Study on Long Term Agreements for Energy-Intensive Industries (LOTAFENIS)

EU-SAVE Project

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Foreword

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http://www.ier.uni-stuttgart.de/public/en/organisation/dept/eam/projects/lotafenis/

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Abstract

Within the project LOTAFENIS, energy efficiency potentials in the energy intensive industries in the EU have been identified and subsequently the question has been analysed whether and how these may be activated through the use of negotiated long term agreements. The following sectors have been investigated: iron and steel, non-ferrous metals, chemical industry, pulp & paper and cement. Furthermore, an evaluation of voluntary agreement schemes at company level based on case examples in three European countries have yielded additional insights on the impact of existing national agreements on company activities in the fields of production, logistics and real estate management.

The following steps have been carried out in the *first part of the project*:

- Review and comparison of recent studies on technical and economic potentials of energy efficiency measures in the energy-intensive industrial sectors
- Assessment of the economic and technical potential for efficiency improvements in the 5 main energy intensive industries in the business as usual case up to 2012
- Validation / feedback on the identified potentials by the concerned industries
- Analysis of achievements of existing long term agreements on energy efficiency by country and by sector
- Assessment of the possible future role of long term agreements in energy and climate policies in energy intensive industries, including concertation with the concerned industries
- Development of a proposal for long term agreements

For the analysis at the *company level* the main steps have been as follows:

- Data collection and analysis of the national agreement schemes from a company perspective
- Company interviews and best practice identification
- Best practice analysis
- Comparison analysis

Furthermore, all study outcomes have been disseminated to the relevant stakeholders.

1 Introduction

In the last years, given the commitments taken by the European Union in the Kyoto protocol, various studies have been undertaken both at the EU and the national levels to determine the possibilities for energy efficiency improvements and GHG emission reductions in the industrial sector. Notably, the *European Climate Change Programme (ECCP),* established in June 2000, has been initiated by the European Commission as a multi-stakeholder consultative process including also industry representatives to analyse environmentally and cost effective measures to achieve GHG emission reductions. One focus has been energy and industry and there have been recommendations by different working groups of the ECCP to use voluntary agreements for fostering energy efficiency improvements.

The objective of the present study “Long term agreements for energy intensive industries” (LOTAFENIS) in this context has been to investigate the *economic and technical potential for energy efficiency improvements* in the main energy consuming industrial sectors (iron & steel, non-ferrous metals, pulp & paper, chemical and cement) and to *analyse whether and how long term agreements (LTAs) may be used to activate these potentials*. This study has been directly linked to earlier research activities in the fields of energy saving and voluntary agreements but goes several steps further to carry on and synthesise previous and ongoing research efforts. Furthermore, the perspective of the main stakeholders concerned, i.e. industrial companies and their sectoral associations have been closely scrutinised and accounted for, to ensure the practical relevance of the research outcomes and to provide a basis for later negotiations.

This report is the outcome of the work of two separate working packages (WPs) having two different focuses on long term agreements and consisting of two project teams. Within the project, these teams have been clustered as to ensure maximum outcome of the overall study on Long term agreements for energy intensive industry. The corresponding work packages are:

- **Working package A:** Focus on investigation of existing LTA schemes on national level and a qualitative and quantitative analysis of potential impacts of LTA schemes on innovation processes in energy-intensive sectors. Moreover, investigation of the economic and technical potentials for energy efficiency in five energy intensive industrial sectors. Team members for this WP have been IER, University of Stuttgart, CIMATEC s.r.l., Italy, i.con innovation GmbH, Germany and Kungl Tekniska Högskolan (KTH), Sweden. This WP has been led by IER who also was the co-ordinator of the overall clustered project.
- **Working package B:** Focus on evaluation of the implementation of long term energy agreement schemes at company level. This working package has been led by Arthur Andersen Oy, Finland (now Ernst&Young), in co-operation with Arthur Andersen KB,

Sweden (now Deloitte-Touche) and UMR, Society for Environmental Management and Risk Service Ltd., Germany.

The overall aim of the present study has been to enable the European Union and the European industrial associations in energy-intensive sectors to negotiate long term agreements that contribute substantially to the objectives of energy efficiency, climate change mitigation and competitiveness. Therefore, on the one hand the technical and economic potentials for energy efficiency have been analysed at European level by working package A. On the other hand, an analysis of the effects of voluntary agreements at company level has been carried out by working package B. Both groups have analysed existing LTAs at national level and from these findings a proposal for the use of LTAs at the EU level has been developed.

In the following, an overview of the main outcomes of the study is presented whereas the material volume contains detailed descriptions of the findings. In the next section, the methodological approach is outlined. Section three is an empirical review of the effects of existing agreements in various countries outlining first implications for LTAs at European level. An overlook of the main quantitative results on potential energy efficiency improvements in the sectors under study is given in section four. Section five covers the main findings of the evaluation of voluntary agreements schemes at company level. The results of a stakeholder survey identifying success factors for European LTAs are given in chapter six while the proposal for European harmonised LTAs is presented in chapter seven. Final remarks and an outlook are summarised in the last section.

2 Methodological approach

In order to investigate the potential use of LTAs in Europe for fostering energy savings in industry, an analysis taking into account the decision making behaviour in industry is viewed to be essential. The possible impact and role of LTAs and other policy instruments is thereby conceptualised as depicted in Figure 2-1.

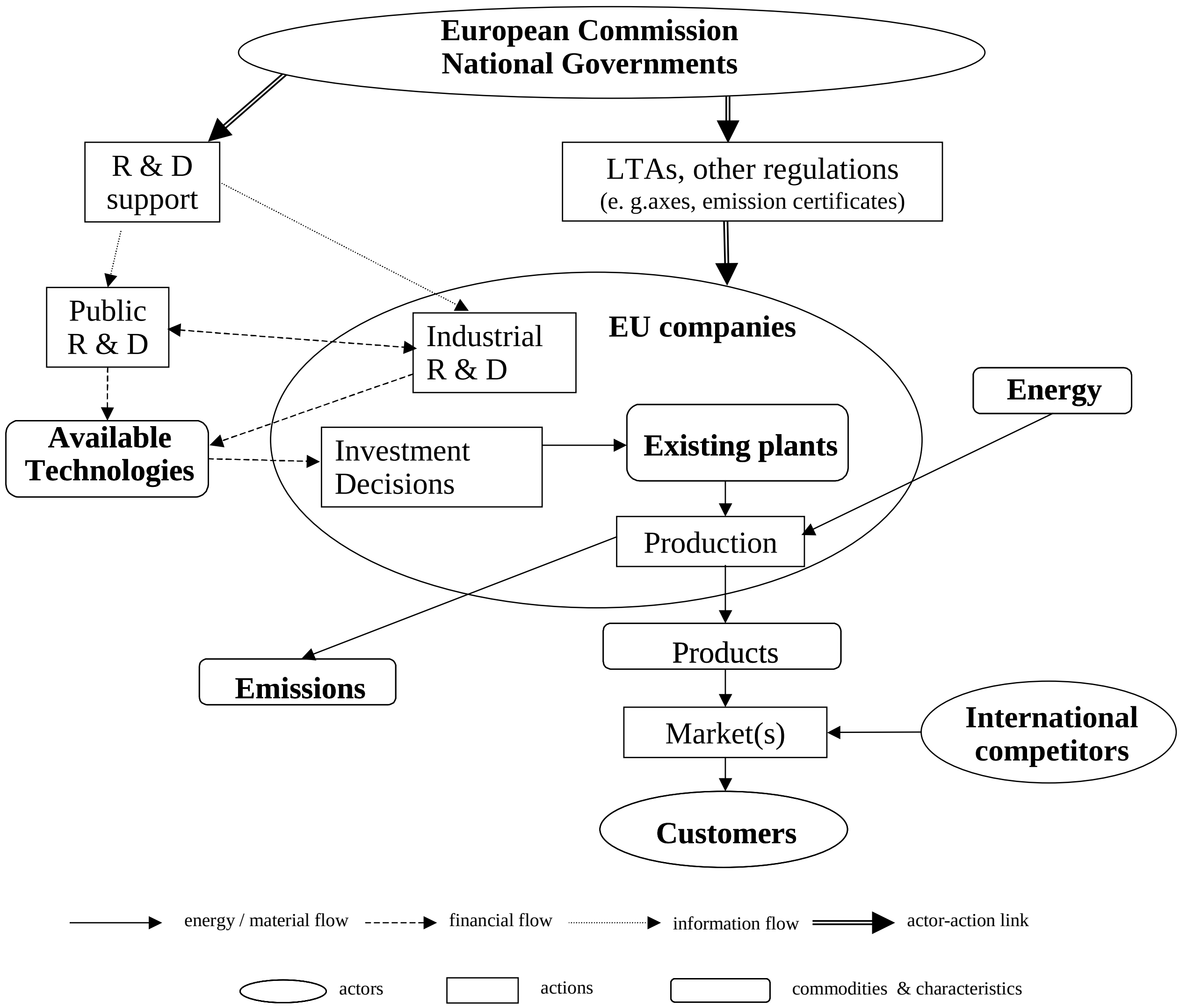

Figure 2-1: Role of LTAs in environmental policy

Correspondingly, the following five major steps have been carried out in the study.

2.1 Analysis of LTA schemes

The present study builds on the findings of previous studies carried out under the European projects VAIE and CAVA. But also own investigations of existing LTA schemes in different member states (Denmark, Finland, France, Germany, the Netherlands, Sweden, UK) have been carried out, because new LTA schemes have been concluded or existing ones have been modified. Hereby, the analysis of the potential influence of LTAs on decision making in industry has played major role.

As a theoretical background for the LTA analysis, the concept of the *resource-based strategy* has been taken into account. At the core of the resource-based strategy are always real-life management decisions. Based on new insights on the role of firm resources as forms of capital, such as natural or social capital, several types of opportunities for voluntary policies have been identified (cf. /Paton 1999/). This approach is closely linked to two contemporary debates in energy and environmental policy concerning the „Porter hypothesis" (cf. /Paton 1999/), and the „energy efficiency gap" focussing on the potential for voluntary environmental initiatives to increase economic efficiency and on the barriers which prevent some firms from taking advantage of these opportunities.

2.2 Identification of possible energy efficiency improvements in the sectors under study

In the last years, various studies have been undertaken both at the EU and the national levels to determine the possibilities for energy efficiency improvements in the industrial sector. The most topical studies performed on behalf of the EC to estimate the energy saving potential in industry are /Fletcher et al. 1999/, /Haworth et al. 2000/ and /Hendriks at al. 2001/. The results of these studies as well as the so-called BREF reports (cf. /IPPC 2000a-h/) represent the present state of analysis at the EC and have been considered as a base line for the analysis of industrial energy efficiency potentials. Thereby, the existing knowledge has been critically assessed and completed by own analyses and also through discussions with industrial companies and associations. As a result,

- a detailed list of relevant energy efficient technologies for each sector has been developed and an assessment of the techno-economic potential for energy efficiency has been undertaken.
- Hereby also potential barriers for the implementation of single technologies have been considered, an essential point for the analysis of investment behaviour.
- The results have been validated and approved through discussions with the concerned industries in order to arrive at a common basis for the discussion of Long Term (Voluntary) Agreements at EU level.

The present study therefore not only links and further completes recent studies on the potential for energy efficient technologies but goes several steps further.

2.3 Analysis of investment decision behaviour - modelling energy saving options and realistic targets until 2010

The investment decision behaviour in industry has been analysed both by *quantitative modelling* of techno-economic energy saving options and *qualitatively* by investigating into account the influence of non-monetary factors and barriers on investment decisions in order to arrive at a more comprehensive basis for a discussion of climate change mitigation options.

In order to assess *quantitatively* the potential for energy-efficiency improvements through long term agreements, a *techno-economic analysis* has been carried out for the five industrial sectors under study (iron & steel, chemical, non-ferrous metals, pulp & paper and cement). The focus has been on the investment profitability, thereby determining an economically reasonable „upper limit" of the technological energy saving and emission reduction potential for the individual industrial sector as well as the potential market shares of the single technologies until 2010. Thereby the overall costs for industry and the respective energy saving potential for different scenarios have been determined. Thus, the following questions have been addressed:

- What are realistic targets for emission reduction/energy efficiency improvement in the frame of voluntary agreements/LTAs?
- How should these efficiency goals be differentiated by sector (and country)?
- Which technologies can contribute to reach these efficiency targets most cost effectively?

The study has thereby explicitly accounted for the existing equipment stock and the technology level reached so far. Consequently, a clear distinction has been made between "greenfield" and "brownfield" respectively retrofit investments. Furthermore, the variations in the profitability of retrofit investments and uncertainties have been explicitly accounted for.

For a policy assessment, the effects of negotiated agreements have to be compared to alternative policy instruments aiming at the same goal of emission reduction. Currently, three main policy measures which aim at reducing CO_2 emission are discussed and partially implemented in Europe. These are *emission taxes*, *emission certificates* and *negotiated agreements* between governments and industry. Economists tend to regard CO_2 emission taxes and emission certificates as the most efficient and effective tools in view of achieving environmental objectives (e.g. /Baumol; Oates 1988, Böhringer 1996/). On the other hand, voluntary agreements are regarded by the industries concerned as more flexible and more suited to maintain competitiveness. Hence different scenarios have been assessed, comparing the introduction of energy taxes or auctioned certificates to the use of LTAs. Furthermore the impact of different profitability requirements (applied pay-back times/interest rates) on the energy saving potential has been assessed.

It has to be remarked that a cross-influence between environmental protection measures like e.g. waste water treatment and energy saving measures exists. Some environmental protection measures will increase energy use, but have to be taken into account in real investment decisions, too.

In order to build a link between the techno-economic potential and the influence of LTAs on management decisions, a *qualitative assessment* of the *impact of non-monetary factors* on investment decisions has additionally been carried out. The techno-economic analysis model can only take into account the quantitative factors (costs/energy savings) of investment decisions and describes therefore only a potential economically reasonable „equilibrium state" („optimal" state). This „optimal state" cannot be reached in reality because of existing uncertainties, information lacks, irrationality and other barriers of decision makers. The main impact of LTAs, however, has been considered to be on *management decisions concerning the implementation of energy saving measures* depending, on the one hand, on the *economic profitability*, but also on a *variety of so-called "qualitative" factors*, such as the uncertainty of technical risks, the availability of financial resources or the lack of information. LTAs have in principle the potential for a major influence on these „qualitative factors" of investment decision making, which can represent significant barriers to investments and therefore equally need to be addressed by policy measures. If properly addressing the „qualitative factors“, the LTAs impact on energy saving and emission reduction can be achieved through improving the ‘uptaking’ of new and economically viable energy-saving technologies; i.e. reducing the time until a new technology has been implemented in the industry, and increasing the degree of implementation of the technology throughout the industry.

Beside the described influence on investment decisions, which corresponds to an influence on the implementation phase of the technological innovation process, an influence of LTAs on the *research and development phase of technology innovation process* can also be assumed. In order to increase further energy saving potential, e.g. in industrial sectors where the maximal energy saving potential is nearly reached, LTAs should mainly support the *further development of energy saving technologies* in the single sectors.

In contrast to taxes or certificate trading systems, LTAs could therefore eventually be shaped to specifically address the key „qualitative factors" of investment decision making. This gives reason to assume that within a certain threshold, LTAs properly addressing the decision making process could even be more efficient than a tax system but securing also the necessary flexibility for industry. Such LTAs may contribute to actually achieve the economically reasonable „upper limit“ of energy saving and emission reduction.

Within this study management decisions of individual companies have therefore been considered to be the key to implementing energy saving and CO_2 mitigation measures in industry. Consequently, an effective long term agreement scheme needs to be optimised concerning the impact on the management decisions and especially on decisions to invest in energy saving and new energy efficient technologies. In order to identify key factors influencing investment decisions as well as potential demands and incentives for industry to be included in a European LTA scheme, a *questionnaire* for industrial sectors *on the shaping of a potential European LTA scheme* has been developed (cf. material volume).

