only one instrument (R&D support) is mentioned in literature to promote market introduction of this technique. However, it is clear that introduction of stricter emission limit values will also promote market introduction of IGCC technique. Stakeholders such as environmental authorities and agencies, research institutes, and suppliers of technology play here an important role of ‘pushing innovative technique’.

Effectiveness of R&D support

IGCC (coal)
The key to the success of the IGCC technology is the integration of components into an operating system. It is difficult to trace the influence of DOE’s (Department of Energy, US) basic and applied research
programs on IGCC development, in comparison with the efforts of manufacturing industry, which were built on a long history of petroleum technology and chemical processing matched with gas turbine technology. The electricity supply industry’s interest in IGCC was also stimulated mainly by the private sector and its concern over the viability of coal as a fuel.

However, both government and the private sector realized in the mid-1980s that coal continued to be the preferred fuel for electricity production but had to be used in the face of very stringent environmental constraints. This realization led to considerable industrial investment in a variety of coal-based power generation techniques.

IGCC development and demonstration provide a good example of a long-term, sustained cooperative public- and private-sector-funded program that has taken important steps to achieving national strategic goals. The benefits of this R&D investment are not yet positive economically, but it does give the United States a practical option for maintaining a coal-based electricity resource while meeting environmental objectives. The experience gained from the IGCC program points to the need to consider national investment in R&D at three levels—national strategy, technological priorities, and critical selection of options. At the first level, national strategy, the history of gasification and its application to IGCC shows the results of a wavering and inconsistent national energy policy through the last 30 years. At present, the United States faces most of the same pressures on its energy supply that it did in the 1970s. Yet the nation’s apparent energy policy has reacted with short-term responses to the availability of cheap fuels, dictated by the international marketplace, and to increasingly stringent environmental constraints. The long-term viability of a stable and inexpensive energy supply based primarily on domestic resources has been a low priority. If this objective had remained the top priority, IGCC might well be farther along in its applications.

At the second level, technological priorities, many publicly funded projects were financed on the basis of perceived value in basic and applied component research at the pre-system scale (pilot or bench-scale). This agenda has proven to be inefficient in the creation of energy production facilities that require inherently large capital investments. Early conceptual recognition of the potential of IGCC systems (which integrate chemical processing technology with thermodynamically staged, advanced power generation) provided a focus on component research specifications. This physical and intellectual integration of researchers and manufacturers served to set priorities for R&D investment early on, enabling a focus on solving key problems.

At the third level, critical selection of options, the experience gained from IGCC developments indicates that the successful development and demonstration of energy production techniques that require large capital investment are greatly enhanced with public and private partnerships, particularly for accelerating technique development to demonstration plants. DOE’s main contribution to IGCC resulted from developing a close working relationship with industry to move the technique through the commercial demonstration stage. This is very critical to commercial acceptance in the electricity production sector, where reliability of the technique is a primary consideration. Industry is increasingly averse to using its limited capital funds for pre-commercial demonstrations of new coal-based energy techniques. A degree of risk sharing, with public funds injected at the scale-up demonstration stage, assures that new approaches to energy production will experience a smooth transition from bench-scale to full-scale commercialisation [DOE, 2001].

**IGCC (biomass/waste)**

R&D support in the development of IGCC for biomass and waste resulted in acceleration of development of solutions to technological problems in the different processes. For biomass and waste R&D support did not result in commercial installations partly because of existing technological problems and partly because
of higher costs relative to existing techniques for power production by burning of biomass and waste inclusive costs for compliance to existing emission regulations.

**Conclusion on effectiveness of R&D support**

In all IGCC projects for coal, biomass and waste R&D support was necessary to overcome technological problems specific for the type of fuel to be used. For coal R&D support for pre-commercial demonstration promoted commercial acceptance in the electricity sector. This resulted in commercial installations. For biomass and waste technological problems still have to be solved. In general it could be stated that R&D support promotes cooperation between stakeholders (producers and users of new technique) and accelerates development and implementation of the new technique. One of the advantages of R&D support is that results of projects are more or less available for competitors in the same branch of industry but also in other branches of industry. In the IGCC case R&D support promoted development and implementation of IGCC of coal for power plants and the availability of the results of IGCC for coal for other branches of industry. In this sense R&D support for IGCC of coal did promote the development of new applications of IGCC in other branches of industry like biomass and household and industrial waste (e.g. refinery residuals, black liquor) even without R&D support of the new initiatives.

**Incentives for R&D support**

**IGCC (coal)**

The electric utility industry in the USA (as well as in Europe) will continue to face additional pressure from the proposed environmental regulations on SO2, NOx, hazardous air pollutants, (HAPs) and above all CO2 emissions during the next ten years or so.

Clean Coal Technologies are intrinsically beneficial to the United States and to other countries with abundant coal supplies. It is of paramount importance that the industry leaders and the government representatives continue to support the development, deployment and commercialisation of efficient, environmentally compatible and economically competitive techniques based on life cycle cost rather than first cost to allow the continued use of coal to fulfil this nation’s demand for electricity and economic growth. Because of tightening of environmental regulations on pollution especially with respect to CO2, SO2, mercury and NOx emissions, the advanced high efficiency Integrated Coal Gasification Combined Cycle (IGCC) technique will have the best chance of penetrating the market at competitive price. This was the main incentive for R&D support by DOE in the development of IGCC for coal. The Department of Energy in the USA (DOE) envisages future power plants based on gasification of coal to produce electricity to the grid and hydrogen for transportation fuels and distributed generation. An innovative concept utilizing IGCC technique could play an important role in penetrating the energy market on its own merit without any government subsidies [Guha, 2001].

Even though projections call for the implementation of several IGCC systems worldwide, their cost of electric power production in the United States remains higher than that of conventional natural-gas-fired turbine generators at natural gas prices for the year 2001. For widespread coal-based power generation, DOE has estimated that electricity produced in IGCC plants will remain more costly in the United States than that produced in conventional plants. However, according to DOE projections (made in 2001) they expected that economies may begin to favour IGCC in the next 5 years as a result of added costs for emission controls on conventional pulverized coal-fired plants, rising natural gas costs, and assumed improvements in IGCC performance. As economic benefits of IGCC systems were not compelling in themselves as a rationale for DOE investment at that time, the environmental and security benefits need to be considered as well to decide on further implementation of IGCC. DOE states that IGCC system
development provided an almost economically viable, environmentally benign technique option for continued use of coal as a primary means of electricity production through the 21st century.

The current level of IGCC development opens the door for major improvements in the thermal efficiency of coal-fired power generation and represents an important option for the reduction of greenhouse gas emissions [DOE, 2001]. Break-through of IGCC coal technique is expected in the period between 2005 and 2010 [UBA-DFIU/IFARE, 2005]. As a result of above DOE projections IGCC should have been implemented in economies now.

**IGCC (biomass/waste)**

In accordance with the energy, environmental, agricultural and social policy stated by the EU and the National Parliaments in the participating countries there will be a need for further development of the techniques for power and heat generation in an environmentally balanced way. A life cycle assessment (LCA) shows the important environmental advantages of biomass utilisation in terms of reduction of both greenhouse gas emissions and natural resource depletion [Carpentieri, 2005].

Additional research and demonstration of the Chemrec process for black liquor is needed before gaining market acceptance. It seems clear that a cost-shred, public-private partnership that involves several companies would be needed to help overcome the technological barriers and to reduce risks given the high capital cost of initial units. The opportunities of this technique are large because of the fact that the majority of recovery furnaces and conventional power boilers in existing pulp and paper plants are 20 to 30 years old and more than half of them will need to be replaced or upgraded in the near future [UBA-DFIU/IFARE, 2005].

From a national strategic energy point of view, a large-scale utilisation of black liquor gasification in Swedish pulp industry would yield a significant addition of electrical power (order of 1000 MW) to the national electricity network. This additional electricity will be available all year round, except at scheduled breaks for maintenance (typically one week per year for each plant), and also satisfies the demands for long-term sustainability in future energy systems due to the use of biomass [Gebart, 2005; Babu, 2005].

**Conclusion on incentives of R&D support**

Incentives for all IGCC projects were more cost efficient use of coal, biomass and/or waste to produce electricity and at the same time achieving lesser emissions of pollutants to the environment.
4.7.2.2 ET 2: Cyclone Converter Furnace (CCF)

Summary

The Cyclone Converter Furnace (CCF) technology is a direct smelting and reduction process for the production of pig iron. Direct smelting and reduction techniques like CCF have the ambition to replace the current blast furnace including coke and sinter facilities which would offer advantages of a smaller footprint and less emissions. The CCF technology is based on a cyclone in which the iron ore is pre-reduced and melted. The molten mixture falls into the lower part of the vessel where reduction is completed. The fuel consists of granular coal, which is injected together with oxygen in the lower part of the vessel. The high operating temperature of the cyclone reactor and the fact that it can handle a high level of entrained materials from the iron bath make the direct connection of the pre-reduction and final reduction stages possible.

CCF is expected to operate on fine ore and coal. This would result in considerable cost advantages in both operation and investment. Implementation of CCF might thus result in smaller steel production sites, as coke ovens and ore agglomeration (sinter) plants might not be necessary. Its design, with all reactions taking place in a single vessel, would result in simple operation and short start-up and shutdown procedures. The fact that both pre-reduction and final reduction takes place in one vessel is an important difference between the CCF and the other existing techniques for smelting reduction. Combining the two stages means that the heat transfer efficiency is not critical since there is no interstage cooling. [Daniels, 2002]\(^{100}\)

The development of the Cyclone Converter Furnace (CCF) technology was a joint initiative of Hoogovens (NL) and Iłva (I) and supported by the Research Technology and Demonstration programme of the European Coal and Steel Community ECSC).

The incentives for the development of CCF for Corus were:
- Expected cost- and environmental benefits from the CCF technology
- External pressure to improve environmental performance
- Need to replace the present coke ovens

R&D support from the ECSC (instrument) made it possible to initiate the development of CCF. The fact that this development did not result in a pilot plant was due to the economical factors (CCF appeared to be no competitive technique within the economics of Corus).

Environmental aspects

Since no coke oven plant, sinter plant or pellet plant is required; a significant reduction of emissions can be achieved. Energy consumption per tonne steel will also be lower. Apart from its lower \(\text{CO}_2\) emissions, CCF (as well as other direct smelting and reduction processes) also has lower emissions of dust, \(\text{NO}_x\), \(\text{SO}_x\) and other pollutants. Furthermore, power can be generated from the flue gases, which exit the cyclone at about 1800°C. [BREF, 2001]\(^{101}\)

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\(^{101}\) Source: BRef document on Iron and Steel production, p. 327 AISI-DOE/CCF
Figure 16. Scheme of Cyclone Converter Furnace iron making process [Daniels, 2002]

Status of development

Almost 10 years of research in coal based iron-making preceded the first large scale trials. In this period, the Hoogovens Company cooperated with British Steel and Ilva. CCF consists of a converter and the cyclone, which is much more innovative. The small-scale tests concentrated on the cyclone part. Hoogovens already received a subsidy from the European Union (ECSC) to proceed with a CCF pilot production plant with 500 kt annual capacity, to study whether CCF is to be considered as a promising technology to reduce energy consumption as well as CO₂ and other emissions in steel production. Then however, Hoogovens terminated the further development of CCF as they could not find industrial partners. The CCF pilot project with Hoogovens was cancelled in 1999.

The environmental benefits of the CCF pilot installation were already included in ‘het Bedrijfsmilieuplan’ (corporate environmental plan, which was agreed upon in the environmental permit) and were considered essential for the environmental performance of the iron and steel branch in the Netherlands. Because of the cancellation of the CCF Corus (Hoogovens) agreed to take more conventional additional measures to reduce emissions [Nieuwsbank, 1999][102].

The further development might be reinitiated when the coke ovens are worn out. [Daniels, 2002]. Continuous, incremental improvement of the conventional production blast furnace route and the existing capital stock lead at that time to a halt for development of CCF and most other melt-reduction techniques (except for the COREX technology) [Luiten, 2001]. CCF is therefore currently still in a semi-industrial stage: only components of the CCF have been operational in small-scale tests. CORUS (merger of former Hoogovens and British Steel) has no current plans for a further development of CCF. [FO-Industrie, 2004]. Ilva continues the development under the name of CleanSmelt, further details are unknown [Moors, 2002]. However, it is expected that in the near future (2020 – 2030) these 2nd generation processes will replace worn out blast furnaces and/or coke plants [DFIU/FAIRE&UBA, 2004].

Although the development of the CCF technology is halted at Corus, there are perspectives. The European Steel industry established in 2004 a Steel Technology Platform, which sets out a roadmap for steel industry research to 2030, and it sets a basis for collaborative work. The steel industry was challenged by the Commission to consider how carbon lean techniques could be applied to reduce CO2 emissions from this industry where the coal and coke-based blast furnace production route still dominates. Through efficiency measures, the industry has already made significant progress, halving CO2 emissions per tonne of steel produced by the blast furnace process over the last 50 years and it is reaching the technological limits of today’s process routes.