2.4 Analysis at company level

Three different voluntary agreement schemes in Finland, Germany and Sweden have been analysed at company level. 10 companies have participated in this study to share their experiences of national energy related voluntary agreement schemes with regard to implementation and achieved results. In order to monitor and compare the actions and results of the companies, an analysis framework has been developed taking inot account the following areas:

- Analysis of LTAs, legal structures, similarities and differences
- Company actions and results in relation to LTA and energy efficiencyEvaluation of LTAs from the viewpoint of company actions and results and creation of indicators
- Other factors explaining differences in company actions and results

2.5 Guidelines for future LTAs at European level

Based on the results of the steps mentioned above, a proposal for implementing LTAs in the individual sectors at European level has been be developed. Hereby the climate gas reduction objectives of Kyoto as well as economic aspects especially relevant in the individual sectors have been considered in order to optimise the LTA scheme both in view of energy saving potentials in the individual sectors and of economical feasibility.

3 Existing LTA schemes in the European Union

The use of long term agreements (LTAs) in the European Union started in France in the 1970's and spread widely from the 1990's onwards, due to the positive attitude of both industry and public authorities towards this relatively new instrument.

The industrial sector in the EU, on the one hand, appreciates that LTAs in energy and environmental policy are flexible instruments which can satisfy specific needs and reduce costs of implementation. Public authorities, on the other hand, believe that LTAs help promote cooperation and partnership with industry and reinforce the participation of the private sector. Furthermore, the use of LTAs is encouraged and supported by the European Commission as one of the means to set policy making within a sustainable framework of an economic and social development.

For energy efficiency, the most relevant experiences are the agreement schemes in the Netherlands, Germany, France, Denmark, United Kingdom, Finland and Sweden which have been covered within this study. For each of these seven countries a number of main aspects have been analysed, namely, the parties to the agreements, the targets, the monitoring and reporting procedures, the accompanying measures, the interference with other national policies and offer and sanctions. Moreover, thorough assessments of these agreements have been carried out. Based on the analysis of existing LTA schemes, implications for LTAs at European level are drawn.

In the following, a summary of each of the above mentioned aspects is given (cf. sections 3.1 - 3.4) while details are provided in the material volume.

3.1 LTA country analysis

This section contains a brief overview of the seven analysed LTAs schemes mentioned above while detailed descriptions are given in the material volume. The investigation bases on a review of the relevant literature, including notably the European project VAIE, but also on interviews with the concerned stakeholders.

3.1.1 The Netherlands

The Dutch national government came up with the so-called National Environmental Policy Plan (NEPP) in 1989, addressing mainly aspects of sustainable development including the problem of energy expansion. A year later a new version of the NEPP (NEPP +) was published, discussing global warming and policy on energy efficiency. In the memoranda on energy saving based on the NEPP +, voluntary agreements with industry were first mentioned as a possible energy saving policy instrument.

The Dutch Long Term Agreements on Energy-Efficiency were introduced in the early nineties. In the First Memorandum on Energy Conservation in 1990, the Dutch government decided to add voluntary industrial long term agreements (LTAs) to the policy mix aiming at an improvement of the energy-efficiency in the Dutch industry /EZ 1990/. Target groups were all industrial branches with an energy consumption over 1 PJ per branch. Firms joining an LTA must improve energy-efficiency as far as practically and economically feasible. In return the Dutch government agreed not to introduce new regulations on energy-efficiency and to give financial support.

In the first round of LTAs (1998-1999) 29 industrial LTAs have been concluded (+ 14 non-industrial) covering about 90 % of the total industrial energy consumption of the Netherlands. Approximately 1250 firms were actually involved. The general target set in the LTAs was an energy-efficiency improvement of 20 % in 2000 compared to 1989 levels, but the targets were constructed tailor made to different sectors.

In 2000 most LTAs expired and the Third Memorandum on Energy announced several changes for the new LTAs to set up /EZ 1998/. Furthermore, for high energy-intensive firms a new type of agreement is established: the benchmark covenant. Under this agreement companies aim for their plants to become (and remain) among the most energy efficient as soon as possible, but not later than 2012 /Phylipsen 2000/. The government in return promises not to develop any additional policy concerning energy savings for these target groups.

The companies that do not qualify for the benchmark covenant will be offered to sign the second round of LTAs. Overall, the enthusiasm for the second round of LTAs is lower than it was for the first round of LTAs 10 years ago.

3.1.2 Germany

The Declaration of German Industry on Global Warming Prevention (DGWP) was issued in 1996 by a series of associations represented by the BDI, and including among others the Federal Association of the German Gas and Water Industry (BGW), the Association of German Electric Utilities (VDEW), the Association of Industrial Energy and Power Users (VIK) and the Association of Municipal Enterprises (VKU). The businesses grouped together in these associations represent more than 70 % of the final industrial energy consumption.

The general goal of the German industry to reduce the specific CO_2 consumption by 20 % between 1990 and 2005 is largely varied from industry to industry, ranging from 16 % –17 % in the steel industry to 66 % in the Potassium Association. In exchange for their unilateral declarations, the industrial associations expect that policy will give priority to these voluntary initiatives against other regulatory or fiscal climate policy instruments. The implementation of the DGWP takes place entirely under the self-responsibility of industry, and the branch associations are in charge of implementing their declaration.

The Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI, Essen) was entrusted to carry out an annual sector-by-sector monitoring on the basis of progress reports provided by the branch associations. As far as possible, the self-reported data are checked against official statistics; however, an independent data collection and auditing does not take place /Ramesohl; Kristof 2000/.

In 2000, a Climate Protection Agreement between the aforementioned industrial associations and the German government was launched, extending the objectives to a 28 % reduction of specific CO_2 emissions in 2005, and 35 % for all 6 Kyoto-Gases until 2012. According to the government, the extended DGWP from November 2000 should save another 10 Mill. tons of CO_2 emissions until 2005 within the industry and energy suppliers.

3.1.3 France

The French Voluntary Agreements on CO_2 emission reduction have been initialised in the framework of French Rio (1992) commitments implying the stabilisation of CO_2 emissions at 1990 levels by the year 2000. After the ratification of the commitment in 1994, the French government designed the National Programme for the Prevention of Climate Change in February 1995. This programme defined that for energy-intensive industrial sectors a consensus and dialogue approach would be initiated by launching voluntary agreements for CO_2 emission reduction. The main purpose of implementing voluntary agreements was to limit the competitive effects of CO_2 reduction policies for energy-intensive industries.

Seven voluntary agreements for CO_2 reduction have been concluded between the French government and industry, five related to industrial GHG emissions, concluded with the aluminium (May 1996), fat and magnesia lime (July 1996), cement (October 1996), steel (December 1996) and packaging glass (February 1997) industry. The remaining two involved the transport sector. Many VA negotiations, however, were unsuccessful (paper, chemical, sugar, dairy products, plaster and foundry industries) because of low incentives for participation and different opinions on voluntary agreements held by industry and government.

As far as the methodology has been made clear, the quantitative targets for emission reduction proposed by industry were principally accepted by the Ministry for the Environment /Chidiak; Glachant 2000/. A regular reporting procedure was stipulated containing self reported progress information by industry and data collection by the government but without further checking or analysing the data provided by industry. No monitoring of third parties has been planned /Krarup; Ramesohl 2000/. Furthermore, no accompanying measures were included in the voluntary agreements. The French government has also clearly excluded the use of energy taxation towards energy-intensive industries. On the whole, there was not only a lack of alternative instruments, enforcement or sanction mechanism but also of incentives for participation or supportive measures.

3.1.4 Denmark

The voluntary agreements for energy-intensive companies in Denmark are a part of the so called “Green Tax Package” issued in 1995, consisting of the following major elements:

1. Three different taxes: energy, CO_2 and SO_2
2. Three different purposes for energy use are defined when assessing the tax: space heating, light industrial processes and heavy industrial processes
3. Reduced tax rate for energy-intensive companies/sectors if they enter into a voluntary agreement on energy-efficiency with the Danish Energy Agency (DEA).

The first voluntary agreements were signed in 1996. The company must first perform an energy audit prepared by an independent consultant and present an action plan based on the audit demonstrating how the company/sector will implement an system of energy management, apply procurement policies favouring energy efficiency and educate staff in energy efficiency. A negotiation phase can take place where the audit may be disputed and reviewed or the company/sector may propose alternative measures to achieve equivalent CO_2 reductions.

On the basis of the accepted action plan, the company/sector signs a three-year agreement with the government and is guaranteed a partial reimbursement of carbon tax rates conditional on the fulfilment of the obligations issued in the action plan. At the end of the three-year period the agreement can either be terminated or renewed. The Danish Voluntary Agreements have a clear parliamentary basis.

The parties to the agreement are energy-intensive companies and DEA. There are no quantitative targets in the Danish Voluntary Agreements. Instead, the following qualitative targets have to be formulated and agreed upon: Accomplishments of energy-saving investments (projects) which have been identified in an energy audit and implementation of an energy management system according to the instructions formulated by DEA. The companies report to DEA once a year and produce a final report at the end of the agreement period. Energy intensive companies entering a voluntary agreement will receive a subsidy to cover the CO_2 taxation which is 22 % of the charge. If the company does not fulfil the terms of the agreement (which can be the result of the verification procedure), DEA can decide that the agreement is cancelled and demand that the company pays back the received subsidies.

3.1.5 United Kingdom

As a result of economic growth, traffic growth and the closure of the nuclear power stations, the UK’s emissions are projected to increase again without further action. Therefore the Climate Change Programme was introduced in November 2000 covering the domestic sector, the transport sector, industry and electric utilities, the public sector and agriculture. The Programme is designed to reach UK’s Kyoto targets of reducing greenhouse gas emissions by

12.5 % below 1990 levels over the period 2008-2012, and to move towards the domestic goal of a 20 % reduction in carbon dioxide emissions by 2010. The programme includes measures like the climate change levy, an emission trading scheme, a carbon trust as well as the LTA agreement schemes.

The overall intention of the programme and especially the design of the levy is to not increase the tax burden on industry as a whole in order to protect the competitiveness of UK firms. Business will also benefit from an additional support for energy efficiency schemes and renewable sources of energy.

Because of their energy usage, the requirements of the Integrated Pollution Prevention and Control regime and their exposure to international competition, energy-intensive sectors have the possibility to conclude LTA agreements for improving energy efficiency or reducing carbon emissions. The facilities identified in these agreements are eligible for a 80 % levy discount until the end of the first certification period in March 2003. The eligibility for a discount from April 2003 onwards will depend on whether the first targets set in the agreements have been met.

3.1.6 Finland

Conservation and an efficient use of energy are part of the Finnish Government's Energy Strategy, which was approved by the Finnish Parliament in 1997. The Energy Conservation Programme (ECP) within the Energy Strategy aims at an increase of energy efficiency by 10 % to 20 % by the year 2010 and at a stop of the growth of primary energy consumption within a 10 to 15 year period.

According to the Energy Strategy, LTA schemes including energy audits are examples of energy conservation with encouraging results. The energy audits belong to one of the key elements of the ECP. Finland has one clean-cut and full-scale official energy audit programme, the Energy Audit Programme (EAP) which has been launched by the Ministry of Trade and Industry (MTI) in the beginning of 1992 as a part of the ECP.

Finland had its first voluntary agreements with quantitative targets in 1992, but due to negative company feedback and experience the agreement scheme was revised in 1997. It was linked to the already existing Energy Audit Programme.

The target for the LTA aimed at the industrial sector was to cover 80 % of industrial energy use by 2005. This target has been achieved in advance. By the end of May 1999, the Finnish Ministry of Trade and Industry (MTI) had signed voluntary agreements with a total of nine organisations that represent various branches of industry, the producers and distributors of energy, municipalities and commercial buildings. 115 companies representing 85 % of industrial energy consumption have joined the LTA for the industry by 17.1.2002. This includes also the most significant actors of the chemical, iron and steel, non-ferrous metal, cement, pulp and paper. There are no specific industrial or branch targets in the LTA.

Companies set individual, company-specific qualitative and quantitative targets on hand of the audit. The agreements are mainly effective until the year 2005.

3.1.7 Sweden

The Swedish EKO-Energi Programme started in 1994 and was initiated by the National board for Industrial and Technological Development (NUTEK), later transferred to STEM. The aim of EKO-Energi has been to achieve energy efficiency within the participating companies by reducing the energy consumption of various internal processes on the industrial sites, apart from the specific production process. It is a non-binding program, often regarded more as a "project" for energy efficiency measures in industry, rather than a full-fledged environmental agreement. Today, the EKO-Energi program is closed for any new participants but is still running until 2002. The core idea for firms is to submit to an independent energy audit and commit themselves to a series of measures to improve energy efficiency.

Starting in March 2001, the EKO-Energi programme has been transformed to a program for municipalities (EKO Energi, Kommuner). The aim is to give municipalities an incentive to work with energy and climate issues within the framework of Agenda 21.

Until date, 47 individual companies are participants to the agreement (cf. /STEM 2001/), including in this figure some 70 industry sites, as the agreement is, as a rule, set on a plant/site level, rather than on a corporate level. The agreement covers a broad range of industrial sectors, including some energy intensive industry, predominantly pulp/paper.

There are no absolute targets in EKO Energi, instead each company sets individual targets within economically reasonable measures, as a result of the findings made in the energy audit. The authorities, on the other hand, commit themselves to pay for the audit and information, also allowing the firms to use a specific "Energy label" in their advertising /Kågström; Helby 1998/.

The EKO Energi agreement does not imply any tax exemptions. Instead, the main "carrot" for the participating companies has been to receive an energy audit, made by a third party consultant and paid by the energy agency. Another "unofficial" offer is the network created by participating companies of the agreement, coordinated by the energy agency.

3.2 Review of major aspects included in the LTA analysis

The following sections gives a summary of the key aspects which have been covered within the study when analysing the seven national LTA schemes briefly described above.

3.2.1 Parties to the agreements

The main actors involved in LTAs can be quite different from one country to another in particular for the public authorities. National energy agencies are often involved in this process. With few exceptions the national industrial associations are always part of the agreements. The ministries participating in the agreement are quite different from one country to another. They range for example from the Ministry of Environment (FR) to the Ministry of Economic Affairs (NL) to the Ministry of Trade and Industry (FI) etc.

The percentage of energy consumption covered by the participating industry is quite high and reaches in some countries 70 to 90 %.

3.2.2 Targets of agreements

Targets vary from country to country both in terms of definitions and quantities. In the Scandinavian countries, the targets are company specific and agreed on after an energy audit. In the Netherlands, national targets amount to 20 % of energy efficiency improvement in 2000 compared to 1989, while in Germany the specific consumption should be reduced by 20 % by the year 2005 compared to the 1990 level. In France, both absolute and specific quantitative targets exist, negotiated at sectoral level. In the Netherlands, for example, after the 20 % has been accepted as a starting point, a number of sector studies were carried out by independent research centres to define a fair burden sharing among the different sectors and individual companies.

3.2.3 Reporting and monitoring procedures

All LTAs foresee some reporting system. Formally, they are compulsory, except in the case of Sweden. Reporting procedures are different depending on the Country concerned. In the UK, operators report to the sector association at the end of each target period. In the Netherlands, firms provide annual reports on energy efficiency to NOVEM. In Germany, the reporting is executed annually by a research institute (RWI) on the basis of the branch reports and official statistics. In France, the procedures consist of self reported progress information by industry to the government. In Denmark, companies produce to DEA an annual report and a final report at the end of the agreement period. In Finland, an annual report on energy efficiency is delivered to the confederations and to MOTIVA.

Confidentiality of the data included in the report is a general concern. Many countries do not have a monitoring system. For those who have one, it is not always transparent and effective.

3.2.4 Accompanying measures

In almost all EU countries, there are policy measures to support LTAs. The most common accompanying measures are actions associated with awareness and information campaigns. They are different from one country to another and concern energy audits, training, promotion of good practices, workshops etc.. These actions are often subsidised. Industrial associations and or environmental agencies are the vehicle for the information dissemination. When LTAs are part of a national policy and programmes, accompanying measures are even more important and may include tax reductions and major subsidy schemes.

3.2.5 Interference with other national policies

As a whole, there is a great policy diversity among the different LTAs in the EU. Two main categories can be defined: i) LTAs with weak links to other national policies, like in Sweden and Finland and ii) LTAs which are part of a national programmes like in the Netherlands or UK.

LTAs are very seldom used in isolation, but rather in combination with other policy instruments which ideally should be complementary.