In 2004 the ULCOS project (Ultra Low CO2 Steelmaking) was started. This ULCOS project is 44 million euros by industry and EU funded (RFCS and 6FP) initiative launched by the major players in the European Steel Industry and its main partners in other industries and academia (47 partners, 15 European countries). ULCOS is a RTD program in the context of post-Kyoto, which plans to find innovative and breakthrough solutions to decrease the CO2 emissions of the Steel industry. The target is a reduction of specific CO2 emissions of 50% as compared to a modern Blast Furnace. CO2, which is equivalent to energy, is in the future potentially a more important cost factor, which could justify process-integrated innovations. The techniques considered in this project will also affect to a large extend the emissions of non-CO2 emissions of the steel making process. Therefore the project is described in some more detail below.

By the end of the project in 2009, the project will deliver a concept process route, based on iron ore, with a verification of its feasibility in terms of technology, economic projections and social acceptability. To choose among current candidate techniques that show potential for achieving this target, the most successful ones will have to be selected on technical and non-technical criteria (future energy market, internalisation of CO2 mitigation costs in market prices, societal acceptance). The societal acceptance criterion also include the general environmental performance (non CO2 emissions), Low CO2 techniques are only acceptable when other emissions are not increased (IPPC).


In the first phase, the ULCOS project will evaluate a range of options to reduce CO₂ emissions by using new low-carbon techniques applied to existing plant configurations and also by considering more radical potential process routes (like smelting reduction techniques, including CCF) that could become economically viable in the longer term. Corus is a member in the ULCOS consortium and the CCF smelting-reduction route (a derived process called ISARNA) is one of the technology candidates, which have passed a first screening. The CCF technology offers advantages on CO₂ capture compared with other techniques. In 2009 the project should be ready to launch a large-scale demonstration of the ULCOS techniques (one or two of the proposed routes).

**Box 5. Interview with Corus [d.d. 18th of October 2006]**

Corus describes the CCF technology as ‘fairly proven’, where the main uncertainties are in combining the two vessels. Both the cyclone and the converter have functioned separately in pilots.

However, the implementation of the CCF would only be considered in case of replacement of (one of) the present blast furnaces. Only when a blast furnace is at the end of its production life it can be replaced without destruction of capital. This is not foreseen before 2020. Accessory factor in this is that CCF produces relatively large quantities of high calorific gas, which have to be used effectively in the area. This means that a power plant has to be built to get a valuable project. Therefore, the CCF was rejected as an unrealistic option at the IJmuiden site.

The present and near future environmental regulation on among others SO₂, NOₓ and PM in IJmuiden is very strict, The solution for not exceeding environmental standards is sought in the strict application of Best Available Techniques according to IPPC.

Corus sees the continuous upgrading of BREF as a good and fair instrument to improve the environmental performance in the steel sector. ‘This is the only equal level playing field that works for us’, according to Corus.

At present, Corus contributes its CCF know-how in the ULCOS project. Here Corus is able to invest in such a large development trajectory together with the other European steel companies.

**Effectiveness and conditions for R&D support in CCF development**

The development of the Cyclone Converter Furnace (CCF) technology was a joint initiative of Hoogovens (NL) and Ilva (I) and supported by the Research Technology and Demonstration programme of the European Coal and Steel Community ECSC). The total expenditure for the CCF project was 18 M US$, of which 7 M US$ (40%) funded by government support (European Coal and Steel Community ECSC). This expenditure includes the R&D activities of British Steel, Hoogovens and CSM performed in three ECSC supported projects on CCF [Luiten, 2001]
Effectiveness of R&D support used in CCF (ECSC funds)
The European Coal and Steel Community Treaty (ECSC) dates from 1952 when the signatories constructed a way to replace rivalry with solidarity in Europe through a model of economic and political cooperation designed to improve the prosperity of all. The financial activities carried out by the ECSC, over a period of fifty years, generated assets, so that the total fund administered by the ECSC totalled approximately €1600 million when the treaty expired on 23 July 2002. The ECSC’s RTD programme stimulates co-operative projects and also obliges the participants of various supported projects to meet and exchange R&D results. The research programmes financed by the ECSC were considered highly effective. Assessments’ have shown that every unit invested in ECSC research generated, on average, 13 units worth of economic return, largely thanks to the economies of scale achieved. [Cordis, 2006] 107. The funds of the European Coal and Steel Community ECSC (a treaty which has expired in 2002) are being continued in a new EU R&D programme “Research Fund for Coal and Steel” [Cordis, 2006].

The European integrated steel manufacturers British Steel, Hoogovens and Ilva knew each other through regular meetings of the ECSC’s RTD programme. They had also co-operated in earlier projects that were supported by the ECSC. Experts see this set up with meetings and exchange of views as a positive aspect of the RTD programme. It promotes contacts with other companies because you know the people you may address. Steel companies apply for ECSC support typically in pre-competitive stages of a process development when it is attractive to share expertise and equipment and to learn.

The requirement of contacts and exchange between the companies participating in the RTD programme make these companies decide to do without ECSC support when projects reach a more strategic stage of development. However, the RTD programme allows companies to meet other actors who have similar R&D interests and R&D experiences. There is a ‘pool’ of actors who can meet and initiate explorative projects. [Luiten, 2001]. However, with regard to the effect of government R&D support on the development of CCF it was concluded that government R&D support enlarged the technology network, but did not accelerate the actual technology development. The network is now no longer active. [Luiten, 2001].

Conditions for R&D support
An important condition for R&D support to be effective is that the contribution must outweigh the risks associated with technology development. Common practice is decreasing levels of subsidies for fundamental research (high risk) to feasibility studies and demonstration research (risks mostly eliminated). R&D support or subsidies should be granted to techniques with a long time frame of development and / or to techniques that are easily imitated by others. [Luiten, 2001]. Project consortia in which a combination of different actors, like technology producers and users are present can be thought to attribute to the effectiveness and follow-up.

Government R&D support is one of the most common instruments for stimulating R&D and technological development, but also one of the most debated. Arguments are:
- Empirical evidence regarding the effect of R&D support is ambiguous. It is often hard to indicate the additional value of R&D support, since it is hard to know what would have been done without government R&D support
- With regard to large companies, R&D subsidies will hardly affect company decisions

A Dutch PhD study on technology development of process technology considered the development of melting-reduction technology (among CCF). With regard to the effect of government R&D support on CCF it was concluded that government R&D support enlarged the technology network, but did not accelerate technology development [Luiten, 2001].

The effectiveness of R&D support must therefore be seen in the context of forming technology networks and project consortia.

**Incentives**

With respect to the development of CCF the R&D subsidy was not the only incentive for Corus to continue the development and to establish the prototype CCF production plant. Other incentives for the development were:

- Cost- and environmental benefits from to be developed CCF technology
- External pressure to improve environmental performance
- Need to replace of the present coke ovens in the near future

R&D support from ECSC was therefore not a primary incentive.

In the PhD study of Luiten, different experts were asked whether the environmental emissions had been a decisive argument for initiating or performing R&D activities. The need to comply with environmental regulations was usually indicated as one of the factors leading to the cost advantage of the smelting reduction technology over the conventional blast furnace route.

If a smelting reduction technology like CCF were to be applied, other environmental investment would not be needed. However, this incentive would never have been large enough to initiate huge and technologically complex R&D efforts such as the development of smelting reduction technology [Luiten, 2001]

**Relation of emerging technique with environmental improvement plans**

As stated earlier the CCF development was incorporated in the Environmental improvement plan for Corus. This plan is part of the covenant between the Dutch steel industry and the Ministry of Environment. The (voluntary) covenant sets target for the future emissions, which can go beyond current legislation. The covenant instrument gives companies freedom to choose their own way for reaching the targets. This means they can implement new and innovative techniques instead of “conventional” abatement options. Incorporation of emerging techniques in agreements with the regulatory authorities can improve the commitment of a company to proceed in the development of the technique. In the case of Corus, The development stop resulted in a dismissal of a state subsidy. Corus faces now cost for conventional abatement techniques.
4.7.2.3. ET 3: Adsorption of PCDD/F in sinter plants

Summary
In the last decades the highly toxic and accumulate effects of dioxins became clear and the urgency to abate dioxin emissions increased. The iron and steel industry is an important source (~ 8% in EU-25) of dioxin emissions. The emission depends on the scale and type of steel production and abatement measures taken. The sintering process has been identified as the most important source of dioxin emissions. However, available techniques for reduction of dioxin emissions from waste incineration plants could not be directly transferred to sinter plants. Compared to for example waste incineration plants, other important sources for dioxin emissions, sinter plants have:
- larger volumetric waste gas flows,
- different waste gas temperature,
- fluctuating operating conditions during start-up and shutdown,
- high specific electrical resistance of the dust

Different specific end-of-pipe measures were developed in order to reduce the emissions of dioxins (and other organic micro-pollutants) from the sinter plant off-gasses. The abatement of PCDD/F (dioxins and furans) from sinter plants by entrainment adsorption of dioxins with electrostatic filtration of adsorbent looked most promising. This case reviews the development of a specific technique, which was first demonstrated at the Thyssen Stahl AG plant in Duisburg and later adapted by different sinter plants, as for example the Arcelor Mittal facilities in Gent – Belgium (previously Sidmar) and Eisenhüttenstadt in Germany (previously EKO Stahl).

The incentives for the development and adaptation of the dioxin abatement technology for sinter plants were:
- The urgency, due to the new insights on health effects, to find a solution to the dioxin problem in short term;
- Public pressure.

The instrument that contributed to the successful and fast implementation of part of the technique (success for adsorption step, failure for catalytic oxidation step) was the enforcement action of the regulatory body, which anticipated to future stringent emission limits. The availability of test results from a demonstration plant contributed to the speedy implementation.

Reduction of dioxins by entrained flow adsorption and catalytic oxidation.
The operators of different sinter plants in Germany founded in co-operation with the Verein Deutscher Eisenhüttenleute (VDEh) an association called ARGE in order to develop techniques to lower dioxin emissions from sinter plants. This association had the goal to develop a process, which is secure in operation, needs no water and can be applied to existing plants. After preliminary experiments and cost calculations the association built a demonstration plant at Thyssen Krupp Stahl (Duisburg).
The process is based on adsorption by injection of lignite coke (brown coal) powder in an entrained flow reactor to adsorb the dioxins followed by an existing electrostatic precipitator (ESP). Lignite coke was used as adsorbent for dioxins, which are essentially present in a gaseous state and are adsorbed by the lignite coke powder. The device to inject lignite coke powder as an adsorbent into the waste gas manifold is installed about 27 m upstream of the ESP. A controller allows dosing of the adsorbent up to 300 mg/m³. The adsorbent is then precipitated in the ESP and recycled to the sinter strand. A downstream honeycomb oxidative catalytic converter has been installed between the fan and the stack to subsequently remove the remaining pollutants by catalytic oxidation. The remaining dioxins are destroyed, reducing the emission to < 0.1 ng I-TEQ/Nm³. (Comment: such performance was not confirmed at the time the BREF was written and later on was only obtained for very short time due to the rapid deterioration of the catalyst – see here below).

Figure 17. Scheme of waste gas treatment system with adsorption stage and catalytic converter [BREF ISP, 2001]¹¹¹.

1. Sinter strand
2. Ignition furnace
3. Waste gas main with reactor
4. Injection pipes
5. Dose station with control equipment
6. Feed tank for adsorbents
7. Filling device
8. Dust recycling
9. Electrostatic precipitator
10. Measuring station for dust concentrations and for dioxins
11. Fan
12. Measuring station for off gas composition
13. Oxidation catalytic converter (equipment removed in final industrial installations)
14. Measuring station for dioxins
15. Stack

In the BREF document on Iron and Steel [BREF, ISP 2001] it is noted that the two systems (injection of lignite coke powder and catalytic oxidation) were tested separately and that not both systems are necessarily needed to achieve values <0.1 ng l-TEQ/Nm3. Such performance was however not confirmed at the end of the trials. In fact, values of 0.1 ng were only observed during a short period of time with the catalyst. This is also seen in later developments (see below) and confirmed by Sidmar\textsuperscript{112}. The catalyst showed to be very vulnerable and was deactivated within months and hard to regenerate. For adsorption only, Sidmar in Gent confirms values lower than 1 ng (spot control) and lower than 0.5. ng (yearly average).

**Status of development**

With successful demonstration in 1999 the adsorption technology was planned to be installed in the neighbouring sinter plants Hüttenwerke Krupp Mannesmann (HKM) and Krupp Hoesch in Dortmund, according to the Nordrhein West-falen Ministry for Environment\textsuperscript{113}. The ARGE consortium with operators of the German-based sinter plants was later joined by the Belgian company Sidmar (currently Arcelor Mittal facility in Gent) and the French company Sollac (currently Arcelor Mittal facilities in France). Sidmar decided to build an industrial adsorbent injection installation at the sinter plants based on the experiences with the good performance (separation rate) of the demonstration plant in Duisburg. As adsorbent, Sidmar however adopted active coal in place of lignite coke. This installation on sinter plant no. 2 was also started up in 1999. After verification of the results of the installation at sinter plant no. 2, a similar installation was put into use at Sidmar’s sinter plant no.1. The global reduction of the dioxin emissions achieved is about 97 % (2001 situation compared to 1997)\textsuperscript{114}.

*Catalytic oxidation as tested in Duisburg* is, according the environmental plant manager of Arcelor Mittal in Gent, Mr. Ronald Mortier, not being applied in the Steel industry to remove dioxins. Current emission levels at the Sidmar sinter plants are below 0,5 ng TEQ/Nm3 on a year average, with all levels below 1 ng TEQ/Nm3.

Currently at least two engineering companies are deploying and supplying the technology, Küttner GmbH (Germany)\textsuperscript{115} and Paul Wurth SA (Luxemburg)\textsuperscript{116}.

**Impact of new scientific insights on the development of ET**

The development of abatement techniques for sinter plant off-gases was induced by the then new insights in the dangers and sources of dioxins. Dioxins are persistent and, being fat soluble, tend to accumulate in higher animals - including humans. With the development and increasing accuracy of measurement methods in the last few decades, the highly toxic dioxins were found in different products such as milk. Because of this, the emission limits applied to industrial sources followed more or less the development of the increasing accuracy of measurement technology. Since the sinter plants were considered as a major emission source, governmental as well as public pressure built up and led to the development and application of the technology reviewed here.

\textsuperscript{112} Interview with Mr. Ronald Mortier, Environmental Manager Arcelor Mittal site in Gent, on 16\textsuperscript{th} Nov. 2006


\textsuperscript{115} Source: http://www.kuettner.de/d-kokerei.html

\textsuperscript{116} Source: ThyssenKrupp, http://www.thyssenkrupp-steel.com/consulting/en/service/images/brochure/consulting_e.pdf#search=%22duisburg%20thyssen%20k%C3%BCttner%22
EU R&D support did play a role in development of this specific abatement technique as the study was partly funded by ECSC\textsuperscript{117}, now RFCS. It is not known whether national governments have supported the development.

In the case of the Sidmar sinter plant in Gent the public anxiety was large (the sinter plant was designated by the Belgian Vito institute to be the most important dioxin source in the Flemish region and something had to be done). In 1997, high dioxin emission values were recorded at the stacks of the Sidmar sinter plants. In 1998 an extremely intensive dioxin measuring campaign followed. Between 1998 and 2000, three laboratories took in total 530 dioxin measurements. Process control improvements (such as use of burnt lime in this specific case) can reduce the dioxin emissions by 85 %. A further decrease in the dioxin emission was only possible using end-of-pipe technology. It was decided to build an industrial coal injection installation for further reduction of the dioxin emission based on the experiences with the good performance (separation rate) of the demonstration plant in Duisburg.

The Sidmar case of dioxin reduction is being regarded as a success story. Thanks to a systematic approach, Sidmar succeeded in reducing dioxin emissions to below the emission limits (Vlarem II standard of 2.5 ng TEQ/Nm\(^3\) in 2000, and even below the target value of 0.5 ng TEQ/Nm\(^3\)). Sidmar was one of the first steelmakers to incorporate an adsorption installation into the waste gas ducts of its sinter plants. Sidmar received in 2002 an environmental award (Belgische VBO Milieuprijs\textsuperscript{118}) for the reduction of the dioxin emissions of the sinter plant and was nominated for the "European Awards for the Environment". Furthermore, the Flemish environmental inspectorate held a presentation on a international dioxin congress on the experiences with the Sidmar case\textsuperscript{119} called "Reduction of the dioxin emission from iron sinter plants in the Flemish Region: enforcement approach of the Environment Inspection Section’. The inspectorate explained in this presentation how they succeeded in reducing the emissions of the sinter plant by more than 95% with enforcement on the company. The enforcement approach of the inspectorate on Sidmar was described as the combined result of a combination of a preventive and repressive enforcement strategy based on:

\begin{itemize}
  \item highly specialised field inspections;
  \item professional negotiation with the plant operator;
  \item research on emission abatement measures;
  \item a balanced application of criminal justice and administrative measures.
\end{itemize}

The Sidmar case is also being evaluated in the background report of Müller-BBM, IUTA and RDC Environment for the IPPC Directive in relation to dioxin emissions [Müller, 2004]\textsuperscript{120}.

The case report summarizes: "Due to circumstances, mainly feed formulation, the original emission values from Sidmar were definitely higher than average for sintering. When this became apparent, the local Inspectorate heavily tackled the enterprise, even though it spontaneously led to a vast measurement campaign, in which all conceivable parameters were systematically studied. Following a steep learning curve, by selecting the more relevant parameters, the enterprise managed to reduce its emission values significantly, from an original value of 15 ng I-TEQ/Nm\(^3\) to the present values.".

\textsuperscript{117} See for more information on the ECSC the ET 2 case on the development of the cyclone converter furnace (CCF) technology
\textsuperscript{118} Source: http://www.envirodesk.be
Incentives
The development and adaptation of the dioxin abatement technology for sinter plants was driven by the urgency to find a solution to the dioxin problem in short term. The technology development is to be considered as an adaptation of available unit operations such as entrainment adsorption, ESP and catalytic conversion\textsuperscript{121} to fit the specific demands of sinter plants.

In this development no specific instruments can be identified for beyond regulatory compliance behaviour other than the increasing awareness of government, public and industry on the urgency to solve a relatively new, but serious problem, the emissions of dioxins. In the Sidmar case, regulation is being regarded as the driving force. As there were no ELVs for PCDD/F at the time when the high emissions were first measured, the Environmental Inspectorate took action by enforcing the general prevention principle ("irrespectively of the permit, the operator should take all measures to prevent damage and nuisance"). There was concern that the high concentrations of dioxines found in the milk from farms in the vicinity of the plant, could be caused by contamination from the high dioxin emissions from the sinter plant\textsuperscript{122}.

The development initiated by industrial (competitive) partners developing a demonstration plant in Duisburg is seen as a positive aspect. The demonstration plant was fruitful in contributing to the implementation of the successful part of the technique (the adsorption operation) in other plants.

BREF document
In EU there are approximately 50 iron ore sintering plants (IPPC category 2.1) [Müller, 2004]. Sinter installations are covered by Annex I of the IPPC directive\textsuperscript{123}. When not fitted with abatement techniques, sinter plants form a major source of dioxin emissions. The development of the abatement technology from the sinter plant off-gases is induced by the then gained insights in the dangers of dioxin emissions and the setting of new limit values. The BREF document on BAT for the Iron and Steel industry asks for new techniques to be considered when permitting an industrial activity covered by the IPPC directive. The current BREF document dates from 2001 and describes the demonstration plant at the ThyssenKrupp sinterplant in Duisburg as an emerging technology. As can be seen by the case study some elements of the technology have been optimised since then and the technology is performing in different configurations (only without catalytic oxidation which gave disappointing results).

The technology reviewed demonstrated successful implementation at industrial scale in a few years time.

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\textsuperscript{121} Catalytic oxidation is, according the environmental plant manager of Sidmar, mr. Ronald Mortier, not being applied in the Steel industry to remove dioxines.


\textsuperscript{123} Source: IPPC of the IPPC Directive, Annex I, 2. Production and processing of metals, 2.1. Metal ore (including sulphide ore) roasting or sintering installations
4.7.2.4 ET 4: Inorganic binder material for core-making in aluminium foundries

Summary
In aluminium casting the molten aluminium is poured into a mould, which defines the outer shape of the casting. To make hollow products, cores are placed in the mould that avoids the mould to be completely filled up with the aluminium. A core defines the inner shape, or at least the parts not directly attainable by moulding. For core making, chemical binding systems are primarily used. Cores require different physical characteristics than moulds. Cores must be able to withstand the strong forces, which can occur when molten metal fills the mould, but must later often be removed from small passages in the solidified casting. This means that the binding system must produce strong, hard cores that will collapse to allow removal after the casting has hardened. Therefore, cores are typically formed from silica sand (and occasionally olivine, zircon or chromite sand), and strong chemical binders. The sand and binder mix is placed in a core-box where it hardens into the desired shape.

Organic binding materials in aluminium die-casting are responsible for VOC emissions and odour in foundries. There is a large amount of development work going on worldwide to improve the performance of core binders and to make them more environmentally friendly. In order to reduce the consumption of organic binding material (and emissions and odour) in foundries, different compositions of inorganic binding materials are being developed for use in core-making in aluminium die-casting. The applicability of inorganic binders in core making is however still limited. Inorganic binder material for core-making was especially pointed out by the IPPC TWG as “promising, although the current limited scale of testing and implementation does not allow it to be yet incorporated as a technique to consider in the selection of BAT”. [IPPC Bref, 2005] In this case we review the development of inorganic (magnesium-sulphate) binders for aluminium casting by the Volkswagen Nutzfahrzeuge-Werk (VWN) foundry and the Technical University Freiberg [Bisschof, 2003].

The incentives to develop the new binding process for VWN were:
- Reduction of odour problems and organic emissions.
- Economics (considerable cost reduction).
- Image considerations

The latter mentioned incentive is driven by public pressure. Although the new binding process is more economic and environmental friendly it is not yet been implemented full scale. Although not confirmed by VWN it is expected that the transition to the new technique is more difficult and or has larger economic impact then expected. VWN continues to announce full implementation in the near future.

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Description of technology

All cores are being produced using an inorganic binder containing magnesium sulphate (MgSO₄) and/or polyphosphate. The inorganic binders are dissolved in water, with small amounts of additives to prevent sand adhering or sticking to the casting. The proportion of binder relative to the quantity of sand by weight is 3 to 8%.

![MgSO4 binder bridge (REM 500:1)](image1) [Bisschoff, 2003]. ![wet removal of core](image2) [VWN, 2006]

In order to achieve short drying times of 10 to 20 seconds, preheated sand (60 – 80 °C) is blown into heated core-shooting tools (120 – 140 °C), in which the water evaporates and is flushed out. The inorganic ceramic core will then have a temperature stability of more than 1000 °C, and will maintain high strength.

After casting, core removal can be performed either wet or dry. In wet core removal, the castings are cooled rapidly by quenching. When coming directly into contact with water, the core disintegrates within a few seconds. This can cause a desired improvement of the microstructure and causes the binder to dissolve completely. In dry core removal, the lumps of sand are ground, which leaves the binder layer on the quartz sand largely intact. When recycling core sand, only 5 % of the binder quantity originally used must be added [BREF, 2005].

Environmental benefits

The conventional (cold-box) process causes emissions of organic compounds such as amines, pyrolysis products and smoke. The use of inorganic binders as magnesium sulphate generates no emissions. Waste (sand residues) is mostly prevented by recycling. There is no need for costly regeneration. The quantity of sand to be replaced is very small. When a dry technique is used for core removal, all the binder remaining in the sand is claimed to be reused. Note: this claim depends on the possibility to reuse the additives and the sand in a more or less original form. As no gases form during casting, no problems with gas permeability arise. The binder therefore allows the use of very fine sands, which significantly improve surface quality (e.g. depth of roughness). As the regeneration rate is high, it is economically viable to use even expensive alternative synthetic ceramic sands or e.g. zircon sand. The energy costs of this type of core making are higher than in classical (organically bond) cores. However in the future an energy saving of 30% is expected.
Status of development
The technique is applicable for core-making in aluminium die-casting in new plants and in existing plants after adaptation of the core-shooting automats [BREF, 2005]. VWN (Volkswagen) announced to implement the new binder in serial production 2006\(^\text{127}\). Further developments are aimed at adapting the binder for use in iron casting and as a moulding material [BREF, 2005].

Incentives & barriers
Driving forces for the development of the inorganic binder and implementation in the production processes are:
- Reduction of odour problems and organic emissions.
- Economics (considerable cost reduction).
- Image considerations

Reduction of odour problems and organic emissions.
The VWN foundry in Hannover-Stöcken is a large facility, and includes one of the largest aluminium casting shops in Europe. The 11 ha sized facility with 15,550 employees is founded in 1956 and situated in a residential area, with houses situated only 100 m from the plant\(^\text{128}\). Because of this the foundry makes large efforts in controlling their environmental effects. When in 1999 the foundry applied a permit for extension, neighbours and a environmental organisation objected. This caused the foundry to decide to set up a environmental program called PIUS [VWN, 2006]. The PIUS program intends to communicate with the neighbourhood and also to solve environmental problems. The scope hereby us solving the environmental problems of VWN not only with „End-of-the-Pipe“-technology such as filters, but especially aimed to reduce the environmental impact of the processes itself by process optimisation and innovation. [VWN, 2006]

Economics
Despite the need to heat core-shooting tools, the technique leads to overall cost savings for core-making, due among other things to the lower consumption of new sand and the fact that costly thermal regeneration or the disposal of sand is no longer necessary. Costs savings can also be generated by recirculation of the binder. Considerable cost reductions are achieved by the fact that there is no need for waste gas treatment systems to remove organic compounds, such as amines and pyrolysis products, which can arise during core-shooting and casting when organic binders are used. According to rough estimates, the use of this technique reduces the costs for core-making by 30 to 50 % compared to the cold-box process. [BREF, 2005]

Image considerations
The foundry was awarded in November 2002 with the environmental award of the World Foundry Organisation (WFO), the environmental association of the foundry industry for their efforts to reduce the environmental impact by the development of the odourless binders and reduction of odour emissions from the production process was especially [VWN, 2006].