3.2.6 Offers and sanctions

LTAs are combined with information programmes, auditing, financial and fiscal incentives, training, R&D support regulations, etc.. They can be very different from country to country. In the UK, energy intensive sectors are offered an 80 % levy discount through the participation in the energy efficiency agreements. In Germany, LTAs are supposed to stop further regulatory or fiscal climate policy instruments. In terms of sanctions, the situation varies as well depending on the country. Typical sanctions are, in case of non compliance, the loss of the levy discount in the UK, the reimbursement of a subsidy in Finland, the termination of the LTA in Denmark and Netherlands etc..

3.2.7 Other diversities

All members states in the EU use LTAs in some field of industrial and/or environmental policy. Some of them have more experience and tradition in their use like Denmark, Germany and Netherlands while others have started only recently.

LTAs can be legally binding or legally non-binding, depending on whether the public authorities can sign such agreements with firms or associations.

Most of the LTAs in the EU are non-binding, except in the Netherlands and Denmark. The liability rules can be different in the EU depending on the countries. Usually, the targets are set collectively at a sectoral level. There are no explicit sanctions included in the LTAs but in case of non compliance, government authorities could apply existing regulations or issue new legislations.

3.3 Assessment of LTA schemes in the European Union

An assessment has been carried out for each of the seven countries thereby taking into consideration evaluation criteria suggested by the OECD (cf. /OECD 1999/), namely:

- Achievement of targets
- Environmental effectiveness
- Economic efficiency
- Administration and compliance costs
- Competitiveness implications
- Innovation and learning effects
- Soft effects
- Viability and feasibility

With regard to the *achievement of targets*, most of the analysed agreement schemes succeeded in keeping their targets to a high degree. In the Netherlands, the 29 industrial LTAs resulted in an average improvement in energy efficiency of 22.3 % over the period 1989-2000 so that the target of 20 % was met. Within the industry, however, the performance differed. Some sectors such as light industry were behind schedule, whereas base metals and chemical industries were well in line with the targets.

The original goal of the German industry in 1996 was to reduce specific CO_2-emissions by 20 % between 1990 and 2005. The LTA was extended in 2000 by a new agreement between the German government and 19 industrial associations. In order to integrate Kyoto Protocol results into the national energy saving policy, new strategies and goals for climatic gas reduction were set, e.g. to reduce specific CO_2-emissions in industry by 28 % between 1990 and 2005. According to the German government, the entire industrial sector (including electric utilities) reduced specific CO_2-emissions by 27 % between 1990 and 2000, corresponding to more than 50 million tons.

In France, according to the last progress report issued in 1998, most of the VA commitments were already completed in 1997 or to a great extent attained: Both specific targets of Pechiney have already been achieved in 1997 (19 % CO_2 and 73 % CF_4 emission reduction). Moreover, the overall specific GHG emission reduction achieved was 40 % and thereby the original target of 34 % has been exceeded. However, the achievement of absolute emission objectives remained unclear. For the French Steel Association, a CO_2 emission reduction of 11.2 % (total) and of 12.5 % (specific) has been achieved in 1997. The cement industry reduced specific CO_2 emissions by 13.3 % compared to 1990 whereas total CO_2 emission were reduced by 37 % and specific emissions by 18.9 % compared to 1990.

In Denmark, there were no quantitative targets stipulated in the agreements but targets negotiated at company level. Since none of the energy intensive sectors that are covered in the present work has signed a collective voluntary agreement it is not possible to assess the agreements sector by sector. One can conclude, however, that the Danish Voluntary Agreement scheme has had a great impact in these sectors.

In Great Britain, a detailed assessment of the 5 energy-intensive industries is at present not possible, because the first certification period has started in 2001 and will end begin of 2003.

As a result of the LTA in Finland, heat and fuel savings of 1.65 TWh/a and electricity savings of 0.37 TWh/a have been achieved by 2000. According to the Confederation of Finnish Industry and Employers, the effect of these energy savings mean CO_2-cuts of 0.7 million tons. It has been assessed that the saving potential identified by 2005 would be about 11 TWH/a, of which about 5-5.5 TWh could be realized by 2010.

In Sweden, previous studies indicate that the EKO Energi has stimulated companies to include energy as part of the environmental management system. The common viewpoint regarding “hard facts” is, however, that EKO Energi has not been successful in contributing to national and/or international emission targets, in absolute terms or in terms of reduced energy consumption/emission reductions.

The question *whether LTAs are effective* can always be interpreted as to what extent energy efficiency improvements would have occurred had there been no LTAs. However, with the evaluation of an instrument’s ability to induce supplementary effects on energy efficiency in addition to what would have happened anyway, less research experience has been gained. The quantitative evidence for an additional impact of agreements is limited due to the following reasons: 1) A general lack of baselines against which to assess agreements; 2) the difficulty of disentangling the effects of different instruments in a policy mix aimed at energy conservation, and 3) energy efficiency improvements can often not easily be distinguished from structural changes in the economy /Blok 2001a/.

In the Netherlands, undoubtedly LTAs have had an impact on the improvement of energy efficiency. On the basis of the firms and expert judgements (cf. /Glasbergen et al. 1997; Rietbergen 2001/), it can be concluded that 30 to 40 % of the energy savings are considerably or entirely stimulated by LTAs, whereas 60 to 70 % of the measures are slightly or not at all stimulated by LTAs. In Germany, there was no characterisation of a business-as-usual scenario to compare the targets achieved with. Most effective energy saving measures were due to use more energy efficient technology, closing down old facilities, fuel substitution and establishing integrated energy supply concepts. According to a governmental statement in 2002 DGWP initiated a lot of energy saving measures in industry. In France, for the most part necessary investments and technical improvements had already been planned since the late 1980s and were in process during the VA negotiations. The VA objectives corresponded therefore to what was economically interesting for the companies and were set close to business-as-usual. In Finland, without energy saving actions conducted, the companies which have joined agreement, would have consumed in 2000 1.6 % more fuel and heat, and 1.1 % more electricity. In addition, the companies have identified the following saving potentials: fuel and heat 1.5 % (1.6 TWh/a) and electricity 1.8 % (0.9 TWh/a) which will be realised or for which realisation has been considered. The Finnish LTA scheme can be considered as a successful scheme incorporating many crucial elements for succeeding, such as a very well developed audit system. In Sweden, there are no official statistics with results from overall participating companies regarding this point. Data will be compiled and available first at the end of the agreement scheme.

According to the OECD, *economic efficiency* is unclear and hard to estimate in most LTAs due to a lack of data /OECD 1999/. In the Netherlands, there has been no estimation of economic efficiency per sector or per type of measure, but a rough estimate for the LTAs as a whole has been executed. Most (not to say all) investments that were done in the context of the LTA had a pay back time within the critical pay back time used by the companies for normal investments. The LTAs did therefore not contribute to a lot of extra investments in new energy saving technologies. In economic weaker times, there was no room for extra investments and the targets were met using good housekeeping methods. In France, the VA objectives, set close to business-as-usual, were therefore economically interesting to the companies and produced no additional constraint or further impact on energy practice. In Finland, during the years 1998-2000 companies belonging to the LTA invested over 530 million FIM (89 million €) for saving energy. With these investments, annual heat savings of 1.65 TWh and electricity savings of 0.37 TWh have been achieved. Saving potentials identified in the audit are priorized by payback time, so company actions base on a profitable and economically sensible approach.

Little is known about *administration and compliance costs*. In most cases, this cost effectiveness is defined as the amount of money the government needs to spend per unit of carbon emission avoided. In the last few years, some studies on the effectiveness of policy instruments in the Netherlands have been executed /Blok 2000a; Rietbergen 1999; De Beer 2000/. From these investigations it can be concluded that LTAs are cheaper than subsidy schemes, but one has to realise the large margin of error in this outcome and the differences that probably occur per sector but are not investigated yet. Also there is a probable shift from costs from public administrations to the private sector, since the firms have to write monitoring reports themselves and they do no longer fall under (public) permit regulations. However, this has never been investigated. In France, the costs for the public administration and industry can be considered as rather low for several reasons: Specific preparations or active participation of the public authorities during the negotiations, the conclusion or the monitoring and reporting of voluntary agreements didn’t take place, the information provided by industry on CO_2 reduction targets and emission evolution were not assessed or verified. Since there were no accompanying measures or sanctions, no explicit administrative efforts were necessary to evaluate goal attainment or to respond to the monitoring results. In Finland, the main administrative costs are the subsidies for audits and investments as well as costs for operating Motiva.

The implications of the LTAs on *competitiveness* have never been subject of scientific investigations in the Netherlands, but since the accompanying measures are of a general kind and do address both LTA-companies as non-LTA-companies, the advantage of having an LTA on acquirement of subsidies can be neglected. The only real advantage LTA-companies have is that they are offered a free energy audit and that they are not subject to normal environmental regulations. From this point of view, the competitive implications within the Netherlands are limited. In Germany, no provisions reducing the risk for competition distortions were foreseen. In Finland, no competitiveness implications have been assessed.

The OECD argues that it is unlikely that LTAs provide strong incentives to *innovate* because of the relatively low targets set /OECD 1999/. Looking at the targets set in the Netherlands compared to technical potentials estimated in /Icarus 1994/, one cannot say that in general targets were too low, but one can question whether the targets were high enough to stimulate innovation. With respect to the *learning process* for parties involved in the process of LTA setting in the Netherlands, all parties have had advantages on the general level of knowledge with respect to energy issues. Another result of the negotiations is that the networks of governmental parties and branch organisations have crossed, and that people can find one another if necessary. Also the provinces have acquired substantial energy expertise during the late nineties, as have cities like Amsterdam and Rotterdam. This applies also for France, where owing to the information exchange between industry and the Ministry of the Environment, a learning effect on industry's situation concerning CO_2 emissions can be attested. In Finland, on hand of Motiva's view the LTA has improved information sharing and learning effects among the participants of the LTA. The introduction of the LTA in 1998 has had a major effect in increasing the volume of energy audits, especially in the industry. In Sweden, the agreement has been regarded as effective for triggering awareness for energy on the long term within the participating companies.

With regard to *soft effects (and diffusion of information)* of LTAs, the question is what would have happened wouldn't there have been the LTAs. In the Netherlands, undoubtedly, the LTAs have caused environmental awareness and have put energy issues in firms higher on the agenda. It has been argued that LTAs can contribute to diffusion of information on energy efficiency improvement and techniques, because of the co-operation between firms within the agreement. In the process of the LTAs, this certainly happened in the Netherlands because communication between firms has intensified and improved. In Denmark, the companies find that the energy audit sum up the existing knowledge rather than helping to identify new potentials for energy savings. Nevertheless most companies find that agreements are effective since they put energy efficiency on the company agenda. In Finland, on hand of Motiva's view and company feedback there has been improvement of motivation and awareness in the companies due to the LTA. In Sweden, the EKO Energi has stimulated companies to include energy as part of the environmental management system and it also has been successful regarding other specific "soft" issues (cf. /Kågaström et al. 2000/). Notably it increases the experience of companies as well as governmental agencies in co-operating within the framework of an LTA and in the contribution of a new sort of policy instrument, addressing energy efficiency. Furthermore, the agreement contributes to developing mutual trust between companies and the energy agency – this, even though no sticks have been included as parts of the agreement.

The *viability and feasibility* of LTAs can be affected by three lines of reasoning, as summarised in /OECD 1999/:

- LTAs can be seen as just cosmetic, because they are policy instruments agreed upon by industry,
- LTAs leave non-industrial parties (including NGO's) and legislative branches out of the policy process,
- LTAs lack transparency because of ambiguous targets and weak monitoring.

In the Netherlands, the targets were set relatively ambitious and there were (although fairly weak) sanctions. Therefore, the LTAs in the Netherlands are much more than just a cosmetic agreement. With respect to the second line of thought, one can say that this is not applicable to the Dutch organisation of LTAs since there are agreements with non-industrial parties, such as the agricultural sector and the education and health sector. It is certainly a fact that NGOs like Greenpeace and WWF felt left out in the development of this type of policy-scheme. The lack of transparency is indeed a problem and damages the trustworthiness of the agreements. This lack of transparency is caused by the fact that monitoring results on a firm level are (of course) confidential, but that monitoring results on the sector level (that are public) are hardly available. The same applies for Germany, where for future LTAs RWI pleads for a higher transparency of the branch monitoring process, stronger binding agreements and powerful sanctions when goals were not met. The French voluntary agreements can be characterised as "industry commitments with public 'approval'" /Chidiak; Glachant 2000, 26/ implemented as substitution of other climate policy measures. The investments, technical improvements and energy efficiency efforts were economically interesting to the firms and not generated by the voluntary agreements but closely related to the industry's internal situation in the early 1990s. The industrial obligations were too weak and would have presumably been met without voluntary agreements.

3.4 Key issues identified for LTAs at European level

Based on the analysis of existing LTA schemes, in the following some general conclusions on the effectiveness of LTAs for energy efficiency improvements are given as well as some aspects concerning the transferability of LTAs to the European level are highlighted.

Among the *key benefits* of LTAs can be found the co-operative and flexible approach recognising the diversity within an industrial sector, the improvement of intra-sectoral communication, the promotion of an increased awareness on energy-efficiency and the strengthening of existing energy management schemes, the influence of non-monetary factors on investment decisions as well as the long term approach with a long term commitment of both sides. However, effective LTAs cannot be achieved at low administrative cost. In fact, significant administrative resources are needed, e.g. for the permanent training of personnel, the building up of deep knowledge or for a detailed analysis and planning. Substantial awards have to be offered to industry by the public side to achieve deviations from business as usual.

With regard to the *effectiveness of LTAs*, the general idea is that voluntary agreements can be effective in enhancing the rate of energy efficiency improvement, although one can never exactly determine what would have happened had there not been the LTA. The effectiveness of the agreements hereby depends on the design of the agreement deal with respect to targets, accompanying measures, sanctions and time-frame. Moreover, for further evaluation of voluntary agreements as a policy measure, the development of tools for an evaluation of the effectiveness is necessary. Good monitoring procedures and the availability of data are first conditions for executing evaluations.

The following main *"golden rules" for effective agreements* can be derived:

- There has to be a strong negotiation position of the government.
- LTA should be part of a policy mix and combined with substantial offers and credible sanctions.
- There should be long-lasting government support (expertise, R&D budgets, subsidies for feasibility studies, possibilities to set up demonstration projects, et cetera).
- The number of parties to the agreements should be limited to minimise administrative efforts. Therefore the agreements should only be used for big energy intensive companies. For small companies the monitoring and reporting efforts are not in balance with energy savings.
- The targets should be ambitious, binding and clearly defined and the time schedule strict.
- There should be a reliable and consistent monitoring and reporting system guaranteed, e.g., through an independent verification office. Divergences between official statistics and internal branch data should be prevented.
- A regular revision and modification should be stipulated, e.g. regarding the target definition, the data collection or the methodology of self-reporting etc..
- The procedural framework should be clearly defined (tasks, responsibilities and interactions).

From the above points some "for-and-against" arguments can be derived when considering *LTAs at an European level*:

- Because of issues of market distortion, it would be an improvement if policy-measures are developed and executed more and more at the European level. Of course this is also true for LTAs.

- LTAs at European level have to take into account the complex decision-, consensus- and policy-making process as well as the limitation of economic and administrative resources at EU level.
- Improved communication flows, learning effects and diffusion of information can be the results of an LTA. In this regard, the gain of agreements at European level could even be greater.
- Since the LTAs can only be effective in a total policy package, this means that all policy measures (including taxes, subsidies, offers and sanctions) should be convergent on a European level. The development is pointing in that direction, but surely it will take some time to reach a high enough level of uniformity.
- In the Netherlands, e.g., a good branch organisation was a starting point for joining the LTA. This might be more difficult at the European level, where only the large bulk-producers (iron and steel, cement) might have such a level of organisation. Smaller production facilities are less organised at the European level, and negotiation and agreements will therefore be harder to accomplish.
- According to /Blok 2001b/, the number of parties in the agreement should be limited. This argues against agreements on a European level.
- Because of the importance of monitoring, verification and reporting, a separate independent administration should be responsible for the LTAs at European level.

Based on the investigation of the seven most relevant LTA schemes shortly described above with regard to key aspects of the agreements and to evaluation criteria put forward by the OECD as well as on a literature review of existing studies, a questionnaire on the potential influence of LTAs on decision making in industry has been developed and sent to the participating industrial associations and other stakeholders. The results of the stakeholder survey are discussed in chapter 6 while the proposal for sectoral LTAs at European level drawing on the success factors analysed before is given in chapter 7.