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Barriers
The use of inorganic binders for core making seems to be a promising technology. The claimed benefits are large on both environmental and economical grounds. Which such prospects, one should expect that technology development hardly needs stimulation and takes place in a short time period and in a natural way. However, the technology is still in the phase of being announced and seems not yet to be implemented by VWN. Suspect is that there are other barriers and factors that slow down the development. Although not reported, the heating of the inorganically bound cores can be such a factor for example because this implies a new process being installed in the foundry. Furthermore it should be noted that the transformation of a well known (core business) process, with all its limitations, to a new, yet to be proven alternative, needs successful examples and knowledge transfer. A possible barrier that could be expected for dispersion of the results of developments like in this case can be the intellectual property. Large organisations are known to protect the intellectual property resulting from their costly research efforts, ensuring a competitive advantage. The technology can than be successful, but widespread diffusion does not occur. Although in this case no relevant patents were found, this is no guarantee that the results of the development will be available for other companies.
5 DISCUSSION AND GENERAL CONCLUSIONS

The main research questions of the BRC project are:

1. Which measures, tools, or instruments create incentives for companies to perform BRC?
2. In which context were these instruments (measures and tools) successful (or not)?
3. What are the main incentives for companies to go BRC?
4. What is the effectiveness of the instruments (measures) concerned?
5. What is their interaction with the IPPC directive?
6. Is the IPPC Directive considered a barrier to such measures and, if so, how could it be improved if necessary?

Each research question will be answered considering the information obtained during the case studies and the related literature. Evidently this search is not exhaustive; however despite the limited number of cases it is possible to have a good indication of what is possible with the instrument, without drawing strict conclusions on a general level. In the following sections these research questions will be addressed.

5.1 Which instruments create incentives for companies to perform BRC?

Within this study instruments have been categorized as regulative instruments, financial/economic instruments and/or communicative and voluntary instruments (chapter 2). The first category is addressed separately from the other types of instruments within the categories ‘financial/economic instruments’ and ‘communicative/voluntary instruments’, as the study is looking for drivers that stimulate industries to perform better than their regulatory obligation. Regulation however is one of the (main) instruments influencing industries to innovate, and as innovation in the form of emerging technologies in BREFs is part of the IPPC, therefore of interest in this study as well. This mechanism is separately discussed in section 5.6. This mechanism is especially strong in the cases where regulation is combined with an instrument of one of the other categories, e.g. voluntary agreements or taxes. However, the specific impact of one of the instruments is hard to assess in these cases where a combination of instruments was introduced.

Regulation in combination with other instruments

The case studies and literature indicate that in general, stakeholders see regulation together with cost reductions as the most direct and significant incentives for companies to improve their environmental performance. With all financial instruments it appeared that they could be seen as additional to the regulations and often the system operated quite independently from them. Also for the networking initiatives such as the voluntary Danish Green Network and the Performance Track program are combined with the implementation of regulations. Nonetheless it cannot be denied that achieving results depends partly on appropriate regulation or inspection intensity, and also on an effective implementation and monitoring of directives. This is especially the case with the Performance Track program.

The Energy efficiency programs are often initialised by the authorities and are, most of the time, part of government regulations created to encourage companies to improve their efficiency. In some countries like the Netherlands voluntary agreements between authorities and the government also take place that can even result in worldwide benchmark initiatives with very ambitious targets. An example of this is the Brewery industry. In total more than 100 breweries from 38 countries participated in this energy benchmark

129 Wouda, Pennartz, Reuchlin in Brauwelt International, 2002/II
It must be said that frequently also legal requirements exist next to these voluntary initiatives. However, according to some industry representatives, legal requirements are regarded as unnecessary as companies are looking for energy (cost) efficient measures anyway.

**Voluntary and communication instruments**

Instruments that are falling under this category are amongst others environmental agreements and covenants, network creations, environmental management systems (EMS), and publicity. Some instruments, such as the publication of annual reports (SPOTLIGHT on business) by the Environment Agency in England and Wales (see 3.8), can be seen as a more publication oriented tool. Others like the Danish Green Network (see 4.4.) and the U.S. Performance Track program (see 4.3.) can for instance be seen (for a large part) more as a combination of EMS and network creation.

Environmental agreements in combination with regulation, like the Dutch covenants, stimulate industries to look for cost-effective ways to reach the targets that have been set in this agreement. Often the targets are set on a more stringent level than the existing legislation. However, it is the linkage of these targets with the environmental permits that provide the strong incentive.

Environmental management programs (EMS) are significant elements of the Performance Track and Danish Green Network. Energy efficiency management systems often resemble EMS or are a part of the companies integral management system. However in particular for the two initiatives from Denmark and the U.S. the networking program create an incentive for companies to participate as they get their EMS organised in the most cost effective way. Moreover, the network proved to create an incentive for continuous improvement efforts, in some cases even BRC.

From the study it can be concluded that informational ‘regulation’ such as publicity (‘naming and shaming’) is increasingly important to drive environmental improvement in complement to conventional regulation. This is mainly based upon the expectation that stakeholders will exert pressure on those companies to comply with regulation in a manner, which serves the interest of the stakeholder. This approach relies upon economic markets and public opinion as the mechanisms to bring about improved performance. Information provision and publicity is said to be targeted almost exclusively at large enterprises, and in particular at public companies and those who are reputation sensitive (see chapter 2). Exceptions however do exist also here. The Danish Green Network can be considered as a highly regional initiative with also many SMEs participating and with the local authorities as (one of the) main stakeholders. An important incentive of companies, both SMEs as well as multinationals, is the recognition of the local public opinion of the company joining this local Network. In case of the incineration facility in Southeast-Jutland it was even the main criteria for the management and owners (different municipalities) of the company to show to the local community their ‘Green attitude and commitment’ (see 4.4.).

**Financial / Economic instruments**

As mentioned earlier in the report (chapter 2 and 3) categories of economic instruments are:

1) the use of price signals in the shape of taxes or charges;
2) property rights in the form of tradable permits;
3) supply side instruments in terms of subsidies.

The economic instruments in the case studies are under sub category 1 (solvent taxes, NOx tax) and under sub category 3 (emerging technologies such as CCF and IGCC). In this study category 2 was not considered in detail.
In some situations, for instance under the NO\textsubscript{x} charge, it was proved that this economic instrument reduced emissions beyond regulatory compliance with IPPC permits. Some economists argue that economic instruments are usually more cost-effective than direct regulation, in large part because they give companies more flexibility to achieve resource productivity and prevent pollution. This was found to be true in particular for the NO\textsubscript{x} charge system in Sweden and the solvent tax system in Switzerland. In both countries, stakeholders (competent authorities, industry and others) were in general very positive about these instruments that exist quite independently next to the permitting requirements and leave a lot of flexibility and freedom for the companies to take cost effective measures. For the solvent tax in France this incentive appeared to be far less clear in particular due to the too low level of tax to create incentives.

5.2 In which context were these instruments successful?

It is important to realize that not all instruments will be appropriate in all circumstances or for all industries. Effective policy design involves tailoring a particular combination of policy instruments to particular circumstances. Factors that influence circumstances are for example the culture of the industry, the susceptibility of an industry to public pressure, the level of sophistication of a company, the degree of uniformity in company size and management practices, the degree of organisation of an industry association and the type of regulation in a country i.e. centralized or decentralized.

It will be necessary to consider whether or not the industry has a profile that determines the degree to which companies might be susceptible to public/consumer pressure. For large multinational companies, operating often on a global scale, this public sensitivity is clear. This public influence was seen at the inorganic binder development for aluminium casting at Volkswagen foundry and in the case of the Sidmar sinter plant (gas clean up of PCDD/F emissions) at Gent (see 4.7.). Different industries and stakeholders at the Danish Green Network, although operating on a more regional level, also mentioned this public sensitivity aspect, frequently.

Another conditional factor is the level of sophistication in the industry. This is often an indication of the companies’ capacity to adopt complex EMSs, and the need for education and training. At the Performance Track program it was pointed out that it was likely that in most of the cases the larger companies were joining the program because these types of companies are more prepared to comply with many of the program’s requirements. This disadvantage does not arise at the Danish Green Networks as this program is not just about meeting EMS requirements, but is also aiming at supporting companies that do not really have the capacity (are not sophisticated enough) to meet EMS requirements.

The degree of uniformity in size and management practices of an industry is also a contextual aspect to consider. Increased diversity increases the need for companies to develop different strategies for different sub categories. After ISOVER (Denmark) was taken over by a French multinational company group, the relative importance of joining the Green Network seems to have changed (more low profile) probably due to changing to a more diverse and higher level of company strategy.

A well-organised industry association is thought to be necessary to determine the industries capacity to adopt some form of voluntary agreement. Industry associations such as the Dutch environmental covenants can play an important role in negotiations with the authorities. An example of this can be found at the development process of the CCF in the Dutch Steel industry (see 4.7.). An agreement was made between the Dutch Basic Metal industry association and the authorities to meet environmental targets for emissions to air and water. Part of this covenant was the set up of a company plan at regular intervals for the members to improve their environmental performance.
The development of the CCF was part of the Corus’ environmental plan (Metal and steel production) to meet these environmental targets. Industries that are not part of such an association will have a weaker position in negotiations about covenants, for instance.

A very important context variable is the prevailing culture of the (national) industry, and its potential receptivity to different types of approaches. In the case studies in Denmark and Sweden the significance of this aspect was frequently mentioned both by authorities and companies. In Denmark the non-hierarchic and open way of communication between the authorities and the top management of the companies was mentioned to be a crucial factor to the successes of the Danish Green Network. In Sweden the historic trust between companies and authorities and the high environmental awareness of the industry were mentioned as crucial aspects for the smooth operation of the NO\textsubscript{x} charge system. In the Netherlands the covenant approach (e.g. Corus) could be seen as a successful cultural exponent of the worldwide known ‘Dutch polder model’\textsuperscript{130} In the case study involving Slovenia on the other hand, it could be seen that the relation between industries and authorities is more formal and hierarchical, compared to some North-West European countries. In this situation a legislative approach is more common and other instruments, especially voluntary agreements and communication, are less frequently used.

The importance of applying different conditions can clearly be seen in the solvent tax cases. The VOCV in Switzerland and the TGAP in France are both financial instruments that are used in addition to other regulations. For the industries involved this means that they have to comply with (regional) air quality regulation as well as are being ‘driven’ by (national) financial instruments. In France according to most interviewees the driver for emission reduction comes from regulation and not from the financial instrument. The major reason for this is the low tax level, being no ‘hurt’ for industries that are focusing far higher tax levels on waste and wastewater. In addition, no extra stimulus for emission reduction is given like in the Swiss exemption option for industries, which reduce their emission levels to at least 50% below the regulatory emission limit values.

Finally also BAT-based permit conditions are determined in different ways in different Member States, and sometimes in a highly decentralized manner (tailor made permit conditions for companies issued by regional/local authorities), with the BREFs as a common point of reference. In Denmark, Sweden and the Netherlands the BREFs are reported to be used in a highly decentralized way and this does not appear to have lead to any explicit problems till now for, for example the Green Network, or the NO\textsubscript{x} charge system. Tailor made conditions for the specific plant situation appear(ed) to be possible due to this decentralized approach. For the Swiss case it can be mentioned that the solvent tax is seen as a financial instrument that is fully complementary to the national permit system, including use of best available techniques (BAT). Energy efficiency initiatives appear to be less sensitive to contextual factors as this instrument has a very strong financial drive.

Some other contextual factors of influence such as (1) the presence of readily identifiable third parties with commercial power and (2) whether the environmental issues are disparate and numerous, or focussed and limited in number were thought to be of less importance in the case studies.

\textsuperscript{130} Dutch consensus model in which the authorities, industry, employer associations and the labor unions try to find compromise solutions in the field of employment, environment, etc.
5.3 What are the main incentives for companies to go BRC or innovate?

There is a close link between the first research question about instruments and incentives, and this question about main incentives for companies to perform BRC. However this question (5.3.) will put more emphasis on the incentives rather than the instruments. Cost reduction and economics, such as the pressure to maintain liquidity and the emphasis on short-term profit, and the pressure resulting from economic marginality (i.e. low margins on products will give few or no opportunities to companies to make any investments), are considered to be the main incentives for companies, especially for small and medium enterprises (chapter 2). This is why voluntary agreements are supposedly not able to compete with environmentally related taxes, such as the NO\textsubscript{x} tax in Sweden or the solvent tax in Switzerland, or emission trading schemes in terms of economic efficiency\textsuperscript{131}. It is remarkable however that many of the environmental improvements that were mentioned in the (voluntary) Performance Track program were driven by economic considerations. Also at the Danish Green Network economic considerations appeared frequently to play a decisive role. Some companies reduced their environmental efforts after the 'low hanging environmental fruit' was picked. The effort in the network then turned more to social affairs and occupational safety and health issues. The same mechanism was seen at the Performance Track program.

Cost reductions and regulation were seen as the main driving forces behind the energy efficiency initiatives in Slovenia and Netherlands. Firstly more strict regulations together with increased awareness raising stimulated by the authorities instigated the companies to look more critically at their energy use. Best available technologies are now common practice in this sector and even better technologies will be applied if costs can be reduced further even without other incentives. The Slovenian Energy Efficiency initiatives, with easy to implement measures and process improvements have been the result of the schemes established by the national authority. Only few industries gave a follow up on the activities, implementing more expensive measures and improvements, particularly due to management board policy (image) or regulation, and less due to economic factors as these investments have a long pay back period. Nonetheless rising energy prices make new investments more opportune.

Apart from market and image incentives that are important for improved environmental performance other less known driving forces that are explicitly mentioned in literature\textsuperscript{132} are (i) firms involvement in networking activities, (ii) a less hierarchical organization. The case studies of the Danish Green Network and Performance Track U.S. have given evidence of this. The Danish case, in particular, which is performing on a ‘micro level’, clearly demonstrated that environmental improvements, and even innovations, by companies, SMEs as well as large companies, were stimulated by a low hierarchical profile in the organizations and a fruitful cooperation and sharing of information via this (green) network.

\textsuperscript{131} There are however (known) exceptions to this rule.
\textsuperscript{132} Examining the factors influencing environmental innovations, Mazanti and Zoboli, 2006.
5.4 What is the effectiveness of the instruments concerned?

The effectiveness of the applied instruments in the case studies is primarily assessed by their contribution to environmental improvement (impact). Many of the cases that are being looked at can also be used to promote compliance with regulatory standards. But the same instruments can also be useful for promoting beyond regulatory compliance (BRC). The second goal is of specific interest for this study.

The environmental impact of the instruments have been found to be on almost every environmental field or aspect, such as emissions to water and the atmosphere, waste reduction, improved energy efficiency, more efficient use of resources and raw materials, improvement of environmental management systems and the environmental organization. This impact that sometimes is BRC, or innovative or supporting regulatory compliance can in general only be assessed in a qualitative way, as quantitative data was not available in every case. However in some cases such as the NOx charge in Sweden clear figures for performance BRC were available. It is remarkable that a specific thematic instrument such as the NOx charge also shows other environmental benefits (lower water consumption and efficient energy use). The Swedish case study proves that optimizing a gas clean up system for a specific component does not necessarily have to produce a negative impact on other environmental fields such as waste water, waste and energy.

It can be concluded that, although it is not always easy, numerous examples can be found of instruments that encourage companies to do more (BRC, innovative initiatives) than they are strictly required to do by their (IPPC) permits. Although the networking initiatives (Performance Track and Green Network) in general appear to have a positive influence on many of the environmental fields it was also noticed that no important (innovative) developments were mentioned here. These networks can better be characterized as an instrument aiming at continuously improving the environmental performance (sometimes also BRC) of companies just by making only very small improvements.
5.5 What is the interaction with the IPPC directive, and what are barriers?

What is remarkable is that an instrument such as the NO\textsubscript{x} charge can have a positive impact on different environmental fields. Other financial instruments, such as the solvent tax, do not seem to cover such a broad field. This is partly because NO\textsubscript{x} is the result of a combustion process, which is strongly related to energy, waste and air emissions. The coverage will also depend on other factors such as the type of industry involved. A properly integrated approach seems to be important and appears to be possible for this instrument though. Despite the fact that a financial instrument that is aimed primarily at one air pollutant substance also benefits other environmental aspects can be considered as (potential) fitting to one of the general principles (integrated approach) of the IPPC. As was mentioned before in some cases also a few side effects are noticed during the optimization process of NO\textsubscript{x} reduction. The significance of these emissions has been evaluated and happen to be minor, with the exception of N\textsubscript{2}O. Additional regulations on this pollutant are expected in the near future. This can be problematic for some plants. Until now some companies achieved low NO\textsubscript{x} emissions due to SNCR and by leading the ammonia in the flue gas stream to a wastewater plant\textsuperscript{133}. The upcoming regulations on N\textsubscript{2}O could have an impact on the system in place since compliance with IPPC would then be very difficult if not impossible according to the industry\textsuperscript{134}.

The financial instruments, the solvent taxes and NO\textsubscript{x} tax, are both said to be complementary to the national regulations and the IPPC directive and could operate well parallel to these regulations\textsuperscript{135}. Sometimes the companies mention the extra effort due to different reporting requirements under LCP and WID compared with the NO\textsubscript{x} tax system.

The networking initiatives appear to fit perfectly well within the IPPC directive. No negative comments, or even critical notes were encountered in Denmark’s Green Network or in the Performance Track U.S. study. Integrated approach, regulatory flexibility and public participation, and application of EMS and BAT, are all principles of IPPC and are also main issues within these networks.

Also the Energy Efficiency initiatives are closely related to most of the principles mentioned above. Covenants or benchmarking energy efficiency in order to belong to the top 10 of the world is a driving force for implementing at least BAT, setting sharp energy targets and striving for continuous improvements. This is often operating within the framework of an energy- or environmental management system. Most authorities foresee regulatory flexibility in these cases. Operating in a more energy efficient way is in general also not in contradiction with the integrated approach. One comment was received that the energy issue should be left out of IPPC permit conditions, as the clear drive for cost effectiveness in this field would be a strong enough self-regulating factor. Every one does however not share this view.

Finally it can be concluded that in all these case studies no barriers in the IPPC Directive was found which could hamper the development of these instruments. In addition, the instruments studied did not create substantial difficulties in the implementation of the IPPC Directive. Only for the NO\textsubscript{x} charge a potential barrier relating to the IPPC principle of integrated approach could be foreseen in the near future (due to N\textsubscript{2}O regulation).

\textsuperscript{133} The ammonia will serve as a source of nutrition for the bacteria in the WWT plant.
\textsuperscript{134} source: Holmen paper Hallstavik
\textsuperscript{135} source: stakeholders in Sweden, Switzerland and France.
5.6 What specific mechanisms apply to environmental innovation?

Environmental innovation, in the form of emerging technologies, has also been addressed in a case study. A distinctive characteristic of innovation is that regulation is a major driver in addition to BRC mechanisms.

Governments intervene in technological development in several ways, e.g. stimulating the supply of innovative technologies or the demand for technological development and innovation. The instruments can be regulative, financial or voluntary. Examples of commonly known regulative instruments are formulation of research priorities; prescription of technology standards or performance and emission standards; and formulation of technology-forcing standards\(^{136}\). Examples of financial instruments are taxes, fees and tradable emission standards; R&D support or subsidies; and venture capital. Finally, examples of voluntary instruments are the voluntary R&D agreements, technology procurement and establishment of networks.

Many studies reveal the largely positive effects that regulations have on the development of environmentally relevant innovation or ET (emerging technology) activities. This is particularly true of the relatively large development programs that can be characterized as having a very high-risk profile, requiring large investments from companies, and promising to lead to significant environmental benefits. Typical examples of these are the Cyclone Converter Furnace (CCF) and the Integrated Gasification Combined Cycle (IGCC) developments in the steel and energy industry. It appeared that these programs only could be carried out with substantial subsidies from the governmental side.

For large innovative development programs such as the IGCC and CCF the Large Combustion industry (LCP) and the Steel industry subsidies respectively proved to be essential (see 4.7.). These findings seem to be in line with the World Business Council for Sustainable Development (WBCSD), which says that financial incentives encourage producers to conserve resources, to prevent pollution and put efforts in technological and organisational innovation. Economic incentives would be the most direct way of changing producer and consumer behaviour toward more efficient use. It is however not always this straightforward; as with regard to the effect of government R&D support on the development of CCF it was concluded that government R&D support enlarged the technology network, but did not accelerate the actual technology development [Luiten, 2001].

The case study on emerging technologies has shown that different policy instruments or combinations of instruments apply to different emerging technologies and encourage industries in various ways. Main incentives for industries to innovate are financial, market and image incentives (cost-cutting and market share). Other less known driving forces that are important for environmental innovation and that are explicitly mentioned in literature\(^{137}\) are (i) firms involvement in networking activities, (ii) "innovative oriented" industrial relations and a less hierarchical organization. These driving factors contribute to environmental innovations together with (iii) environmental policy costs, (iv) R&D and voluntary environmental schemes. Membership to a network group clearly stimulates R&D. R&D is regarded as one of the main inputs driving innovations and innovative output. This mechanism, i.e. networking group pushing R&D, could be seen quite clearly in the development of the (ETs) CCF and the IGCC development program.

\(^{136}\) Luijten, 2002.

\(^{137}\) Examining the factors influencing environmental innovations, Mazanti and Zoboli, 2006.
Examples of public pressure acting as an incentive can be found in the development of some emerging technologies (see 4.7.). This was shown in particular for the development programs of the inorganic binder material and the gas clean up of PCDD. Although it is evident that for the PCDD case the stricter regulations were also an important incentive for the ET development. This could also be seen from the context in which instruments were successful; large companies are more sensitive to public pressure and publicity. This mechanism is clearly shown in the cases of the Sidmar sinter plant and the inorganic binder at Volkswagen. Also the importance of a well-organised industry association must be acknowledged sometimes. These associations could play a major role in the establishment and implementation of voluntary agreements.
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APPENDIX 1   Fact sheets NOx charge
**Case: NOx charge**

A charge on NOx emissions from energy generation at the industry was introduced in order to reduce emissions of NOx by 30% in 1995 compared to the 1980 level. The intention was to achieve a more rapid reduction in NOx reduction than was considered possible by relying strict on legislation. There would be a drive for cost effective emission reductions beyond the legal guidelines. Companies operating boilers with high emissions relative to their energy output are net payers and the most energy efficient companies are receivers.

<table>
<thead>
<tr>
<th>Instruments or mix of instruments</th>
<th>It can be characterized as a financial instrument.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary incentives (financial, image, flexibility, or other)</td>
<td>Financial. Reputation or image plays also a minor role (list of best performers is available).</td>
</tr>
<tr>
<td>Countries</td>
<td>Sweden</td>
</tr>
<tr>
<td>Type of industries: SME, large industry, multinational, branches, etc.</td>
<td>Large (IPPC) industries with an energy consumption above 50 GWh/year, and after 1995 above 25 GWh/year.</td>
</tr>
<tr>
<td>Parties involved: Ministry, Regional, local authorities, agencies, branch organisations, etc.</td>
<td>The main parties directly involved are the big (IPPC) industries and the Swedish Environmental Agency (SEPA).</td>
</tr>
<tr>
<td>Experience with the instrument</td>
<td>NOx charge was introduced in January 1992. Today almost 500 boilers fall under the system.</td>
</tr>
<tr>
<td>Description of context: administrative framework, way of IPPC implementation, (non) central government, boundary conditions, etc.</td>
<td>In an indirect way the counties (21), the Regional Environmental State Courts (5) and the municipalities are involved as permitting authorities. There is however no direct involvement. IPPC permitting is very decentralised implemented by these local or regional authorities. Key issues or criteria that are mentioned are refunding most of the charges to the industry and a common trust between authorities and the companies. A high environmental awareness of the companies was also mentioned as essential.</td>
</tr>
<tr>
<td>Advantage(s) of instrument</td>
<td>The system drives companies to take cost effective measures that in many cases go beyond the legal requirements with respect to the reduction of NOx. At the same time the system operates parallel to the permitting system without (in general) influencing it in a negative way.</td>
</tr>
</tbody>
</table>
| Drawbacks of instrument | - The sectors involved are not considered as homogeneous. For some industry sectors (heat and power industry) it is easier to take measures compared to other sectors (e.g. Pulp and Paper and wood industry).  
- The relative low NOx contribution of the participating companies in the charge system compared to the total NOx emission in Sweden. |
| Economics: cost structure and costs involved | The administrative work carried out by the SEPA in 2005 represented 5 man years at a cost of about 0.5 million euro. This is equivalent to approximately 0.7% of the total charge amount. Throughout the years the charge fee has been 40 SEK (about 4 euro) per kg NOx, calculated as NO2. |
The monitoring equipment usually cost about 30,000 up to 100,000 €.

Examples of good and/or bad performance, preferably incl. figures

There are numerous examples of good performance and even performance BRC. E.g. at the Holmen paper plant environmental targets are set 20% below the permit ELVs.

Description and/or proof of performance BRC; did the instrument encourage innovative developments or the implementation of emerging technologies (ETs)?

Figures of significantly lower emissions of NOx as required by the permit are available. Also not quantifiable examples are available of performance BRC. E.g. installations of the LCP Söderenergie performed significantly below the permit ELV of 90 MJ/kg. It was mentioned that NOx charge contributes to innovative developments (or ET) in the industry. However no real convincing examples could be given at the time of conducting this case study.