4 Techno-economic analysis for the five energy-intensive sectors

In order to *estimate the energy efficiency and CO_2 reduction potential* in industry, in the last years various studies have been carried out both at the EU and the national level to assess the possibilities for energy efficiency improvements in the industrial sector, notably /Fletcher et al. 1999/, /Haworth et al. 2000/ and /Hendriks et al. 2001a/. The results of these studies as well as the so-called BREF reports (cf. /IPPC 2000a-h/) have been carefully examined, but in addition further assessments have been carried out in order to develop a common knowledge basis for the LTA potential at European level.

After presenting an overview on the basic modelling steps of the techno-economic analysis used in the project including basic data and scenario assumptions, a summary of the results will be given as regards the energy consumption and CO_2 emissions with different marginal abatement costs and the costs for industry under LTA and under tax scheme for the time horizon 2000-2010. However, it has to be clearly stated that these *results have to be considered with care* given the difficulty of getting reliable data (depending on the sector), especially with regard to disaggregated cost and energy data of single technologies as well as the estimated production growth rates. It has to be taken in mind that modelling results can not ensure a transcription of reality, but can give the trend of future development under the given assumptions.

In the material volume, a description of each of the five energy-intensive sectors is given with regard to their structure, energy consumption and data sources based on the critical assessment of basic studies, own literature review and discussion with experts e.g. from research institutes and industrial associations. A detailed list of energy efficient technologies for each sector is presented followed by a description of relevant/new technologies, of other energy saving measures and of the technical potential.

4.1 Overview on basic steps

A *techno-economic analysis* using a behavioural oriented decision model has been carried out to describe investment behaviour based on an economic cost benefit analysis. Thereby energy saving potentials and related costs of principal production processes have been investigated such as, e.g. in the non-ferrous metal sector, the production of copper anode from primary and secondary raw materials.

The following steps have been carried out:

- Identification of relevant production processes (products)
- Identification of relevant production lines and related technologies used at present and probably in future in Europe
- Data collection for these production lines

- Simulation of energy use and related CO_2 emissions from 2000 to 2010 based on an economic model describing investment behaviour of industry with regard to energy efficient technologies
- Analysis of the impact of LTAs and tax schemes on energy use, CO_2 emissions and costs for industry

The data requirements and model assumptions are described in more detail in the following sections.

4.1.1 Data base

Based on the so-called BREF-reports on best available technologies (cf. /IPPC 2000a-h/), the IKARUS database, literature sources and information of the European associations, the most relevant production processes in Europe for each of the five sectors under study have been identified. As one example within the copper production compare Figure 4-1.

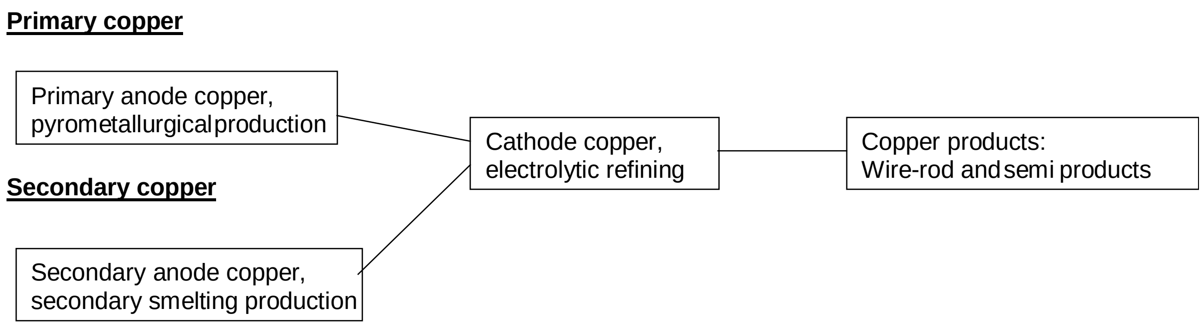

Figure 4-1: Example of analysed processes: copper production

Each of the identified processes is described in more detail in the material volume, including information on production volumes, market shares, energy consumption data, etc. as well as the results of the modelling. The data requirements for the model calculations are summarised in Table 4-1.

4.1.2 Analysis and simulation tool for modelling energy use and CO_2 emissions

The aim of the analysis and simulation tool is to determine the potential market shares of the individual production lines until 2010 based on the data presented in Table 4-1. The model describes the investment decision behaviour of industrial companies based on a cost-benefit analysis of different production lines (compare Figure 4-2): The decision model calculates *probabilities* decision makers have (firms respectively their representatives) for the selection of different investment alternatives depending on their characteristics (energy, investment and operating costs), at given demand level for the final product.

Table 4-1: Overview on data requirements

Data	Description
Production volumes	• Total production volumes of products in 2000
Production shares	• Production shares of different production lines in 2000, e.g. for the Pierce Smith converter producing primary anode copper
Energy consumption	• Energy consumption or potential energy savings of individual production lines including general energy saving measures, if possible separately for each source of energy
Cost data	• Investment costs • Operation and maintenance costs
Use of technology	• Technologies which are used at present and/or in future ("old" technologies, new emerging technologies, BAT)

Moreover, the following *model assumptions* have been considered in the calculations:

- For the development of the existing stock of plants (production lines), a linear decrease is assumed over the supposed lifetime.
- The existing stock of plants is gradually replaced by new investments. That means, new investments are carried out at the end of the lifetime of a plant and not earlier.
- New investments are modelled using an economic decision model, the so-called "Multinomial Logit Model"[1]**.** This means that mostly only costs (investment, operating and energy costs) are taken into account as decision criteria. Non-monetary factors such as product quality or barriers are not taken into account unless a monetary equivalent for benefits/losses can be determined.
- The assumptions on CO_2 emission factors and the development of energy prices are based on literature, EC studies and EC statistics (cf. section 4.1.3).
- The impact of an LTA on energy use and emissions is assumed to be the same than the impact of a CO_2 tax with the same marginal abatement costs (i. e. tax rate).
- The impact on the firms' competitiveness is assessed by determining the corresponding changes in production costs.
- Production cost changes resp. product price changes due to taxes or LTAs may influence the quantities sold by EU industries (market shares lost to competitors outside the EU or

[1] e.g. /Maddala 1993/

reduced consumption due to the substitution of products). However, such effects are difficult to quantify and are therefore not taken into account in the scenario calculations.

- Neither is the effect accounted for that LTAs may contribute to a more stable (political) environment compared to a reference case without LTA, thus lowering the risk premium requested by industry on investment.
- Furthermore, since the model can only take into account quantitative factors as decision criteria but not non-monetary factors like e.g. product quality, safety, risks etc., the LTA scenario tends to underestimate the potential energy saving effect of an LTA.

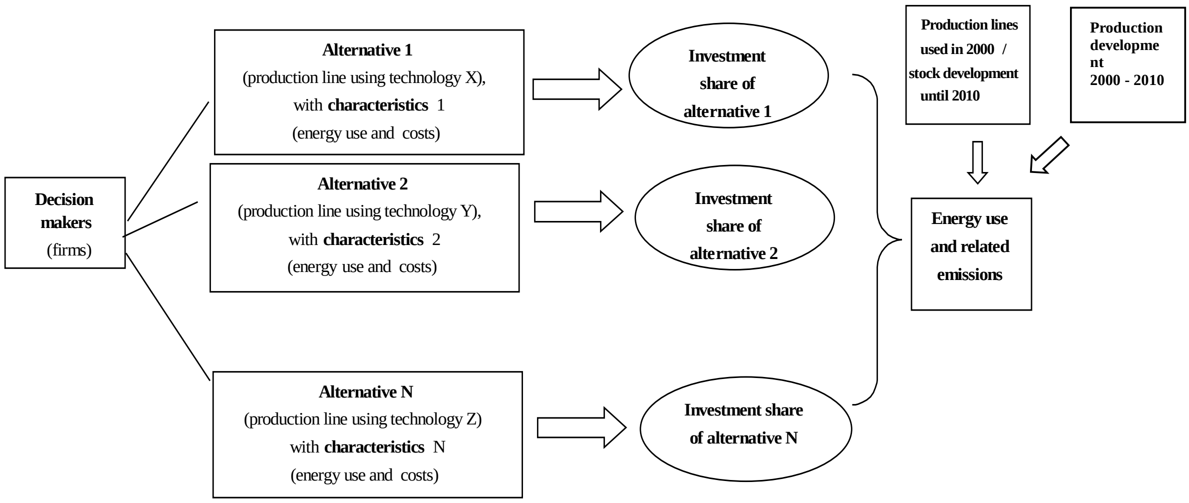

Figure 4-2: Decision model

4.1.3 General data and scenario assumptions

Important input data which strongly determine the results of techno-economic analyses in general and also of the analyses carried out in the following are:

- Emission factors,
- energy prices,
- interest rates and lifetimes and
- acceptable emission abatement costs.

For the techno-economic analysis in a first step the focus has been on the energy-related CO_2-emissions, since these are the most important GHG emissions in industry and those for which (approximate) abatement costs are available. The *CO_2 emission factors* used are given in Table 4-2. Also for the conversion to primary energy, approximately the total energy required for delivering one unit of final energy has been taken into account.

Table 4-2: CO_2 emission factors and primary energy conversion factors for different energy carriers

Energy carrier	Emission factor [g CO /MJ]	Primary energy factor [MJ/MJ]
Electricity	107.6	3.0
Natural gas	55.7	1.1
Other gases	65.0	1.1
Light fuel oil	73.8	1.1
Heavy fuel oil	78.6	1.1
Hard coal	100.7	1.1
Other solid fuels		
Biomass	0	1.1
Others	100.7	1.1
District heat	75.0	1.2
Steam	125.9	1.1

Source: own calculations based on /Borsch, Wagner 1992; EC 1998/

For the energy price development, energy price statistics as well as recent scenario studies for the EU have been considered. The corresponding data on *energy prices* used for the scenario calculations are summarised in Table **4-3**. It should be noted that given the available statistics average energy prices for industrial consumers in the EU have been taken, albeit energy-intensive consumer pay considerably lower tariffs. However, sensitivity calculations have shown, that the impact on the results of these assumptions is not very high.
When comparing the results of existing studies, it becomes evident that the outcomes depend strongly on the assumptions made for the annuity factors in the individual countries:

Table 4-3: Development of industrial energy prices

	Average prices in the EU for industry [€/MJ]		
	2000	2005	2010
Electricity	0.0147	0.0147	0.0147
Natural gas	0.0038	0.0042	0.0045
Other gases	0.0049	0.0055	0.0059
Light fuel oil	0.0094	0.0110	0.0115
Heavy fuel oil	0.0072	0.0088	0.0093
Hard coal	0.0028	0.0027	0.0028
Other solid fuels	0.0028	0.0027	0.0028
District heat	0.0096	0.0095	0.0096
Steam	0.0062	0.0062	0.0062

Source: own calculations based on /IEA 1997a; IEA 1999c; Capros et al. 2000/

/Fletcher et al. 1999/ is based on different assumptions for the annuity factor in the single countries. The most realistic assumption has thereby been made for the Netherlands with a discount rate of 15 % and a depreciation period of 10-15 years (technical lifetime). In

/Hendriks et al. 2001a/, a discount rate of 4 % and a depreciation period of 15 to 20 years are indicated. This leads to very low investment costs estimated for the analysed technologies and therefore to a very high energy saving potential estimated to be achievable with no costs or even with „negative" costs for industry. Moreover, assumptions concerning energy saving potentials of individual technologies in some cases may not be justified by literature and seem not to be agreed with industries' experts.

Therefore the following *scenarios* have been investigated within this study:

i) *Business as usual scenario*: 10 % real interest rate (12 % nominal interest rate); linear depreciation of existing stock over lifetime (lifetime of 20 years for most technologies). This yields an annuity factor of 0.12 which corresponds to 8.5 years of static payback time.

ii) *Alternative Scenario I*: 5 % real interest rate (7 % nominal interest); linear depreciation of existing stock over lifetime (lifetime of 20 years for most technologies). This yields an annuity factor of 0.08 which corresponds to 12.5 years of static payback time.

iii) *Alternative Scenario II*: 15 % real interest rate (12 % nominal interest); linear depreciation of existing stock over lifetime (lifetime of 20 years for most technologies). This yields an annuity factor of 0.16 which corresponds to 6.3 years of static payback time.

For the *acceptable emission abatement costs*, four scenarios have been analysed:

i) 0 €/t CO_2 (reference scenario)

ii) 10 €/t CO_2,

iii) 20 €/t CO_2

iv) 50 €/t CO_2.

These acceptable emission abatement costs correspond in the case of a tax scenario to the tax rate. For the LTA scenario it is the marginal abatement cost, up to which energy efficiency and CO_2 abatement investments will be undertaken. It has to be noted that especially a tax of 50 €/t CO_2 is not a realistic scenario for the coming years. According to the results of the questionnaire (cf. section 6) and other studies, a further increase of costs yields the danger that European plants could be closed or moved to East European countries, Asia or other countries.

In order to give a concise presentation of the results, in the following *results* are mainly presented for the *reference scenario* and the *LTA and tax scenarios with 20 €/t CO_2* acceptable abatement costs. Thereby the business as usual case of 10 % real interest rate is used throughout. In order to show the impact of the scenario assumptions, also the range of variation of the results depending on the scenario assumptions is shown, at least at sectoral level.

Concerning the production growth, an overall growth rate for EU industry of 2 % p.a. seems to be a reasonable assumption for the period 2000 to 2010 (cf. also /Capros et al.

2000/). However, the growth rate of production quantities in the energy intensive base material industries will then be mostly lower, a first estimate is 1 % p.a.. Therefore, this estimate has been applied unless specific information was available.

When interpreting the results presented in the following, the assumptions summarised in section 4.1.2 should always be kept in mind.

4.2 Iron & steel

Four routes are used today for the production of steel: the classic Blast Furnace/Basic Oxygen Furnace route, Electric melting of steel scrap (EAF), Smelting reduction and Direct reduction.

In the European Union, the iron and steel sector can currently be divided into two major groups: Electric steelmaking and Oxygen steelmaking. Steel production by Electric Arc Furnaces (EAF), is based on melting scrap using the thermal energy from electric arcs struck between graphite electrodes. The oxygen conversion process consists of blowing oxygen under pressure into the converter, previously charged with liquid pig iron and scrap. The oxygen is injected until the bath is completely transformed into crude steel. The pig iron used in the oxygen steelmaking is produced in the blast furnace, which is the prevailing iron making technology today. The total crude steel production in EU15 was 158.8 million metric tons in the year 2001, which was a decrease from year 2000, when the production was 163.2 million metric tons. The production of finished steel in year 2000 was 146.9 million metric tons.

In Europe the production of direct reduced iron (DRI) is limited to about 590,000 tons/year (Sweden and Germany). The consumption of DRI in EAF in EU15 is slightly lower than the produced amount. In the EU15 there are currently no smelting reduction units on a commercial scale.

The most energy consuming process in the iron and steel sector is the blast furnace process for pig iron production. The blast furnace consumes a large quantity of coke and hard coal. However, a large part of the coke and the coal act as reductants, which means that they are a raw material in the process, not an energy source. Number two is the electric steelmaking, where steel scrap is melted using electric energy.

The three largest crude steel producing countries in EU are Germany followed by Italy and France. Countries with the lowest crude steel production generally have 100 % electric steelmaking (Denmark, Greece, Ireland and Luxembourg). The only exception from this observation is Portugal, which had both electric (61.3 %) and oxygen (38.7 %) steelmaking. In 2000 there were about 136 electric and 33 oxygen steelmaking plants in EU. Since the major share of the produced crude steel was produced by the oxygen steelmaking route, it is clear that the average oxygen steelmaking plant has a much larger production capacity compared to the average electric steelmaking plant.

The present efforts on the Techno-Economic Analysis for the iron and steel sector have been focused on modelling of specific (intermediate) products. Priority has been given to the production of Hot Metal and Electric Crude Steel, since the connected processes and technologies are the most energy consuming in the sector. Production of Hot Metal represents the conventional blast furnace route and production of Electric Crude Steel represents the electric steelmaking route.

All the scenario calculations have assumed that the (average) total growth of the iron and steel sector in EU15 is 1 % per year during the period 2000-2010.

4.2.1 Blast Furnace Route (Hot Metal/Oxygen Steelmaking)

The calculations for Hot Metal production have considered the blast furnace as the only realistic technological alternative in the time period 2000-2010. However, several energy-saving additional technologies have been included and evaluated (see the appendices).

The results for the above reference scenario are summarised in Table 4-4 and Table **4-5** indicating that new investments in additional technologies is ecpected to decrease the use of total primary energy in this scenario by about 0.2-0.3 % for production of steel through the Blast furnace route from 2000 to 2010. The corresponding decrease of total CO_2 emissions during the same interval is zero. The decrease of specific energy use and specific CO_2 emissions is 9-10 % during the time interval in question. The figures should be treated with great care and not be seen as an exact forecast. The model rather analyses the effect of LTAs and tax scenarios than giving a forecast. The saving potentials tend to be overestimated.

For the other scenarios, there are, according to the model, no changes in energy savings compared with the reference scenario.

Table 4-4: Iron and steel: production, energy use and CO_2 emissions 2000 to 2010

	Production volume [Mt]		**Primary energy use** [PJ]			**Energy related CO2 emissions** [Mt]		
	2000	**2010**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**
Oxygen steel-making Absolute figures	97.9	108.1	1876.3	1871.6	1871.6	155.4	155.4	155.4
Range of variation		-		(1871.6 – 1871.6)	(1871,6 – 1871.6)		(155.4 – 155.4)	(155.4 – 154.4)
Change in %		*+10.4*		*- 0.25*	*- 0.25*		*0*	*0*
Electric steel-making Absolute figures	65.3	72.1	377.2	351.1	350.2	16.1	15.4	15.4
Range of variation		-		(350.6 –351.7)	(349.4 - 351.1)		(15.4 – 15.4)	(15.3 – 15.4)
Change in %		*+10.4*		*- 6.9*	*- 7.2*		*- 4.3*	*- 4.3*
Total Absolute figures	**163.2**	**180.2**	**2253.5**	**2222.7**	**2221.8**	**171.5**	**170.8**	**170.8**
Range of variation		-		(2222.2 – 2223.3)	(2221.0 – 2222.7)		(170.8 – 170.8)	(170.8 – 170.8)
Change in %		*+10.4*		*- 1.37*	*- 1.41*		*- 0.41*	*- 0.41*

Table 4-5: Iron and steel: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use [GJ/t]			**Specific CO2 emissions** [t/t]		
	2000	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**
Oxygen steel-making Absolute figures	19.1	17.2	17.2	1.58	1.43	1.43
Range of variation		(17.2 – 17.2)	(17.2 – 17.2)		(1.43 – 1.43)	(1.43 – 1.43)
Change in %		*- 9.9*	*- 9.9*		*- 9.1*	*- 9.1*
Electric steel-making Absolute figures	5.82	4.91	4.89	0.25	0.22	0.22
Range of variation		(4.90 – 4.92	(4.88 – 4.89)		(0.22 – 0.22)	(0.21 – 0.22)
Change in %		*- 15.6*	*- 16.0*	-	*-12.0*	*-12.0*
Total Absolute figures	**13.8**	**12.3**	**12.3**	**1.05**	**0.95**	**0.95**
Range of variation		(12.3 – 12.3)	(12.3 – 12.3)		(0.95 – 0.95)	(0.95 – 0.95)
Change in %		*- 10.7*	*- 10.7*		*- 9.5*	*- 9.5*

4.2.2 Production of Electric Crude Steel

Electric crude steel can be produced by the alternative technologies AC electric arc furnace, DC electric arc furnace or the continuous scrap feeding process (CON Steel). The AC electric arc furnace is the most commonly used technology today and there are several additional technologies (see the material volume).

The model calculations indicate that the total primary energy use for electric crude steel production during year 2000 was 377.2 PJ, while the specific primary energy use was 5.82 GJ/t. The corresponding model results for the total CO_2 emissions in 2000 were 16.1 Mt and the specific CO_2 emissions were 0.25 t/t. The results from the model calculations for the different scenarios are shown Table 4-4 and Table **4-5**.

The results for the scenarios indicate that the total primary energy use for production of steel by electric steelmaking decreases by about 6.8 % from 2000 to 2010, if there are no taxes on CO_2 emissions, depending on the real interest rate. If the CO_2 tax is assumed to be as high as 50 €/t CO_2 the total energy use will decrease slightly more with about 7.2 %

The corresponding change in total CO_2 emissions is then a decrease of 4.3 % if no tax on CO_2 emissions is assumed. If the CO_2 tax is assumed to be as high as 50 €/t CO_2 the effect on the total CO_2 emissions will be insignificantly.

The influence of the tax burden (10, 20 and 50 €/ton of CO_2, respectively) on energy savings is small compared to the no-tax scenario.

4.2.3 Overall results and comments

The decrease in total energy use and CO_2 emissions for both electric crude steel and hot metal/oxygen crude steel are summarised Table 4-4 and Table **4-5**. It has then been assumed that the annual growth rate for both products is 1 %. It can be seen that the model predicts a total decrease of energy use by 1.37 % (reference scenario). The effect of LTA/tax is insignificant, since the decrease of total energy use then changes by 1.41 %. The corresponding changes of total CO_2 emissions are 0.41 % and there is no difference between the reference case and the LTA/tax scenario.

The total costs for LTA respective tax are shown in Table 4-6. The costs represent the production of both electric crude steel and oxygen crude steel together. They are based on the assumption that the annual growth rate for both products is 1 %. The results should only be regarded as approximations. As can be seen, there is a dramatic increase of costs when a CO_2 tax is imposed.

Table 4-6: Iron and Steel: Additional costs of CO_2 abatement for industry

	Additional costs (2000 – 2010) for industry [bill. €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	0.1	19.8
Range of variation	(0.0 – 0.1)	(8.4 – 60.1)
Change in % vs. reference scenario	*+0.2*	*+33.8*

The results so far are based on the assumption that the annual growth of electric and oxygen steelmaking is 1 %, respectively during the period 2000-2010. However, the share of electric steel making in EU15 has increased during the last decade (1990-2000) from 30 % to 40 %. The share of electric steel making is likely to increase also in the future.

If it is assumed that the share of electric steel making is 45 % of the total production in 2010, the production of electric crude steel would be about 81.1 Mt, if the total growth rate for the whole iron and steel sector is 1 % per year during the same period. The corresponding figure for crude steel produced by the blast furnace route would then be about 99.1 Mton. Using the model results for specific energy use, it is possible to estimate the effect on the energy consumption for a BaU scenario. This would give total energy consumption for production of *crude steel* (electric steel making and blast furnace route taken together) of about 2104 PJ, which is a decrease of 6-7 % compared with 2000. If the electric steel making share were kept at the same level during the same period (40 %) the corresponding decrease would be 1,4 %. The same exercise was done for CO_2 emissions, assuming 45 % electric steel making in 2010. The total CO_2 emissions would then change from 171.5 Mton in 2000 to 159.6 Mton in 2010, which is a decrease of 6-7 %. The results clearly illustrate the important effect of an increased share of electric steel making in the sector on the total energy savings and CO_2 emissions.

The main results from the TEA modelling concerns the effect of increased taxation and LTAs on CO_2-emissions. The results show clearly that the increase in potential for energy savings and CO_2-emission reduction under the different tax scenarios is insignificant compared to the no-tax scenario. The reason is that all the assumed energy savings are already in itself very profitable for the companies.

The additional costs under the tax scenarios will probably be regarded as unreasonably high compared to the CO_2 reductions achieved. A consequence of the tax scenarios would rather be reductions of production capacity and closure of production sites.

The future use of energy and CO_2 emissions in the EU15 iron and steel sector will be influenced to a great deal by the share of electric steel making, which depend on the market situation for steel scrap. If the share of electric steel making continues to increase with the same rate as during 1990-2000, the specific energy use and specific CO_2 emissions will decrease significantly. However availability of scrap will of course limit the share of electric steel making.

Other structural changes within the EU15 iron and steel industry, such as closure of non-profitable sites with high specific energy consumption, will also contribute to decreasing the specific energy use and specific CO_2 emissions. On the other hand, the model is overestimating the reduction of energy consumption and CO_2 emission. In spite of the fact that most of the new energy saving technologies are very profitable all of them will for different reasons not be implemented to full extent. Our estimate is therefore that in a forecast the specific reduction of energy consumption per ton has to be reduced by 20 %. Taking all aspects into account we consequently foresee a decrease of specific CO_2 emissions of around 0.8 % per year.

4.3 Non-ferrous metals

Modelling of such a complex system as the non-ferrous metal industry makes simplifications necessary. Moreover uncertainty of data has to be taken into account. In some cases, data is also not complete. Therefore the saving potential calculated in the following can only be seen as a estimate and does not ensure a transcription of reality. What modelling results can do is to give a trend for future development of the whole system. Thus, the general comparison of business as usual development with the development under LTA or tax should be valid and also the conclusions given below are expected to be rather robust.

4.3.1 Aluminium production

An overview on the different routes for aluminium production is given in Figure 4-3. The technology and investment alternatives considered for each process are described in more detail in the material volume. When analysing the aluminium production using the simulation model, CO_2 emissions are found to increase from 19.0 Mt in 2000 to 20.4 Mt in 2010 (cf.

Table 4-7). In the same period, the primary energy consumption increases from 484 PJ to 534 PJ. Thereby a growth in total demand of 3 % p. a. has been assumed, corresponding to a growth in primary aluminium production of about 1 % p. a. These growth rates correspond to what has been historically observed on average during the period 1992 to 2001. For alumina production, no growth is assumed, since new production capacities are expected to be installed outside EU. Also for primary aluminium, no greenfield plant construction is expected during the coming years in the EU, yet revamping of existing plants will both increase energy efficiency and capacity.

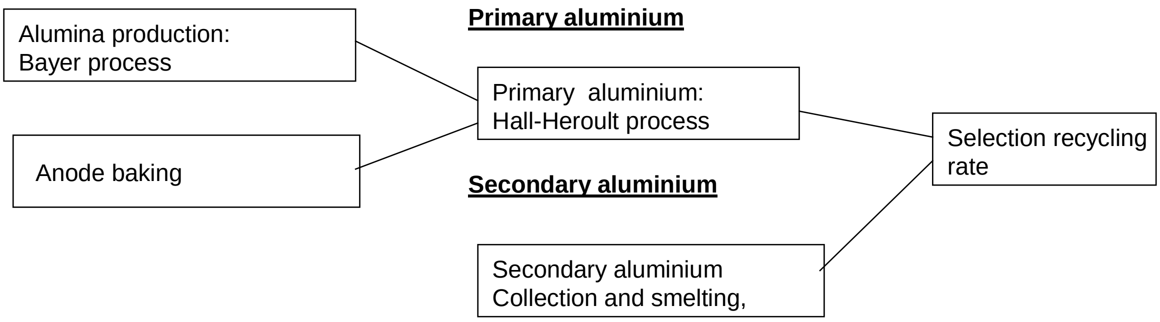

Figure 4-3: Overview on aluminium production

The major energy consuming process in aluminium production is the Hall-Heroult process for electrolysis of primary aluminium. Here energy-related CO_2 emissions are expected to increase from 12.8 Mt in 2000 to 13.6 Mt in 2010. The decrease in specific energy use and specific CO_2 emissions (cf. Table 4-8) occurring in primary production is mainly due to the already mentioned revamp operations, including notably the conversion of existing Soderberg and SWPB cells to Point-feed Prebake Technology. Further contributions come from improved process control, whereas no impact is expected in the time horizon considered from advanced cathodes (wettable cathode etc.) and inert anodes.

Reductions in specific energy use and CO_2 emissions occur also in secondary smelting, notably through the increased efficiency of furnaces and in the alumina production, where new investments in State of the art Bayer process, fuel switching from heavy fuel oil to natural gas and the replacement of rotary kilns by fluidised bed kilns lead to considerable emission decreases.

For the decrease in overall energy intensity, the increased recycling rate is of primary importance. The increase from an average 49 % in 2000 to 59 % in 2010 leads to a growth in secondary aluminium production by more than 60 % in the same period. At the same time the growth in primary aluminium production is dampened and specific emissions decrease on average by about 20 %.

In the LTA and tax scenario, especially some more investment in improved furnaces for secondary aluminium occurs and fuel switching in alumina production is intensified, but the effect on overall energy use and emissions is limited. On the other hand a considerable impact on production costs is expected, if a CO_2 tax is introduced (cf. Table 4-9).

Table 4-7: Aluminium: production, energy consumption and emissions 2000 - 2010

	Production volume (Mt)		**Primary energy use (PJ)**			**Total CO2 emissions (Mt)**		
	2000	2010	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Alumina Absolute figures	4.7	4.7	63.9	55.8	55.4	3.9	3.2	3.1
Change in %		*+0.0*		*-12.7*	*-13.3*		*-19.5*	*-20.0*
Primary Aluminium Absolute figures	2.4	2.6	356.7	378.3	377.8	12.8	13.6	13.6
Change in %		*+9.6*		*+6.1*	*+5.9*		*+6.2*	*-6.1*
Secondary Aluminium Absolute figures	2.3	3.6	63.5	99.9	97.3	2.3	3.6	3.5
Change in %		*+60.2*		*+57.2*	*+53.1*		*+57.2*	*+53.1*
Total **Absolute figures**	**4.6**	**6.2**	**484.2**	**534.0**	**530.6**	**19.0**	**20.4**	**20.2**
Range of variation	-	-		(527.2 – 540.8)	(522.8 – 539.3)		(20.1 - 20.7)	(20.0 – 20.6)
Change in %		***+34.4***		***+10.3***	***+9.6***		***+7.0***	***+6.3***

Table 4-8: Aluminium: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use (GJ/t)			**Specific CO2 emissions (t/t)**		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Alumina Specific figures	13.6	11.9	11.8	0.84	0.67	0.67
Change in %		*-12.7*	*-13.3*		*-19.5*	*-20.0*
Primary Aluminium Specific figures	152.0	146.8	146.	5.47	5.28	5.28
Change in %		*-3.5*	*-3.5*		*-3.3*	*-3.3*
Secondary Aluminium Specific figures	28.2	27.7	27.0	1.01	0.99	0.97
Change in %		*-1.7*	*-4.3*		*-1.7*	*-4.3*
Total **Specific figures**	**105.3** [a]	**86.4** [a]	**85.8** [a]	**4.14**[a]	**3.29**[a]	**3.27**[a]
Range of variation		(85.3 – 87.5)	(84.6 – 87.3)		(3.25 – 3.34)	(3.23 - 3.33)
Change in %		*-17.9*	*-18.5*		*-20.4*	*-20.9*
[a] per t of aluminium						

Table 4-9: Aluminium: Additional costs of CO_2 abatement for industry

	Additional costs (2000 – 2010) for industry [bill. €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	0.04	2.5
Range of variation	(0.01 – 0.04)	(1.1 – 7.6)
Change in % vs. reference scenario	*+0.1*	*+12.9*

4.3.2 Copper production

An overview on copper production is shown in Figure 4-4. The modelling results for energy use and CO_2 emissions are summarised in Table 4-10 and Table 4-11. In Table 4-10, also the development of production quantities is summarised. The additional costs for industry are given in Table 4-12.