Interaction with IPPC:

**Integrated approach**: though the NOx charge can be regarded as a thematically approach of an environmental problem, in most cases this does not affect the integral approach (of the IPPC) permitting negatively. In some cases a negative impact due to NOx reduction is noticed (NH₃ slip to water, and increase of VOC and CO emissions). However these emissions are kept within the permitting conditions and are considered to be of minor significance.

**Interaction with national legislation**: there is in principle no (direct) interaction with the (national and IPPC) legislation.

**Possibility of taking into account of flexible elements**: it is mentioned several times as well by industry as the competent authorities that a common trust and good relationship is the base of cooperation. This has been translated to a fairly flexible attitude of the competent authorities, leaving much room for the companies to operate, especially for the good performers. A high degree of self-monitoring by the companies is a result of this.

**BAT**: the BAT is considered by a Statement of the companies about BAT and is issued to the authorities, which have to assess and approve this. No direct relation between NOx charge and the BAT is present, other than companies looking for the most cost effective solution for measures.

**Reporting**: industry is not happy to issue different reporting formats required by various directives (a.o. WID and IPPC) and the NOx charge (not digital yet). Reporting must be harmonized in order to reduce reporting efforts by the industry.
APPENDIX 2  Fact sheet Performance Track
**Case: US Performance track**

The National Environmental Performance Track ("**Performance Track**") is a voluntary partnership program that stimulates the use of environmental management systems (EMS) and which recognizes and rewards private and public facilities that demonstrate strong environmental performance beyond current US requirements. Performance Track is designed to expand the existing regulatory system by creating incentives for facilities to achieve environmental results beyond those required by law.

### Instruments or mix of instruments

Mix of instruments as avoiding unnecessary duplication of monitoring and enforcement activities, EMS and regulatory flexibility.

### Primary incentives (financial, image, flexibility, or other)

Primary incentives of Performance Track are regulatory flexibility, financial savings through environmental improvements and improving the members environmental image and accountability.

### Countries

United States

### Type of industries: SME, large industry, multinational, branches, etc.

Public or private U.S. facilities of any type, size, complexity level, or economic sector, can participate in Performance Track.

### Parties involved: Ministry, Regional, local authorities, agencies, branch organisations, etc.

Performance Track program is a partnership with participating facilities, states, trade associations and other EPA voluntary programs. EPA coordinates with states in development and implementation of complementary performance-based programs on state level.

### Experience with the instrument

The National Environmental Performance Track program was launched in June of 2000 by EPA and has admitted about 400 facilities (members).

### Description of context: administrative framework, way of IPPC implementation, (non) central government, boundary conditions, etc.

Performance Track is a voluntary public-private partnership that encourages continuous environmental improvement through the use of EMS and local community involvement. The Performance Track team consists of:
- Program staff at EPA Headquarters;
- Regional Coordinators at each of the EPA regions;
- State Performance Track Representatives from state-level environmental agencies
- Performance Track Network Partners; and
- The Performance Track Information Centre

### Advantage(s) of instrument

The environmental improvements made by the facilities in Performance Track are to be beyond regulatory compliance. The reported environmental performance would therefore not haven been reached with the existing regulatory framework. Specific advantages for regulatory bodies are a shift inspection resources from facilities with strong compliance records to facilities that present a greater risk of non-compliance. Promoted implementation of EMS in industry.

### Drawbacks of instrument

Performance Track is voluntary. The companies are free to define there performance targets, without an relevance check from the EPA. This is a weak base for major environmental improvement.

### Economics: cost structure and costs involved

Performance Track has no application fee and no membership fee.
The program is intended to be an inclusive, voluntary, and flexible program.
The amount of time and money a facility invests in improving its performance varies depending on the size of the facility and the types of environmental improvements sought.
The annual budget of EPA for developing and maintaining Performance Track is about 37 million $, funded by the States.

| Examples of good and/or bad performance, preferably incl. figures | EPA removed 49 facilities from the Performance Track program (total program is about 400 facilities):
- 34 facilities during their membership (22 for reasons related to deficient environmental management systems and 12 for failing to submit Annual Performance Reports);
- an additional 15 facilities were not accepted during renewal (8 for non-compliance, 4 for insufficient environmental commitments, 1 due to a deficient environmental management system, and 2 for other reasons). |
| Description and/or proof of performance BRC; did the instrument encourage innovative developments or the implementation of ETs? | The EPA Annual report 2006 (over 2004) lists collected data on environmental achievements of all Performance Track members over 2004 (water use, land conservation, recycled materials, energy use, etc.). It is not possible to assess the significance related to the environmental pressure of all US facilities. The performance of the facilities reviewed showed large differences in the type of improvements and reporting. |
| Interaction with IPPC: | Integrated approach:
In Performance Track facilities are to select a limited number of environmental indicators on which should be reported and improvements are to be made. The integrated approach in IPPC means that permits must take into account the whole environmental performance of facilities.
Performance Track builds on efforts at state level to promote the use of EMS in facilities, while in IPPC an EMS is more and more regarded as integral part of BAT for large installations under IPPC. |
| Interaction with national legislation: | The scheme does not interfere with state legislation. Under the scheme only the way the legislation is enforced is changed. |
| Possibility of taking into account of flexible elements: | Members benefits are lower priority for routine inspections, possibility of networking with EPA officials and members of the program and reducing paperwork and reporting requirements. Performance Track allows for regulatory flexibility, comparable to the IPPC elements of flexibility of allowing the licensing authorities, in determining permit conditions, to take into account specific technical characteristics of the installation, geographical location and the local environmental conditions. |
### Reporting:
The Performance Track facilities are to report their environmental improvements annually. The reporting standard is derived from various US and international guidelines, but the actual reported environmental is limited to the selected indicators. IPPC facilities need to report on all relevant environmental indicators as described in Annex III of IPPC.

An important part of Performance Track is community outreach (communication to the public) of the facilities. Public Participation as meant by the IPPC Directive goes however further, while IPPC ensures that the public has a right to participate in the decision making process, and to be informed of its consequences, by having access to information as permit applications in order to give opinions, permits and results of monitoring of releases.

### Other facts obtained during interviews or desk study
Performance Track is not that popular partly because the industry view that membership increases the risk of liability of having an (poorly) implemented EMS in the US. Reservations of facilities to implement an EMS could possibly be found in legal arguments, as enhanced tort liability or even enhanced criminal liability. This seems however a specific US law based argument and may not so much be applicable to the situation in Europe. A similar system in Europe will likely be less affected by these liability aspects.
APPENDIX 3  Fact sheet Green Network
<table>
<thead>
<tr>
<th><strong>Case:</strong> Danish Green Networks</th>
<th><strong>Short description of case:</strong> The Green network in Southeast of Jutland (Denmark). Industries and authorities are working together in a network, aiming at continuous improvement. Large industries as well as SMEs are taking part in the network. Results are reduction of energy consumption, waste and waste water, air-emissions etc. The key words in this cooperation are dialogue, voluntary agreement and commitment. As support for the work, key employees, from the authority members are available to assist the companies with consultancy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruments or mix of instruments</td>
<td>It can be characterized as a combination of instruments, i.e. public-private agreement, benchmarking, EMS, regulatory flexibility and social responsibility.</td>
</tr>
<tr>
<td>Primary incentives (financial, image, flexibility, or other)</td>
<td>Financial, image and regulatory flexibility (easy and effective cooperation) are the most relevant incentives.</td>
</tr>
<tr>
<td>Countries</td>
<td>Denmark</td>
</tr>
<tr>
<td>Type of industries: SME, large industry, multinational, branches, etc.</td>
<td>Large industries as well as SMEs. Many branches such as waste, glass, metal surface treatment, LCP, food and refineries. The IPPC Directive covers some of these industries.</td>
</tr>
<tr>
<td>Parties involved: Ministry, Regional, local authorities, agencies, branch organisations, etc.</td>
<td>The Green Network is a regional network located in the Southeast of Jutland. Green Network was established as collaboration between industry and regional and municipal environmental authorities. Today Green Network has about 250 members.</td>
</tr>
<tr>
<td>Experience with the instrument</td>
<td>Green Network was established in 1994.</td>
</tr>
<tr>
<td>Description of context: administrative framework, way of IPPC implementation, (non) central government, boundary conditions, etc.</td>
<td>In Denmark the local counties and municipalities are mostly involved in the permitting and enforcement of (IPPC) companies. The Green Network is based on this local approach in which mayors of county council and the municipalities play an important role. The State itself is barely involved. Regional identity, cultural aspects and the Board members being mayors and top management of the companies are criteria for success.</td>
</tr>
<tr>
<td>Advantage(s) of instrument</td>
<td>Green networks can provide the incentives to go BRC in a cost-effective way, and the exchange of experience between industrial sectors has supported innovative solutions. Green Network is a voluntary tool and an example of cross-linking different tools to obtain performance BRC, as it involves implementation of EMS, cooperation with authorities (differentiated inspections and enforcement) and social responsibility.</td>
</tr>
<tr>
<td>Drawbacks of instrument</td>
<td>No one of the stakeholders interviewed could mention one real disadvantage. The steps of environmental improvement are in general small steps.</td>
</tr>
<tr>
<td>Economics: cost structure and costs involved</td>
<td>About 600,000 Euro is available per year for running the Green Network administration and for running the projects. The municipalities and the companies contribute both each 16%. The county is donating the remaining part.</td>
</tr>
</tbody>
</table>
| Examples of good and/or bad performance, preferably incl. figures | --15 % reduction in energy consumption over two years (Gumlink) 
-95 % recycling of waste, decreased consumption of water and energy relative to produced amounts (Coca Cola) 
- more examples can be found in the report |
| Description and/or proof of performance BRC; did the instrument encourage innovative developments or the implementation of ETs? | There are not many quantifiable figures about performance BRC, however many examples exist of activities resulting in clear environmental improvements that could be considered as BRC (e.g. setting up a glass recycling system and granting budgets for environmental innovations). It is noticed however that no big innovation break-through could be shown. Though smaller innovation efforts were mentioned. |
| Interaction with IPPC: | **Integrated approach:** Companies joining the network as V-members have to implement EMS and are supported by the network. Manuals are available and training facilities and efforts are numerous. All (integral) aspects of EMS and in particular reporting is getting much attention. 
**Interaction with national legislation:** There is a strong integration of national environmental legislation and EC-directives including the IPPC. In most cases the local municipalities and counties are the competent authorities. The Green Network is based on this local approach. National reporting requirements are harmonised with the network manuals. 
**Possibility of taking into account of flexible elements:** Green Network includes flexible elements that are in compliance with IPPC; it involves implementation of EMS, flexible cooperation with authorities (i.e. differentiated inspections and enforcement and consultancy from authority employees). 
**BAT:** Every 8 years the permit of the company can be renewed by order of the authorities and the basis for the renewed permit being best available applied techniques at the time. The IPPC permit must be renewed every 10 years. The BREFs national guidelines and regulations and are considered during this assessment of permits. Support is offered by the network to accelerate and facilitate this process. 
**Reporting:** the Green Network members are asked every 2 years to confirm EMS compliance and report about their environmental performance and emissions. In the near future it is expected to harmonize this with requirements from the IPPC, i.e. the EPER/EPTRTR formats. |
| Other facts obtained during interviews or desk study | In May 2002 an evaluation of the environmental (green) networks was initiated. The report is only available in Danish, with English summary. The specific purpose of the evaluation was to acquire systematic and documented knowledge about the networks and their function. Many things were looked at in this study including critical success factors, interaction between the networks and the environmental strategies of the society, supervision of the networks, etc. |
Some critical success factors that are mentioned are reflecting local dialogue and strengthening of regional cooperation, such as:

- Political support for ensuring development and embedding of visions.
- The network volume (number of members) so that there are resources to carry out both core activities and development activities.
APPENDIX 4.  Fact sheet solvent tax
**Case:** Solvent tax systems in Switzerland and France

**Short description of case:** The use of solvents is reduced by introducing a tax system, and therewith emission of Volatile Organic Compounds (VOCs) is reduced. In France a follow up (TGAP) of an environmental tax on air polluters, has been introduced in 1999. In Switzerland the VOC tax has been introduced in 1997, which came into force and effect in 2000. Having to pay for the use of solvents (containing products) industries are stimulated to look for substitutes or to reduce their emission levels. Specifically, the Swiss tax exemption option for industries reducing their VOC emission levels at least 50 % below the regulatory emission level standards, stimulated companies to invest in waste gas incineration.