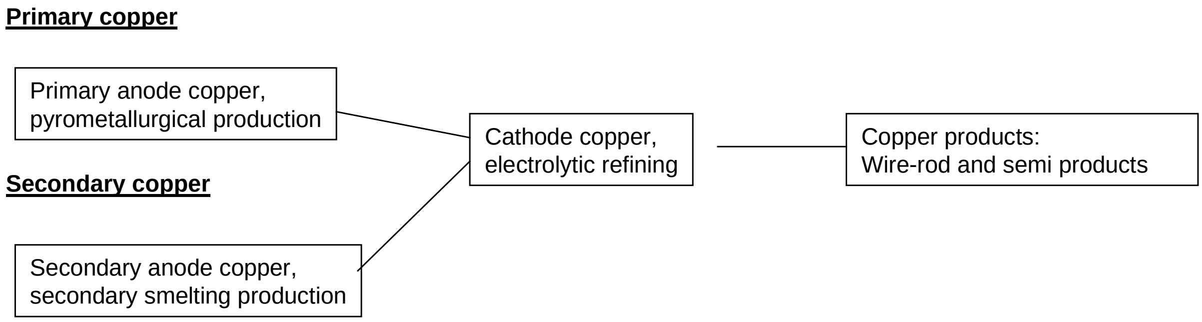

Figure 4-4: Overview on copper production

Table 4-10: Copper: production, energy use and CO_2 emissions 2000 to 2010

	Production volume [Mt]		**Primary energy use** [PJ]			**Energy related CO2 emissions** [Mt]		
	2000	**2010**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**
Primary anode copper Absolute figures	841.6	977.1	10.52	11.09	11.05	580.2	646.4	623.6
Range of variation				(11.04-11.14)	(11.00-11.10)		(643.3-649.4)	(620.7 – 626.5)
Change in %		*16.1*		*7.0*	*5.0*		*6.0*	*3.5*
Secondary anode copper Absolute figures	308.3	325.7	3.33	3.29	3.25	242.3	247.40	244.0
Range of variation				(3.27-3.31)	(3.21 – 3.28)		(245.9 – 248.9)	(240.7 – 247.3)
Change in %		*5.6*		*-1.3*	*-2.7*		*0.9*	*0.7*
Cathode copper Absolute figures	2000.0	2277.8	7.40	8.20	8.19	265.5	294.3	293.9
Range of variation				(8.10 – 8.30)	(8.09-8.28)		(290.7-297.9)	(290.4-297.3)
Change in %		*13.2*		*10.6*	*5.6*		*5.6*	*5.4*
Copper semi products Absolute figures	2507.0	2749.4	35.85	33.68	33.58	906.4	1329.7	1324.4
Range of variation				(33.60–33.76)	(33.50–33.65)		(1327.7-1331.7)	(1322.4-1326.4)
Change in %		*10.5*		*0.7*	*0.3*		*0.2*	*0.2*
Copper wirerod Absolute figures	2525.9	2792.6	6.82	7.54	7.54	307.8	340.6	340.6
Range of variation				(7.48-7.60)	(7.48-7.60)		(337.9-343.3)	(337.9-343.3)
Change in %		*10.5*		*4.8*	*4.8*		*5.8*	*5.8*
Total Absolute figures			**63.92**	**63.77**	**63.59**	**1802.3**	**2856.5**	**2826.4**
Range of variation				(63.76-63.77)	(63.57-63.60)		(2855.5-2857.4)	(2825.6-2827.2)
Change in %				*0.6*	*0.3*		*1.5*	*0.1*

Table 4-11: Copper: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use (GJ/t)			Specific CO2 emissions (t/t)		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Primary anode copper Specific figures	12.5	11.4	11.3	0.69	0.66	0.64
Range of variation		(11.3-11.4)	(11.2-11.4)		(0.66-0.67)	(0.64-0.64)
Change in %		*-9.2*	*-9.5*		*-4.1*	*-7.4*
Secondary anode copper Specific figures	10.8	10.1	10.0	0.78	0.76	0.75
Range of variation		(10.0 - 10.2)	(9.8 - 10.1)		(0.75-0.76)	(0.74-0.76)
Change in %		*-6.1*	*-7.5*		*-2.9*	*-4.2*
Cathode copper Specific figures	3.7	3.6	3.7	0.13	0.13	0.13
Range of variation		(3.6)	(3.6-3.7)		(0.13-0.13)	(0.13-0.13)
Change in %		*-2.2*	*-2.2*		*-2.2*	*-2.3*
Copper semi products Specific figures	14.3	12.3	12.2	0.56	0.48	0.48
Range of variation		(12.2-12.3)	(12.1-12.2)		(0.48-0.48)	(0.48-0.48)
Change in %		*0.3*	*0.2*		*-14.5*	*-14.8*
Copper wirerod Specific figures	2.7	2.7	2.7	0.12	0.12	0.12
Range of variation		(2.7)	(2.7)		(0.12-0.12)	(0.12-0.12)
Change in %		*0.1*	*0.1*		*0.5*	*0.5*

Table 4-12: Copper: additional costs for industry 2000 - 2010

	Additional costs (2000 – 2010) for industry [M €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total Range of variation	30.0 (29.9-30.1)	942 (939 – 946)
Change in %	0.3-0.4	9.9 - 10.8

The main findings can be summarised as follows:

1. Within these scenarios, the *main energy and CO_2 emission saving potential* for copper production is given for the production of primary anode copper and copper semi production.
2. For *primary anode copper*, the Outokumpu process which is already very energy efficient is mostly used for smelting. Further energy savings can be mainly achieved by general energy saving measures like improved management etc.
3. Energy savings for *secondary anode copper* can be mainly achieved by using measures like improved management or the use of recuperative burners for the shaft furnace and partially for the TBRC furnace for smelting.

4. Copper *semis production* has a high energy saving potential by applying continuos casting instead of discontinuous casting.
5. *Copper cathode and copper wirerod* production have only low energy saving potential. In copper cathode production, the Mount ISA process is mostly used, which is already very energy efficient. For Copper wirerod the Contirod and Southwire processes are applied, which are also very energy efficient and have very similar energy consumption and costs.

4.3.3 Lead production

An overview on lead production is sketched in Figure 4-5. The modelling results are summarised hereafter. In Table 4-13, the modelling inputs for production development and the results for energy consumption and CO_2 emissions are shown. The development of specific energy consumption and CO_2 emissions is given in Table 4-14. The additional costs for industry (2000-2010) are summarised in Table 4-15.

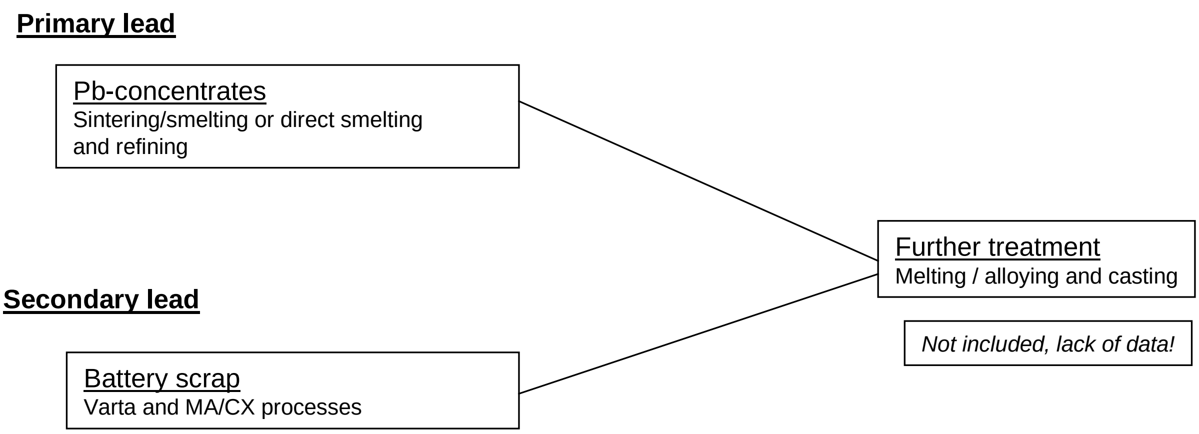

Figure 4-5: Overview on lead production

The following conclusions can be drawn:

1. Within these scenarios the *main energy and CO_2 emission saving potential* for lead production is given for the production of primary lead by smelting
2. For *primary lead smelting*, the QSL process which is very energy efficient will replace the shaft furnace. Also the Kivcet process will have an increasing production share.
3. The TBRC furnace is most economic for secondary lead production from batteries; its wider application will increase *primary energy use while* CO_2 emissions remain nearly stable.

Table 4-13: Lead: production, energy consumption and emissions 2000 - 2010

	Production volume [kt]		**Primary energy use** [PJ]			**Total CO2 emissions** [Mt]		
	2000	2010	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Primary lead Absolute figures	564.0	539.2	5.64	4.61	4.61	0.395	0.326	0.325
Range of variation				(4.60-4.62)	(4.60-4.61)		(0.326-0.327)	(0.325-0.326)
Change in %		*-4.4*		*-18.3*	*-18.4*		*-17.3*	*-17.4*
Secondary lead from batteries Absolute figures	1046.7	1260.7	6.28	7.69	7.67	0.365	0.475	0.473
Range of variation				(7.58-7.80)	(7.55-7.78)		(0.469-0.481)	(0.467-0.479)
Change in %		*20.4*		*-3.6*	*-3.6*		*19.8*	*19.2*
Total lead Absolute figures	1610.7	1799.8	11.87	12.30	12.27	0.791	0.801	0.798
Range of variation				(12.42-12.18)	(12.39-12.15)		(0.795-0.808)	(0.792-0.805)
Change in %		*11.7*		*4.0*	*3.0*		*0.5*	*3.5*

Table 4-14: Lead: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use [GJ/t]			**Specific CO2 emissions** [t/t]		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Primary lead Specific figures	10.0	8.6	8.6	0.70	0.60	0.60
Range of variation		(8.5-8.6)	(8.5-8.6)		(0.60-0.61)	(0.60-0.61)
Change in %		-14.1	-14.2		-13.0	-13.2
Secondary lead from batteries Specific figures	6.0	6.1	6.1	0.38	0.37	0.37
Range of variation		(6.0-6.2)	(6.0-6.2)		(0.37-0.38)	(0.37-0.38)
Change in %		1.3	1.0		-1.8	-2.3

Table 4-15: Lead: additional costs for industry

	Additional costs (2000 – 2010) for industry [bill. €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	864	1,250
Range of variation	(852-876)	(1,234-1,279)
Change in %	27-31	40-44

4.3.4 Zinc production

An overview on zinc production is given in Figure 4-6.

Primary Zinc

Mixed Zn/Pb concentrates:
Pyrmetallurgical: ISF smelting and New Jersey distillation

Zn sulphide and other concentrates
Hydrometallurgical route

Secondary Zinc

Production of ZnO from dust
Waelz kiln

Other scrap: *Not considered, high variety*

Figure 4-6: Overview on zinc production

Table 4-16 gives an overview on the assumed production growth for 2000-2010. Also it provides the modelling results for energy consumption and CO_2 emissions

Table 4-16: Zinc: production, energy consumption and emissions 2000 - 2010

	Production volume [kt]		**Primary energy use** [PJ]			**Total CO2 emissions** [Mt]		
	2000	2010	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Primary Zinc from Pb/Zn con. (ISF) - Absolute figures	84.0	85.7	4.46	4.38	4.37	0.33	0.32	0.32
Range of variation				(4.378-4.383)	(4.362-4.372)		(0.323-0.323)	(0.322-0.323)
Change in %		*2.0*		*-1.8*	*-2.1*		*-1.8*	*-1.9*
Primary zinc. hydromet. Route - Absolute figures	1664.2	1786.1	73.73	76.71	76.68	2.64	2.75	2.75
Range of variation				(76.597-76.829)	(76.562-76.794)		(2.748-2.756)	(2.746-2.754)
Change in %		*7.2*		*-0.3*	*-0.4*		*-0.3*	*-0.4*
Secondary zinc oxide from dust Absolute figures	45.1	52.3	1.31	1.43	1.42	0.11	0.12	0.12
Range of variation				(1.402-1.465)	(1.397-1.452)		(0.121-0.127)	(0.121-0.125)
Change in %		*16.1*		*-4.8*	*-4.6*		*3.4*	*-4.7*
Total zinc Absolute figures			44.49	82.53	82.48	3.09	3.20	3.20
Range of variation				(82.382-82.672)	(82.331-82.628)		(3.192-3.206)	(3.189-3.203)
Change in %				*1.5*	*6.0*		*6.0*	*5.5*

Table 4-17 gives an overview on the development of specific energy use and specific CO_2-emissions. The additional costs for industry are given in Table 4-18.

Table 4-17: Zinc: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use [GJ/t]			Specific CO2 emissions [t/t]		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Primary Zinc from Pb/Zn con. (ISF)						
Absolute figures	53.1	51.1	51.0	3.91	3.77	3.75
Range of variation		(51.1)	(50.9-51.0)		(3.77-3.77)	(3.75-3.76)
Change in %		*-3.8*	*-4.0*		*-3.7*	*-4.0*
Primary zinc. hydromet. Route						
Absolute figures	44.3	43.0	43.0	1.59	1.54	1.54
Range of variation		(42.9-43.0)	(42.9-43.0)		(1.54-1.54)	(1.54-1.54)
Change in %		*-3.0*	*-3.0*		*-3.0*	*-3.1*
Secondary zinc oxide from dust						
Absolute figures	29.1	27.4	27.3	2.52	2.37	2.26
Range of variation		(26.8-28.0)	(26.7-27.9)		(2.42-2.32)	(2.31-2.21)
Change in %		*-5.8*	*-5.9*		*-5.8*	*-5.9*

Table 4-18: Zinc: additional costs for industry

	Additional costs (2000 – 2010) for industry [M€]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	0.40	1018
Range of variation	(0.40-0.41)	(1009-1027)
Change in % vs. reference scenario	*+0.5*	*+29-31%*

The main findings are:

1. Within these scenarios the *main energy and CO_2 emission saving potential* for zinc production would be given for the production of *primary zinc*, *hydrometallurgical route*, because of its high energy consumption. Existing methods are already very energy efficient, therefore only improvements are possible (e.g. H2 diffusion anodes, improved electrolysis material).
2. For *primary zinc from Zn/Pb concentrates* always the Imperial smelting furnace is used, for which improvements like heat recovery can be applied.
3. Energy savings for *secondary zinc* can be mainly achieved in the production of zinc oxide from zinc dust by general improvement measures like improved management.
4. The modelling results show no significant change of the potential for energy savings and CO_2 emission reductions *under tax* compared to the results of the business as usual scenario.

4.3.5 Overall results and comments

In all production lines of the non-ferrous industry, the energy savings and CO_2 emission reductions *under a tax* are very similar compared to the results of the reference scenario. The same finding is obtained also for LTAs. However, there it has to be remembered that the *business as usual scenario* simulates investment decisions of industry based only on *quantitative criteria* such as investment, operating and energy costs. Other investment criteria like e.g. quality of products or barriers like potential risks or lack of information are not considered in this quantitative model. Therefore the energy saving potential for the reference scenario would probably not be reached in reality. The same may apply if a tax is introduced, because it has no influence on non-monetary investment decision factors. Overall very limited further energy saving potential could be expected in the copper, lead and zinc sectors by introducing a tax.

An *LTA* on the other hand, because it also affects the non-monetary factors like lack of information or other barriers, is to be expected to achieve a higher energy saving potential than a tax. It could be expected that with an LTA at least the business as usual scenario could be achieved by addressing existing barriers to technology implementations.

4.4 Pulp & paper

Figure 4-7 gives an overview on pulp & paper production.

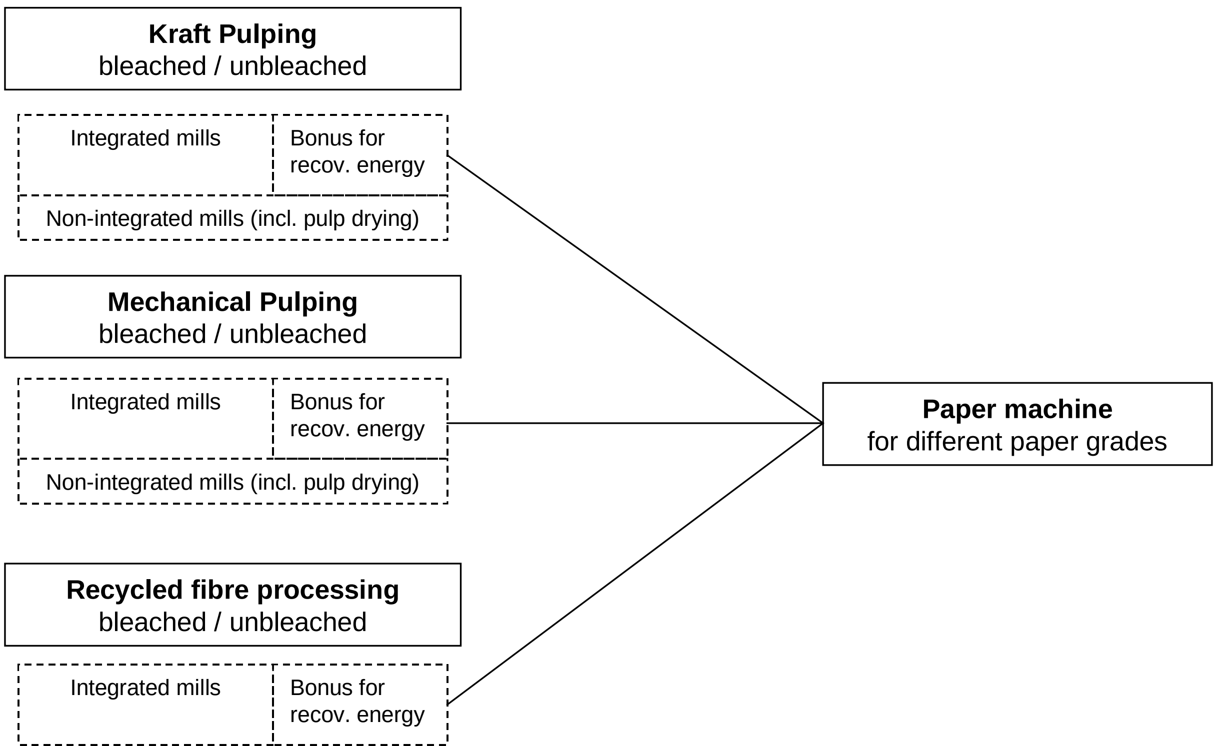

Figure 4-7: Overview on pulp & paper production

The modelling results are summarised hereafter. Table 4-19 shows the results obtained for energy consumption and CO_2 emissions. Thereby throughout a production growth of 1 % p.a. has been assumed.