<table>
<thead>
<tr>
<th>Instruments or mix of instruments</th>
<th>Both solvent tax systems can be characterised as a financial instrument.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary incentives (financial, image, flexibility, or other)</td>
<td>Primarily financial.</td>
</tr>
<tr>
<td>Countries</td>
<td>Switzerland and France.</td>
</tr>
<tr>
<td>Type of industries: SME, large industry, multinational, branches, etc.</td>
<td>In Switzerland various (larger and medium sized) industries identified in annexes of the fiscal act, as well as households. In France combustion plants, waste incinerators and large industries emitting more than 150 tonnes of VOC.</td>
</tr>
<tr>
<td>Parties involved: Ministry, Regional, local authorities, agencies, branch organisations, etc.</td>
<td>The main parties involved in Switzerland are the Federal Customs Administration; the Agency for the Environment, Forests and Landscape; the cantons, the health insurance organisations and the industries. The main parties involved in France are the Customs Administration, branch organisations and industries. To a lesser extent the regional environmental authorities (DRIRE) and the Ministry of Ecology and Sustainable Development are involved in the instrument. Until 1998 the Environmental and Energy Agency (ADEME) has been involved with the predecessor of the TGAP, instead of the Customs Administration.</td>
</tr>
<tr>
<td>Experience with the instrument</td>
<td>The Swiss solvent tax systems exist since 1997. France introduced a tax on air pollution in 1985; the TGAP came into force in 1999.</td>
</tr>
<tr>
<td>Description of context: administrative framework, way of IPPC implementation, (non) central government, boundary conditions, etc.</td>
<td>Main authorities involved are the financial bodies; in Switzerland assisted by the cantons on substantive issues. The financial instrument is implemented next to environmental regulation such as the IPPC Directive. Switzerland has not implemented the IPPC Directive, but has environmental legislation in place that is comparable. The competent authorities for environmental permitting and inspections are the cantons, providing expert judgements on the tax declarations as well. In France however, no direct contacts and linkages are found between the financial and environmental bodies.</td>
</tr>
<tr>
<td>Advantage(s) of instrument</td>
<td>Financial instruments, like the solvent tax, stimulate industries to look for substitutes for solvents and for VOC emission reduction in a cost effective way. Companies choose either to invest in other...</td>
</tr>
</tbody>
</table>
production processes and/or techniques, or to pay tax on emitted VOCs. As industries often have more knowledge of possible improvements than authorities can ask for or specify in regulation, emissions are reduced in the most cost effective way.

### Drawbacks of instrument

Administrative burden can be high, and additional public institutions have to be set up as financial instruments mostly are regulated through financial/fiscal laws and not environmental laws. As another public actor takes part in the environmental policy, a less – environmentally – skilled actor an ineffective implementation of air pollution policy might occur.

### Economics: cost structure and costs involved

The solvent tax level in Switzerland is € 1,50 per kilogram VOC. Tax revenues are used to – partially - finance the Customs Administration, the administrative costs of the cantons and of the health insurance companies.

The solvent tax level in France is € 38,11 per tonne VOC. No figures of tax revenues specifically for VOC are available; no earmarked budgets or financing of public bodies. Industries can be exempted of a part of the solvent tax if they join an industry association, which in turn is monitoring air quality.

### Examples of good and/or bad performance, preferably incl. figures

On an overall level 34 % reduction of VOC emission levels between 2001 and 2004 at the Swiss industries. In France about 40 % reduction has been achieved between 1988 and 2005; and 12 % between 2001 and 2004. Most results have been achieved through end-of-pipe techniques such as waste gas incineration. Industry specific examples are provided in the report.

### Description and/or proof of performance BRC; did the instrument encourage innovative developments or the implementation of ETs?

Within the Swiss solvent tax system industries can be exempted from the tax when reducing emission levels at least 50 % the regulatory emission limit values. Many Swiss industries made use of this option, lowering their emissions significantly beyond what is (regulatory) required. In France, however, no such stimulus exists and industries improve production processes and technologies due to environmental regulation such as the IPPC and – more – the VOC Solvent regulation.

### Interaction with IPPC:

**Integrated approach:** Although the VOC tax is a thematic, i.e. air, oriented instrument, it fits within the integrated approach of the IPPC. Emission reduction measures taken are presented in the Brefs and often not negatively affecting other themes such as waste, and water. The advantage of the newer waste gas incinerators as well is the recuperation of heat, positively affecting the energy consumption.

**Interaction with national legislation:** in principal no interaction with (inter)national environmental legislation.

### Possibility of taking into account of flexible elements:

As taxes leave it open to the industries to select the best way of reducing VOC emissions, often the most cost effective reduction measures are taken. Permits issued need to be flexible and not prescriptive regarding the implementation of specific measures.
**IPPC requirements:** There is no direct relation between the IPPC and the tax system in Switzerland as well as in France. In Switzerland no IPPC Directive is implemented; emission limit values however are comparable to BAT in the IPPC Directive. Industries can be exempted from the solvent tax when reducing VOC levels at least 50% below these (BAT) levels. In France, the VOC Solvents Directive seems to drive industries more than the IPPC Directive, as emission levels are implemented more stringent.
APPENDIX 5  Fact sheet Energy Efficiency
**Case: Energy efficiency initiatives**

Short description of case: Various initiatives have been set up by authorities as well as industries to reduce energy consumption and therewith emission of greenhouse gases. Examples are CO2 taxes, energy benchmark covenants, and (financial) support projects like energy auditing programmes.

<table>
<thead>
<tr>
<th>Instruments or mix of instruments</th>
<th>Voluntary (public-private) agreement, benchmarking, publicity, funding and taxing.</th>
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</thead>
<tbody>
<tr>
<td>Primary incentives (financial, image, flexibility, or other)</td>
<td>As energy efficiency pays itself back directly, these instruments are financial incentives. In the Netherlands, the ‘threat’ of additional legislation being imposed if industry does not join the covenant, is an incentive as well. The financial support in both countries is a positive incentive. Finally, the obligation within the benchmarking covenant to rank the company’s energy consumption with the world top is a (publicity) incentive as well.</td>
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<tr>
<td>Countries</td>
<td>Slovenia and the Netherlands</td>
</tr>
<tr>
<td>Type of industries: SME, large industry, multinational, branches, etc.</td>
<td>Large (IPPC and non-IPPC) industries as well as SMEs. The focus of the case study is however on steel and cement industry.</td>
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<tr>
<td>Parties involved: Ministry, Regional, local authorities, agencies, branch organisations, etc.</td>
<td>In Slovenia the industry, the Ministry of Environment and the Energy Efficiency Centre are the main parties involved in various energy efficiency initiatives. In the Netherlands many parties are participating in the benchmarking covenant, i.e the Ministry of Economic Affairs and the Ministry of Environment, the provinces, the (sectoral) industry associations and the industries itself.</td>
</tr>
<tr>
<td>Experience with the instrument</td>
<td>Slovenia has experienced with the energy efficiency instruments since 1995. The Netherlands introduced negotiated agreements in 1989.</td>
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<tr>
<td>Description of context: administrative framework, way of IPPC implementation, (non) central government, boundary conditions, etc.</td>
<td>Both in the Netherlands and Slovenia energy efficiency was on the policy agenda many years before the IPPC Directive was implemented. As these initiatives fit well within a regulatory context, such as environmental permitting, no major drawbacks have been identified so far. Implementing a CO2 tax system implicates the involvement of fiscal/financial departments in the environmental policy. The same goes for subsidies and funding of e.g. energy audits and implementation of energy efficient installations; in Slovenia either a private banks are managing the budgets. Voluntary agreements, and specifically benchmarking covenants as in the Netherlands, require an institute that is competent and skilled to the specific (benchmarking) tasks. In the Slovenian initiatives no regional authority is involved; in the Netherlands however the regional and local environmental permit writers are responsible for incorporating energy efficiency measures in the permit and checking the required energy management plans.</td>
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</table>
## Advantage(s) of instrument

The energy efficiency initiatives in Slovenia raised the industries' awareness of the advantages auditing energy consumption and implementing efficiency measures. Auditing and benchmarking are rather inexpensive instruments leading to significant emission reductions and energy efficiency. Supporting audits, and giving soft loans by the government are often the first steps for industry to adopt energy efficiency management. Results are easily achieved without authorities having to take the steering wheel.

In the Netherlands, being individually liable if not complying with the covenant, is a strong driver. The same accounts for the ‘regulatory threat’ of new, additional legislation instead or above the existing voluntary covenant.

## Drawbacks of instrument

The implementation and execution of voluntary agreements have to be monitored by the authority; leading to additional tasks at the national or regional authority level. A combination with the environmental permit (requirements) seems to be a condition for success.

Subsidies and soft loans are financial instruments that often fall within the responsibility of other departments and ministries than the environmental authorities. Involving other actors in achieving environmental goals could be a critical element in the success of the instrument.

Tax revenues that are not earmarked and flow back into the state budget are less accepted by industries than tax revenues that are reused for industry purposes (e.g. as subsidies, investments, loans etc.).

## Economics: cost structure and costs involved

Voluntary agreements and energy benchmarking covenants require authorities to monitor and enforce the achievements made by industry. These tasks at national and regional level lead to additional administrative costs. E.g. the Dutch Benchmarking Institute consists of seven authority and industry representatives meeting several times a year and a secretariat assisting on daily work for about 190 companies participating in the covenant.

An example of a Slovenian energy efficiency initiative is the Energy audit programme, during which the government invested € 627.000 for supporting audits at 68 buildings and 98 industries.

## Examples of good and/or bad performance, preferably incl. figures

Slovenian industries participating in the Energy audit programme reduced their energy consumption with 7.3%. Forty IPPC installations participating in the Energy audit scheme decreased CO₂ levels with 60 % between 1990 and 2005.

A Slovenian steel industry, Acroni, reduced its CO₂ emissions from 1.79 tonnes per year in 1986 to 0.67 tonnes in 2005; due to change of production processes. By installing a Targeting and Monitoring system, in order to comply with IPPC requirements, the specific energy consumption decreased by 10 % per production unit.
| Description and/or proof of performance BRC; did the instrument encourage innovative developments or the implementation of ETs? | The Slovenian cement company, Salonit, changed its fuel sources in alternative sources like waste tires, and installed a pre-heater tower, leading to a reduction of specific energy consumption of 50%. In the Netherlands approximately 190 industries participate in the energy benchmarking covenant. Their energy consumption increased 6%; however if no energy efficiency measures had been taken this increase would have been 11%. The Energy Efficiency Index improved 4.5% between 1999 and 2004. The Dutch cement industry decreased its total energy consumption from 5.3 Peta Joule in 1989 to 3.4 PJ in 1996. |
| Interaction with IPPC: | Reducing production costs forces industries to look for new production processes, improvement of existing processes. The environmental permits do not take account of energy consumption on a detailed level; often only requiring to monitor energy consumption in order to raise awareness of energy efficiency. Facilitating this awareness raising process, through either voluntary agreements, taxes or other initiatives, can lead to innovations or the implementation of emerging technologies. |
| Interaction with national legislation: | Integrated approach: Energy efficiency is one of the issues in the IPPC Directive. Implementation of energy efficiency improvements might lead to a change of waste streams or waste gases. Although a significantly negative effect will not often occur. |
| Possibility of taking into account of flexible elements: | Interaction with national legislation: Energy efficiency initiatives are not national legislation dependent; but interaction with the emission trading scheme is evident. |
| Possibility of taking into account of flexible elements: Energy efficiency initiatives' main objective is to raise awareness of industries on their energy consumption and possible improvements that could be implemented. A link with environmental management systems is evident, and Slovenia as well as the Netherlands have experienced with relating environmental management with energy management. Through IPPC and/or other environmental permits implementation of these management systems can be stimulated. Main advantage of energy efficiency instruments is the freedom they leave to industries to improve their energy consumption levels on the most cost effective way. |
Check with the articles of the IPPC: Energy consumption levels are stated in some Bref documents such as the Bref for the cement and lime industry. Although according to experts interviewed these levels are too low. In addition, horizontal Brefs on energy efficiency and cooling systems consist. The Dutch voluntary agreement is consistent with the IPPC, as are the various Slovenian energy efficiency initiatives. Linking environmental management systems to energy management systems, the first required by the IPPC, could be an improvement of the current IPPC Directive.
APPENDIX 6  Emerging Technologies
This appendix describes the procedure followed to identify the emerging technologies (ET) that are addressed in chapter 4.

A different methodology for identifying and assessing (policy) instruments stimulating industries to go beyond what is required by permit is looking at industries that already implemented or developed an innovative, or so called, emerging technology. To decide on what policy instrument has been most effective for development and market introduction, a selection of emerging technologies was preferred that evolved to at least a demonstration plant and preferably to some full-scale installations.

For the project it was agreed to carry out four case studies to get detailed information on drivers and if relevant the policy instruments which play a role in the development and market introduction of the selected emerging techniques (ET). To decide on what policy instrument has been most effective for development and market introduction, a selection of emerging technologies was preferred that evolved to at least a demonstration plant and preferably to some full-scale installations. This document represents the pre-selection of the ETs that was worked out in this project After selection the ETs the drivers and instruments (figure 6) that led to success or failure of the ET in specific cases were elaborated.

**Figure. Selecting emerging technologies for case study.**

Emerging technologies can be divided into two main groups of technologies: process-integrated technologies and add-on technologies (end-of-pipe). It is expected that both kinds of technologies have different drivers and barriers in relation to implementation. To get the most complete information on effective policy instruments it was therefore proposed to select cases belonging to both groups.