Table 4-19: Pulp & paper: production, energy consumption and emissions 2000 - 2010

	Production volume [kt]		**Primary energy use** [PJ]			**Total CO2 emissions** [Mt]		
	2000	2010	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Kraft pulp Absolute figures	19.4	21.4	343.7	355.9	354.6	30.93	31.79	31.70
Range of variation				(351.4-360.5)	(350.4-358.8)		(31.33-32.24)	(31.33-32.07)
Change in %		*10.6*		5.5	3.0		1.5	4.0
Mechanical pulp Absolute figures	0.27	0.30	5.41	5.34	5.30	0.20	0.19	0.19
Range of variation				(5.27-5.40)	(5.25-5.35)		(0.191-0.196)	(0.191-0.196)
Change in %		*10.6*		-1.4			-1.3	-1.5
RCF Absolute figures	38.2	43.1	133.7	144.45	144.40	5.43	5.87	5.86
Range of variation				(143.7-145.2)	(143.6-145.2)		(5.84-5.89)	(5.83-5.89)
Change in %		*10.6*		6.5	6.5		6.5	6.5
Paper Absolute figures	85.1	94.2	1,174	1,172	1,152	85.34	83.34	80.19
Range of variation				(1,162-1,183)	(1,141-1,164)		(82.83-83.85)	(79.06-81.31)
Change in %		*10.6*		0.1	-1.8		-2.4	-6.1
Total p&p production Absolute figures			1,657	1,677	1,656	121.9	120.9	117.9
Range of variation				(1,661-1,693)	(1,640-1,673)		(119.9-121.9)	(116.4-119.4)
Change in %				4.5	0.5		-0.9	-3.3

Table 4-20 gives an overview on the development of specific energy use and specific CO_2-emissions. The additional costs for industry under the various scenarios are indicated Table 4-21.

The following points should be highlighted:

1. Data are not complete and especially investment and operating costs are for most technologies not available. Moreover modelling of such a complex system as pulp and paper production makes simplifications necessary. Therefore the calculated saving potential can only be seen as an estimate and does not ensure a transcription of reality. What modelling results can do, is to give a trend for future development of the whole system. Thus, the general comparison of business as usual development with the development under LTA or tax and therefore also the conclusions given below are valid.
2. Within these scenarios, the *main energy and* CO_2 *emission saving potential* for pulp and paper production is given for the production of Kraft pulp and the paper machine.

Table 4-20: Pulp & paper: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use [GJ/t]			Specific CO2 emissions [t/t]		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Kraft pulp						
Specific figures	17.7	16.6	16.5	0.00	0.00	0.00
Range of variation		(16.4-16.8)	(16.3-16.7)		(0.00-0.00)	(0.00-0.00)
Change in %		-6.3	-6.6		-7.0	-7.4
Mechanical pulp						
Specific figures	19.9	17.8	17.7	0.72	0.64	0.64
Range of variation		(17.5-18.0)	(17.5-17.9)		(0.64-0.65)	(0.64-0.65)
Change in %		1.1	1.2		1.1	1.1
RCF processing						
Specific figures	3.5	3.4	3.4	0.14	0.14	0.14
Range of variation		(3.3-3.4)	(3.3-3.4)		(0.14-0.14)	(0.14-0.14)
Change in %		-1.7	-1.7		-1.7	-1.7

Table 4-21: Pulp & paper: additional costs for industry

	Additional costs (2000 – 2010) for industry [bill. €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	0.13	38.8
Range of variation	(0.08 - 0.18)	(38.7 – 38.9)
Change in % vs. reference scenario[a]	*+0.3*	*+93.5*

[a] not all costs included in the scenarios, in most cases no investment costs and generally no operation costs, therefore the percentages are presumably to high

3. For *Kraft pulp* significant energy savings can be achieved in the cooking stage (modified cooking) and the recovery line (improvements of evaporation).
4. Energy savings for *mechanical pulping* can for example be achieved by improvements in the TMP process like heat recovery, improved refinery etc.
5. RCF processing has only little improvement potential by general energy saving measures like improved energy monitoring.
6. In the paper machine the highest saving potentials are in stock preparation, forming, press and drying section. For these, new energy efficient technologies like e.g. Condebelt drying but also general improvement measures like heat recovery can be effective.
7. Again, the modelling results show no significant change of the potential for energy savings and CO_2 emission reductions *under tax* compared to the results of the business as usual scenario.

4.5 Chemical industry

In the following, the results on energy efficiency improvements and Greenhouse Gas emission reductions in the Chemical industry (corresponding to NACE sector 24) are discussed. The focus has been on selected basic chemical processes which are mostly part of the NACE subsector 24.1 manufacture of basic chemicals. This subsector contributes about 37 % to the total production value of the chemical industry /CEFIC 2001/. Within this subsector, a large variety of products, especially a broad range of petrochemicals and inorganic chemicals is fabricated. However, the main energy consumption occurs in the production of a limited number of basic chemicals (cf. material volume). These are summarised in Table 4-22 in six broad categories. The corresponding production values have been taken from various sources /CEFIC 2002, CIRFS 2002, CEH 2002, Eurostat 2002, Methanol 2002/, since the official Eurostat data were found to comprise many lacunas. For the growth rates, own estimates have been made based on forecasts by /VKI 2002, CEH 2002/ and others.

Table 4-22: Chemical industry: production, energy consumption and emissions 2000 - 2010

	Production volume [Mt]		**Primary energy use** [PJ]			**Total CO2 emissions** [Mt]		
	2000	2010	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Inorganic base chemicals Absolute figures	40.4	45.5	710	677	675	34.6	32.6	32.5
Change in %		*12.7*		*-4.7*	*-4.9*		*-5.8*	*-6.0*
Lower Olefins Absolute figures	34.3	43.5	601	723	723	30.1	36.2	36.2
Change in %		26.8		20.4	20.4		20.4	20.4
Polymers Absolute figures	18.8	26.2	182	237	236	9.1	11.3	11.2
Change in %		*39.4*		*29.9*	*29.6*		*24.8*	*24.5*
Other organic subst. Absolute figures	12.3	12.9	79	73	73	5.5	4.9	4.9
Change in %		*5.1*		*-7.5*	*-8.0*		*-11.0*	*-7.7*
Manmade fibres Absolute figures	3.6	3.8	153	145	145	8.7	7.6	7.6
Change in %		*5.7*		*-5.4*	*-5.4*		*-12.5*	*-8.8*
Remaining chemical industry (prod. in bill. €) Absolute figures	214.0	287.6	1306	1345	1340	48.4	50.2	49.9
Change in %		*34.4*		*2.9*	*2.6*		*3.7*	*3.2*
Total			**3032**	**3200**	**3193**	**136.4**	**142.8**	**142.4**
Range of variation				(3181 – 3206)	(3176- 3204)		(141.9-143.2)	(141.6-143.0)
Change in %				*5.5*	*5.3*		*4.7*	*4.4*

For the 25 base chemicals analysed in detail, the major process routes and the relevant energy saving potentials have been considered (cf. material volume). The focus is thereby throughout on energy-related GHG emissions, i.e. CO_2. According to /Hendriks et al. 1998/, other greenhouse gas emissions are of considerable importance in the chemical industry. Especially, in the production of adipic acid and nitric acid, important nitrous oxide (N_2O) emissions occur, which are equivalent to 109 Mt CO_2 emissions. Also the emissions of hydrofluorocarbons (HFC) reported by /Harnisch and Hendriks 1998/ are mostly stemming from the chemical industry, these correspond to about 31 Mt CO_2.

The results for energy use and CO_2 emissions are summarised in Table 4-22. The production processes analysed in detail cover about 60 % of the energy consumption (excluding feedstocks) in the EU chemical industry. The primary energy use is expected to increase by about 5.5 % in the period 2000 to 2010 whereas CO_2 emissions are expected to increase less, with a total growth of less than 5 %. This is due to fuel switching in some processes. The increases calculated for energy use and CO_2 emissions are much lower than the corresponding production growth, which ranges from 5 % to 40 % in volume for the different product groups. Correspondingly the energy and CO_2 intensities for all product groups decrease, as shown in Table 4-23. These figures have however to be considered with great care, because they include also the effect of structural changes within the product groups. This is particularly true in the *remaining chemical industry*, where a shift towards high value derived chemicals is expected.

Table 4-23: Chemical industry: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use (GJ/t)			Specific CO2 emissions (t/t)		
	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)	2000	2010 (Reference scenario)	2010 (LTA/tax scenario)
Inorganic base chemicals						
Specific figures	17.6	14.9	14.8	0.86	0.72	0.71
Change in %		*-15.4*	*-15.6*		*-16.4*	*-16.6*
Lower Olefins						
Specific figures	17.5	16.6	16.6	0.88	0.83	0.83
Change in %		*-5.0*	*-5.0*		*-5.0*	*-5.0*
Polymers						
Specific figures	9.7	9.0	9.0	0.48	0.43	0.43
Change in %		*-6.8*	*-7.1*		*-10.5*	*-11.1*
Other organic substances						
Specific figures	6.4	5.7	5.6	0.45	0.38	0.38
Change in %		*-12.0*	*-12.5*		*-15.3*	*-15.9*
Manmade fibres						
Specific figures	42.2	37.8	37.8	2.41	1.99	1.99
Change in %		*-10.5*	*-10.5*		*-17.2*	*-17.2*
Remaining Chemical industry						
Specific figures [per k€]	6.1	4.7	4.7	0.23	0.17	0.17
Change in %		*-23.4*	*-23.7*		*-22.8*	*-23.2*

Among the product groups considered in detail, only lower olefins and polymers exhibit an increase in absolute emissions. These are in both cases, For some The strongest decrease of energy use and emissions is observed in the production of man-made fibres – a product group where almost no output growth is expected except for a few products like polypropylene. But also in the production of lower olefins, energy use and emissions are expected to decrease substantially, especially through the use of improved cracking processes. On the other hand, the production of polymers causes increased resource use, given notably the high production growth in that field.

According to the results, less than one percentage point of additional emission reduction could be achieved at marginal CO_2-emission reduction costs of less than 50 €/t. This would mean that most of the energy efficiency technologies available to date are either cost-effective on their own or far from cost effectivity. However, these results have to be treated with care and should be scrutinised in more detail, particularly through further discussions with experts.

Table 4-24: Chemical industry: additional costs of CO_2 abatement for industry

	Additional costs (2000 – 2010) for industry (in bill €)	
	2010 (with LTAs)	**2010 (with tax)**
Total **Absolute figures**	0.09	19.8
Range of variation	(0.01 – 0.09)	(8.3 – 60.5)
Change in % vs. reference scenario	+0.1	+12.9

4.6 Cement production

Cement production consists of the three main process steps raw meal preparation, clinker production and grinding. The production of cement has remained fairly stable in the EU during the last decade and therefore also no output growth is assumed for the period 2000 to 2010 (cf. Table 4-25). Production of clinker and raw meal will even decline somewhat since a decrease of the cement to clinker ratio is part of the possible measures to increase energy efficiency. Energy use and CO_2 emissions are expected to be reduced considerably between 2000 and 2010 according to the model calculations. CO2-emissions decrease from 54.8 Mt in 2000 to 44.7 Mt in 2010 (cf. Table 4-25), whereas the primary energy consumption is reduced from 743.7 PJ to 664.1 PJ. Major improvements occur thereby in the clinker production, which is at the same time the most energy consuming production step in cement manufacturing. Notably the replacement of old kilns (especially wet kilns and long dry kilns) and an increased use of waste as fuel contributes to emission reduction. The benefits of using waste fuels in cement kilns have thereby been evaluated using the methodology proposed by /CEMBUREAU 1999/, which is based on an LCA approach for different system alternatives.

Conversion of older kilns to more modern concepts such as precalciner preheater kilns, advanced combustion systems and improvements in the cooling process also contribute to the substantial emission reduction in the clinker production.

Improvements in grinding include notably the use of improved classifiers and better grinding processes, most substantial is however the increased use of additives. In raw meal preparation far from all proposed measures are cost effective, but through the use of roller mills and high efficiency classifiers energy efficiency is somewhat lowered (cf. Table 4-26).

Table 4-25: Cement: production, energy use and CO_2 emissions 2000 to 2010

	Production volume [Mt]		**Primary energy use** [PJ]			**Energy related CO2 emissions** [Mt]		
	2000	**2010**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**
Raw material prepar. Absolute figures	151.6	149.2	31.7	30.1	30.0	1.1	1.1	1.1
Change in %		*-1.6*		*-4.8*	*-5.3*		*-4.8*	*-5.3*
Clinker production Absolute figures	151.6	149.2	631.3	556.9	552.8	50.8	40.9	40.5
Change in %		*-1.6*		*-11.1*	*-12.4*		*-19.5*	*-20.2*
Grinding Absolute figures	189.5	189.5	80.8	77.1	77.1	2.9	2.8	2.8
Change in %		*+0.0*		*-4.6*	*-4.6*		*-4.6*	*-4.6*
Total Absolute figures	189.5	189.5	743.7	664.1	660.3	54.8	44.7	44.4
Range of variation	-	-		(657.2 - 684.9)	(657.2 - 671.5)		(44.2 – 46.5)	(44.2 – 45.3)
Change in %		*+0.0*		*-10.7*	*-11.2*		*-18.4*	*-19.1*

Table 4-26: Cement: specific energy use and specific CO_2 emissions 2000 to 2010

	Specific energy use [GJ/t]			**Specific CO2 emissions** [t/t]		
	2000	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**	**2000**	**2010 (Reference scenario)**	**2010 (LTA/tax scenario)**
Raw material prepar. Specific figures	0.21	0.20	0.20	0.007	0.007	0.007
Change in %		*-3.3*	*-3.8*		*-3.3*	*-3.3*
Clinker production Specific figures	4.16	3.73	3.71	0.33	0.27	0.27
Change in %		*-10.4*	*-11.0*		*-18.2*	*-19.0*
Grinding Specific figures	0.43	0.41	0.41	0.015	0.015	0.015
Change in %		*-4.6*	*-4.6*		*-4.6*	*-4.6*
Total Specific figures	3.92	3.50	3.48	0.29	0.24	0.23
Range of variation		(3.47 - 3.61)	(3.47 –3.54)		(0.23 - 0.25)	(0.23 - 0.24)
Change in %		*-10.7*	*-11.2*		*-18.4*	*-19.1*

As in the other sectors, the introduction of LTAs or taxes has only a limited effect on energy use and emissions. According to the modelling results, some additional 0.7 % in emission reduction may be obtained. On the other hand, costs for industry will increase considerably under a tax scheme as shown in Table 4-27.