**Selection procedure for specific cases**

Another important aspect in the selection is the possible potential impact of introduction of the technology in relation to the potential emission reduction of different kinds of pollutants in the EU. In relation to this, techniques that reduce pollutants listed in the appendix 3 of the IPPC directive was explored. Possible ET's should at least involve the abatement of one of the IPCC compounds.
Initial list of Emerging Technologies (ETs)

In the current BREFs a large amount of emerging technologies are mentioned for reduction of emissions to air, water and soil. Most of the technologies have impact on emissions to the air. As a result of the EU project “Assessment of the air emissions impact of emerging technologies” (study contract no 21350-2003-10 F1ED SEV DE) (www-iip.wiwi.uni-karlsruhe.de/dfiu/dfiu_emtech.htm ) a total of about 20 technologies are considered as emerging (i.e. be in general in demonstration or pilot plant scale), promising (i.e. should gain a significant market share) and relevant (i.e. should have an impact on air emissions in EU-25 in 2005-2030) for emission reduction in the EU. For most of these emerging technologies, fact sheets are available with relevant information on technical-, environmental-, economical- and diffusion (implementation) aspects.

On the basis of above results the selection started with about 25 ETs. For these ETs relevant information from BREFs and fact sheets were brought together in an excel file (appendix 3, ‘Overview ETs’). In this worksheet information can be found for the selected ETs in relation to:
- application in industrial sectors;
- name of emerging technology/application;
- the EU countries with expertise in the mentioned ET;
- positive effect of ET on reduction of emissions, energy, raw material input, costs;
- implementation status of ET (research, demonstration and/or full scale plants);
- relevant remarks to the ETs.

Pre-selection

On the basis of the information in this worksheet a pre-selection was made. ET’s have been skipped when there were still technological problems, the relevant BREF declared it as BAT and when development was still in research/laboratory phase. The result of this exercise was a list with 11 remaining ETs. On the basis of the relevant information of these ETs a priority list has been made for the ETs to be evaluated in relation to BRC instruments. This resulted in a priority list of 6 ETs. As can be seen from the information in the worksheet the 6 ETs together fulfil the criteria for the ETs to be useful for the evaluation process:
- Implementation status: including ETs with pilot, demonstration and full scale experience;
- Character of technology: Process integrated as well as end of pipe;
- Positive impact of implementation on emission reduction in EU;
- Relevant pollutants (PM, Heavy metals, PCDD/F and CO2);
- Different industrial sectors (waste incineration, iron and steel industry, smitheries and foundries, refineries, cement industry);
- Experience in different EU countries (Germany, Netherlands, Sweden, Italy, Spain, Czech).

The result of the pre-selection is given in the worksheet ‘Pre-selection’ of the excel file with a priority ranking for 4 emerging technologies.
### Case: Emerging Techniques

#### Incentives for technology development

Identification of incentives for technology development, based on a review of 4 different emerging techniques mentioned in the BREFs:

1. Integrated Gasification Combined Cycle (IGCC) with heat recovery
2. Smelting reduction with Cyclone Converter Furnace (CCF) in iron and steel industry
3. Adsorption of PCDD/F in sinter plants
4. Inorganic binder material for core-making in foundries

#### Technology development

Technology development can help to bring production processes and abatement techniques to a higher level with respect to the environmental performance. Technology development can result from existing R&D infrastructure (technology push) or can be problem- or demand driven (technology pull). The former is usually public funded whereas the second one is mainly private funded, but both can develop techniques that go beyond the environmental performance of the BAT techniques described in the BREFs. The advantage of public funded technology development is the lack of protection of the intellectual rights for the new technology. Private funded technology development does not dissipate as fast or as broad as public funded developments.

#### Incentives

Main incentives for the technology development identified in the cases are:

- more efficient use of resources and improved environmental performance (case 1, 2, 4);
- (production) cost-reduction (case 1, 2, 4);
- compliance with (future) emission limit values (3);
- public pressure (case 3, 4)

#### Countries

Various EU countries: countries involved in the reviewed cases are the Netherlands (case 1, 2), Spain (1), Czech (1), Germany (3, 4), Italy (3) and Belgium (4).

#### Type of industries

In principle all industries may benefit from the results of (or may initiate) technology development. But in general the larger companies will benefit first as is shown in the reviewed case: large multinational companies and industrial branches from energy (1), waste (1) and the iron and steel industry (2, 3) a large foundry in the automotive industry (4).

#### Parties involved

Technology development involves various parties (with different roles):

- Individual companies (demand for technology, funding)
- Industrial sectors (demand for technology and funding)
- Research institutes /engineering firms (supply of technology development)
- National governments or EU (funding and facilitators).

#### Advantages of stimulating technology development

Advantages of stimulating technology development, for instance by subsidies, is minimizing the companies cost and risks and to enlarges technology networks.
| Limitations of stimulating technology development | From the review it appears the funding of technology development in itself is not enough to be decisive for companies to start new developments. Additional internal and external factors (such as costs for implementation, competitiveness and public pressure) influence the decision. |
APPENDIX 7  Development of Integrated Gasification Combined Cycle (ICGCC)
Development of IGCC

In the development of IGCC a lot of initiatives in different countries, by different parties and for different fuels have been taken. The development of IGCC started with the success of coal gasification projects and was driven by the possibilities to enhance the thermal energy to power conversion efficiency by integration of gasification in a combined cycle with turbines. Later on development of IGCC technique was broadened by other sources of energy like biomass and waste. The relation between the different projects is not clear neither the impact of the projects on new initiatives. There is a lack of available information to evaluate impact of specific R&D project on new initiatives started later on. For efficiency reasons usually it will be the case that a new initiative tries to implement results from own research and results gained by other parties. This depends more or less on the availability of project results for other parties. In the case of government subsidy part of the results are publicly available because of use of public money. Because of the succession in development of IGCC for coal and IGCC for biomass and waste both developments are evaluated separately in this section.

Development phase of IGCC for coal

The first IGCC demonstration for coal with commercial potential took place during the 1980s without direct DOE sponsorship. In 2001 efficiencies of IGCC are well above the 35 percent levels of conventional plants, and emissions of air pollutants are only a small fraction of U.S. New Source Performance Standards, with recovery of sulphur as a commercial by-product. Emissions of air toxic compounds is minimal, contaminated water discharges are negligible, and solid wastes are produced as vitrified material impervious to leaching in storage. The IGCC plants also offer a significant opportunity for the capture and sequestration of CO₂, a greenhouse gas. As a practical matter, coal-based IGCC plants directly compete with combined-cycle natural gas plants. [DOE, 2001]. The government of Japan and the electric utility companies are pushing ahead with plans to build and operate a 250 MW demonstration plant [Criepi, Japan]. Biomass and waste can be used for co-gasification with coal, which leads to lower CO₂-emissions from fossil fuels. The 235 MW power plant in Buggenum (NL) is an IGCC demonstration plant with co-gasification of biomass and waste. Since 2001 the plant has been successfully operated with coal at moderate capacity. Since that time co-gasification of biomass is introduced in the plant. The intention is to replace 50% of the coal by biomass [Pastoors, 2003]. Plans to expand the electricity generation by another 600 MW IGCC plant were postponed, partly due to high cost. [OECD/IEA, 2000].

Development phase of Integrated Gasification Combined Cycle (IGCC) for biomass

IGCC for biomass

The possibilities and limitations of the growing, harvest, handling and conversion of biomass into heat and power by means of the pressurized gasification technique constructed as an Integrated Gasification Combined Cycle plant are demonstrated in an EU project: THERMIE 1 – Treatment of waste. I/S ELSAM (Danmark) executed the demonstration project in the period 1995 to 1998 with 50% EU subsidy [Luxhoi, 1999].

Sydkraft AB has built the world’s first complete IGCC Power Plant, which utilizes wood as fuel in Värnamo, Sweden. The 18 MW demonstration plant has been successfully operated on different wood fuels as well as straw and RDF. The demonstration program was partly financed by the Swedish National Energy Administration and the European Commission and was concluded in 2000. The plant has been mothballed since because it is not economical to operate given the commercial conditions prevailing in Sweden. New projects planned for this plant are application of RDF fuels, production of clean hydrogen-rich synthesis gas and rebuilding of the plant to incorporate production of alternative motor fuels. [Stahl, 2004]
The VTT organization in Espoo (Finland) is executing an EU project ('BIGPower') in the Sixth Framework Programme. The project aims to develop reliable, cost-effective and fuel flexible gasification techniques for high-efficiency small-to-medium scale (1-100 MWe) power production from biomass. The project is designed to create the fundamental and technical basis for successful industrial follow-up developments and demonstration projects aiming to commercial breakthrough by 2010-20. This overall aim is approached by carrying out a pre-competitive manner well-focused activities on the key bottlenecks of advanced biomass gasification power systems. Three most potential power production cycle alternatives are examined and developed: 1) gas engines, 2) molten carbonate fuel cells (MCFC) and 3) the simplified Integrated Gasification Combined Cycle process. The performance and techno-economic feasibility of these advanced gasification-to-power concepts will be examined by carrying out detailed case studies in different European regions [VTT, 2006].

In the Netherlands the EU grants a project proposed by Energie Noord West N.V. This is part of the Fourth Framework Programme to demonstrate the technical and financial viability of a 30 MWe atmospheric circulating fluid bed biomass gasifier/combined cycle plant. The fuel gas is -after cleaning- fed to a modified aeroderivative gas turbine originally developed for natural gas. For this demonstration plant an efficiency of 41%, based on the lower heating value of the fuel, was expected with emissions less than the strict Dutch standards for waste incineration (which are more stringent than the power production standards) [Van der Poel, 2002].

**IGCC for waste**

Gasification has several advantages over traditional combustion of municipal solid waste (MSW). It takes place in a low oxygen environment that limits the formation of dioxins and of large quantities of SOx and NOx. Furthermore, it requires just a fraction of the amount of oxygen necessary for combustion. As a result, the volume of process gas is low, requiring smaller and less expensive gas cleaning equipment. During gasification, tars, heavy metals, halogens and alkaline compounds are released within the product gas and can cause environmental and operational problems. The key to achieving cost efficient, clean energy recovery from municipal waste gasification will be overcoming problems associated with the release and formation of these contaminants. The limited number of commercial gasification plants, and the operational difficulties experienced at several pilot and large scale demonstration plants, indicate that improvements in operating conditions and in gas cleaning techniques are necessary before gasification can be considered a reliable, off-the-shelf solution to the waste disposal problems of large municipalities [Klein, 2002]. These improvements are researched in experimental pilot and demonstration plants for different kinds of solid and liquid fuel (coal, biomass and waste). Gasification generates a fuel gas that can be integrated with combined cycle turbines if cleaned. In general this R&D is stimulated by governmental subsidies.

Black liquor (BL), a by-product of the papermaking process, is an important liquid fuel in the pulp and paper industry. It consists of remaining substances after the digestive process where the cellulose fibres have been cooked out from the wood. Chemically, black liquor is a mixture of several basic elements where the largest fractions are carbon, oxygen, sodium and sulphur. One of the major driving forces for the interest in black liquor gasification is the possibility of using the product gas for combined cycle power generation. Studies have indicated that this has the potential for a significant increase in the amount of electrical power that can be produces from the black liquor. Gasification processes convert the organic substances in the liquor into combustible fuel gases and the inorganics into compounds suitable for regeneration of pulping chemicals. In this way chemicals in the black liquor waste are recycled to the pulping process. Maybe the most promising technique is Chemrec’s pressurised black liquor gasification process with an integrated combined cycle for power generation.
It has the potential to double the amount of net electrical energy for a kraft pulp mill compared to a modern recovery boiler with steam turbine. In 1978, the development of the Chemrec process for black liquor gasification was started in Sweden. Since 2002 the Chemrec process for black liquor gasification is owned by Chemrec and Nykomb Synergetics.

At the laboratory of Energy Technique Centre (ETC) in Pitea, Sweden, a pressurized black liquor gasification unit is under construction. This new, world unique unit (owned by Chemrec) will form the basis for a development program of a full-scale commercial unit and bring Sweden to the front of the research in black liquor gasification [Marklund, 2006].

A focused effort in Sweden to finally bring high temperature black liquor waste gasification technique to the market was started in 2004 when a consortium with eight partners joined forces to fund a 3-year research program ("the Swedish Black Liquor Gasification research program") with a budget of 60 million EURO [Gebart, 2005; Babu, 2005]. Two gasification plants utilize unique gas cleaning and gasification techniques to produce a synthesis gas from biomass and waste suitable as fuel in a combined cycle turbine. The ‘TPS Termiska system’ has been operating using 200 tonnes of “refuse-derived fuel (RDF)” per day since 1993 in Italy (sending the product gas to a closely coupled boiler). This process uses partial combustion with air at atmospheric pressure in a bubbling fluidized bed, followed by a circulating fluidized bed vessel containing dolomite that catalytically ‘cracks’ the tars. The ‘Batelle-Columbus system’ (Columbia University, USA) uses an indirectly heated atmospheric pressure gasifier that avoids nitrogen in the fuel stream and produces medium caloric value gas and is near the commercial stage for biomass gasification with a capacity of 200 tons/day [Klein, 2002].