Table 4-27: Cement: Additional costs of CO_2 abatement for industry

	Additional costs (2000 – 2010) for industry [bill. €]	
	2010 (LTA scenario)	2010 (tax scenario)
Total	0.05	6.6
Range of variation	(0.01 – 0.13)	(4.0 – 14.0)
Change in % vs. reference scenario	*+0.4*	*52.1*

4.7 Key issues identified for LTAs at European level

In the model-based analysis of technical and economic potentials for energy efficiency improvement and CO_2 emission abatement, three points emerged repeatedly:

- The introduction of LTAs, CO_2 taxes or any other policy instrument will have most probably only a limited additional effect on energy efficiency improvements. This becomes apparent when, as done here, the policy intervention case is compared to a reference development which is *not* frozen efficiency. The large energy efficiency and emission abatement potentials highlighted in studies like /Haworth et al. 2000/ and /Hendriks et al. 2001a/ are always in comparison to a frozen efficiency case, which is not a realistic scenario. If cost effective measures (abatement costs below 0 €) are included in the baseline, then also in those studies the additional potential which can be activated through policy instruments decreases considerably.
- Since industry has only limited additional possibilities for reducing energy use and CO_2 emissions, the introduction of a CO_2 and/or energy tax will strongly affect the production costs of industry, without generating large additional emission reductions. If industry is exposed to strong international competition from countries outside the EU (as is e. g. the case for the aluminium industry), the introduction of energy or emission taxes will directly affect the competitiveness of the industry. The same is of course true for the introduction of auctioned certificates.
- Furthermore, the development of absolute energy consumption and CO_2 emission levels is according to the modelling results closely tied to the (assumed) development of production. Since there are only limited opportunities for reducing specific energy and emission intensities per t of output, severe absolute emission targets will limit economic growth in the sectors under study. In a world of uncertain growth expectations, industry has therefore clearly a strong preference for targets in terms of specific energy and emission intensities.

Of course, as any model, the approach used here has its limitations (cf. section 4.1.2). Since new, unknown technologies or those, for which the current knowledge is very limited, cannot be included in the model, the model might somewhat underestimate the impacts of policy instruments. But it is unlikely that a technology unkown today will reach a large market share in the mature industries considered here within 10 years. In the case of taxes or certificates, substitutions on the demand side may enhance somewhat the impact of the policy instruments – of course at the detriment of the industries under study. For LTAs on the other hand, the approach is likely to understate the impact given that it does not account for qualitative factors such as improved information availability or modified investment priorities.

5 Case studies for selected companies

The aim of the case studies is to evaluate the implementation of three long term agreements in Finland, Sweden and Germany at company level as well as the effects of the agreement. The actions and results of the 10 companies are analysed on case examples of energy intensive industry companies.

The objective is to monitor technical and other energy saving solutions in the different fields of company activities (production, logistics, real estate maintenance) and to compare the energy efficiency improvements at company level to national agreement schemes. In the following, the key results are given while detailed findings are included in the material volume.

5.1 Key influence on company level energy strategy

The energy strategies of energy intensive companies are strongly dependent on the national energy strategies and the electricity market, which affect the business environment. Companies are making decisions and choosing their strategies on the basis of these economical and political factors (cf. Table 5-1).

Table 5-1: Key influence on company level energy strategy

Key influence	Outcome	Reasons
National energy and climate strategies	Strategies and energy efficiency tools of the energy intensive companies have elements characteristic of national strategies.	• National energy strategy controls energy consumption structure, sets definition of energy policy and sets policy tools. • National climate strategy controls CO_2 emission structure, sets definition of CO_2 policy and sets policy tools. • These two areas are in linkage.
The electricity market	Energy intensive companies with a high share of electricity use did not consider alternative energy sources as an important element in their energy strategy.	• The open electricity market is a key-prevailing condition that companies face in energy procurement and consumption. • The results of the interview study indicate that companies recognised that the supply and security of electricity produced by alternative sources of energy, was not sufficient or secure enough for highly energy-intensive production. • The results reflect the fact that in open electricity markets companies do not have full possibilities to influence the CO_2-content of electricity.

The effects of the national energy and climate strategies on agreement schemes and company actions were apparent in all countries. For example in Sweden, alternative energy has less importance for energy intensive industry because of the electricity sources. CO_2-emissions of the national electricity production are already low, with the electricity originating mainly from nuclear and hydropower. However, the situation may change in the future as Sweden aims at out-phasing nuclear power. In addition to the above-mentioned factors, in Germany the energy strategies of companies in energy intensive industries build on a long tradition of energy saving measures supported and promoted by industry branch association activities.

Due to the open electricity markets, companies are concentrating on improving their energy efficiency as their main mean of cutting CO_2-emissions. When developing a portfolio of optimal policy instruments, including the LTA, the current market situation and national strategies have to be taken into account. These conditions will affect both companies operating in several countries and also potential European-wide LTA-schemes.

5.2 Driving forces for joining the LTA

The interview study illustrated that saving costs is one key driver for ensuring energy efficiency measures at a company-level. Therefore the key driver for joining the LTA is the opportunity to start cost-effective saving measures. Especially energy intensive companies operating on global markets are aware of the energy saving level of competitors, which is affecting their realisation of saving potential.

In addition to costs savings there are other key drivers for energy efficiency and joining LTA, such as environmental performance, stakeholder relations and legal requirements.

Environmental issues have been an important driver for investment decisions in production. Environmental issues can even override costs savings, if environmental rewards are high. On the basis of the interview study results, environmental concern has in some cases been the main reason for joining the LTA scheme in Sweden.

Many companies participating in the interview study considered stakeholders such as owners, customers and investors as one driving force. In Sweden the significance of customers and their enquiries was more visible than in other countries. The Swedish scheme also motivated companies by providing positive publicity and awards, for example energy labels and a yearly "EA Champion" award for best performance in energy efficiency. The interview study indicated that the importance of different stakeholders varies from country to country. In Germany insurance companies, banks and branch associations have been stronger drivers for joining LTA than customer demands.

In addition to stakeholders and improvement of external relations and communication, LTAs have also been considered as an internal tool. In Germany and Finland, LTA often helped in improving the energy soft facts. This means that the companies considered that with the LTA it was easier to motivate the entire organisation to promote energy saving and measures.

One key driving force for joining the LTA is the support mechanism for its implementation such as audit models or tools as well as financial and informational support. Well-defined and systematic support mechanisms ensure energy saving results quickly and effectively.

LTA can also support companies in fulfilling legal requirements or the decision in joining LTA could be in anticipation of future legislation related to CO_2 or energy efficiency. On the basis of interview study results, German companies were mostly driven by the legal requirement (Federal Emission Control Act of 1990) to deliver emission data regularly to the authorities. Furthermore, the industry branch association requires energy data for statistical and LTA reasons in Germany.

The main reasons for joining an LTA indicated in the interview study are shown in Table 5-2.

Table 5-2: Internal and external driving forces for joining an LTA

Internal driving forces	External driving forces
Cost savings	Customer demands
Promotion of energy efficiency	Following a branch/industry association initiative
Threat of unfavourable policy tools, promotion of realistic development and policy tools	Demonstration of responsible attitude, public expectations of a response to climate change issues, code of conduct
Cutting GHG-emission in a cost-effective and flexible means	Legal requirements and control of authorities

The results of the interview study emphasized that in promoting energy efficiency measures the LTA has functioned as one factor. However, there are many other factors that are affecting the energy efficiency measures, such as customer demands, technical development and changes in environmental awareness.

5.3 Involvement of different organisational levels

According to the interview study results, the role of top management is essential for engaging and committing the organization and for guaranteeing appropriate attention, investments, resources and actions. However, it is crucial for energy efficiency to have effective energy management to promote and implement energy saving measures.

Involvement of the whole organisation is summarised in Table 5-3 and explained below.

Table 5-3: Levels of organisation involved in the LTA

Level of organisation	Involvement
Top management	Strategic level decisions ensure attention, investment decision and resource allocation for energy efficiency measures.
Energy management	Energy management ensures the practical implementation and results of energy management system.
Personnel	Awareness and motivation of the employees ensures the functionality and therefore the results of the system.

In the Finnish agreement scheme top-management, usually the managing director, signs the agreement personally either at group or site level. This creates better awareness of management responsibility and interest in following up the actions. During the agreement period, top-management commitment can be considered high.

German companies that consider themselves as forerunners or high performance companies in terms of energy saving issues are strongly supported by the top management, even if they do not take part in the LTA implementation process by signing the agreements personally. Involvement of energy management is considerably higher than top-management.

Swedish EKO energi agreement has been a project-style agreement. This kind of agreement is unlikely to encourage companies to long-term energy saving investments and strategic top management involvement in the context of the LTA.

For any future LTA, top management involvement and commitment will most certainly be strategically more important and a key success factor of the agreement scheme.

5.4 Experience and actions

Results of the interview study illustrate the importance of systematic energy audits. Swedish and Finnish companies that have joined LTA schemes considered energy audit as the most important tool for finding new energy saving potential and prioritising investments.

In addition to the audits, action programs within the scope of the agreement were regarded as a valuable tool in successful implementation of LTA. Some of the companies estimated that LTA has been a key success factor in developing a detailed long-term action program for energy monitoring and efficiency. Table 5-4 presents audits in different LTA schemes and benefits in accordance with the interview study findings.

Table 5-4: Experiences and benefits of energy audits

LTA scheme	Combined experience, benefits
Finland Detailed audit models including models for production processes (analysis and audit) that are supported by the national energy agency Motiva Audit models of the companies **Germany** Audit models supported by industrial branches Audit models of the companies **Sweden** Audit model designed for Eko Energi scheme, which excludes production processes Audit models of the companies	• Provided new insight to energy use and helped to identify new savings potential • Clarified the overall view on energy use and linked it to everyday business processes • Contributed to the identification of the investment need for achieving a certain level of energy efficiency as well as the reduction costs for CO_2 • Site-specific audits and target setting was considered as important, because optimal energy efficiency solutions are often site-specific • Knowledge on BAT was improved • Quality assurance of the scheme and good expertise of energy consultants improved results • Energy audits, when conducted as a continuous process, could be incorporated into business processes and environmental and/ or quality audits and management • Different kinds of audit models were needed to serve the different kind of companies- sometimes company's own audit model was the most effective one • Industry branch or energy agency information and support was important in audits • Company cooperation was advantageous in developing practical solutions for factory-level actions • Audit scheme provided a possibility to measure and monitor energy efficiency

The interview study showed that the companies are able to point out positive implications and benefits of the LTA in general. However, to assess quantitative results, companies need to implement monitoring and reporting system if the national audit scheme or organisation supporting the scheme does not provide it. A well-functioning system is crucial in order to monitor both the identified saving potential and also the energy efficiency.

Many of the companies that joined the interview study were able to show precise energy saving statistics and had good monitoring and follow-up systems in place. The follow-up of the quantitative results is a prerequisite of the credible use of the LTA as a policy tool. LTA scheme should ensure that both company-level and energy agency/ governmental-level reporting is reliably and transparently organised.

5.5 Investments

The results of the interview study demonstrate that companies have prioritised energy saving potential with short, up to 2-3 years, payback times. Payback time longer than 5 years is difficult for the investment planning process, because energy efficiency investments are competing for limited resources and the ability of the investment to generate new revenues needs to be taken into account.

Table 5-5 describes investments decision factors and gives reflection of their importance in the decision-making process of a company.

Table 5-5: Overview of investment decision factors

Investment decision factor	**Reflection**
Payback time up to 2-3 year	Companies have prioritised energy saving potential with short payback time, up to 2-3 years Short payback time provides positive results in short term and thus create interest and motivation in the organisation
More than 5 years payback time	Investments enabling the greatest energy efficiency would imply approximately 5-15 years payback time Fairly long payback time in terms of the competitiveness of the energy intensive industry companies
Company resources	Long-term energy investments have lower priority in investment planning due to high initial investment costs and long payback time Ability of the investment to generate new revenue is a significant component in the decision-making process
Public funding	Public funding was considered as an important factor for long-term investment decisions Other kind of public funded incentives for energy efficiency improvements are effective in motivating companies (for example energy audit systems)

Some schemes include a system for applying public funding for LTA implementation, mainly for energy audits, analysis and investments. Public funding was considered as crucial for long-term investment decisions. Results of the interview study indicated that the current public support of 10 % in the Finnish LTA scheme was not considered as an adequate incentive for investment decisions. According to company-level experience, financial support should rather be between 10-30 %.

LTA schemes include also other incentives for energy efficiency action. One example of a well-established incentive is the Finnish LTAs auditing concept of audit models and tools as well as informational and financial support. Other kind of incentives would be to provide tax relief of energy/ CO_2 taxation for verifiably well performing LTA companies.

5.6 Relation of LTAs to management systems and programs

Energy issues are often integrated into the environmental policy as environmental goals. Most of the energy-intensive case companies have started to combine environmental and energy management systems. The results of the interview study specify many advantages of combining energy and environmental issues that were recognized by the case companies (cf. Table 5-6).

Table 5-6: Advantages of combining energy and environmental issues

Interview study viewpoint	Reasoning
Existing management systems provide good assistance for energy management.	• The structure of the existing quality and environmental management systems function as a good base for building/and or integrating the energy management system. • ISO 14001 and other management systems ensure that there is a structure, a framework for energy targets, clearly defined roles and responsibilities and an organisation in place. • The environmental management system is also useful in providing energy-related information.
ISO 14001 is perceived as supporting factor in the implementation phase of the LTA	• Combining energy issues with ISO 14001 and environmental issues contributes to the improvement of organisational motivation, highlighting both cost savings and environment as benefits
Combining energy issues with environmental issues saves resources	• Some areas can be managed with the same system, e.g. parts of audits • Administration of the management system can partly be integrated

The interview study clearly verifies that successful and effective implementation requires a systematic and structured approach to energy efficiency including an assessment of energy use, target setting, long term energy saving plan, management system and an incorporated system for data collection and reporting.

5.7 Best practice

Interview study results indicate some success factors, which can also be considered as best practises in the LTAs. These key factors identified by the case companies are explored more below.

5.7.1 Information sharing & co-operation between the companies and third parties

LTA has improved the networking and information sharing of companies. Internal as well as external knowledge can be extracted to a relatively low cost and with large profit potential. Especially best practice information is considered as important for technical and other energy saving innovations.

However, there is need for a third party, for example an energy association or industry branch organisation, in promoting information and best practise sharing. This kind of third parties has been considered as important to co-operate with in other areas of the LTA as well. Many of the companies agreed that industry branch organisations or energy agencies are essential in negotiating the agreement, setting the efficiency target, following up the results and solicit other companies to LTA scheme.

In addition, there are good examples of successful company co-operation among the companies joined in LTA scheme. For example the Finnish forest industry companies have been co-operating in designing an energy audit model suitable for their production processes.

5.7.2 Effective energy management and awareness of the organisation

It has been important in energy efficiency improvements and LTA implementation that there is organisation for energy management. There has been good experience with an energy auditor, who guarantees consistency of approach at the sites. This person responsible for audits is also able to increase awareness of the organisation on energy efficiency and to ensure that information about site audits is available. In addition to energy management, concepts of outsourcing energy measures have been effective in some large energy intensive companies.

The amount of energy information is extensive in large energy intensive companies. Energy efficiency follow-up information is usually linked to existing energy consumption monitoring. An information management tool, such as an intranet-based energy database and portal has been an useful element in managing energy efficiency. This kind of system raises awareness by providing information about training, benchmarking, R&D-studies, energy investments, energy procurement or energy and environmental related legislation.

5.7.3 Technical solutions and best practise identification

The interview study indicated the importance of technical solutions, and some examples are presented in Table 5-7:

Table 5-7: Importance of technical solutions

Country	Technical solutions
Finland	• Adoption of best available bio fuels (Heat) • More use of combined heat and power production (CHP) (Electricity) • Use of new technology in the press sections of paper and board machines (Heat) • Optimisation of consumption through control systems (Electricity)
Germany	• Gas and steam cogeneration plant is considered to be the most effective measure of energy saving actions • Regular control of the air compressed systems on weekends helps reducing leakage losses from 14 to 9 %. That action has a payback time of only 9 months and therefore is considered to be a very efficient and successful tool for saving energy. • The most effective measure was the installation of the new impregnation plant after a fire in 1999. It helped saving up to 13 % fossil fuels.
Sweden	• Among the accomplished energy efficiency actions within the company, the identification process of compressed air leaks • Change of cooling machines • The largest cost efficiency potential is found in the processes part, such as measures in reducing processing times. However, many of these sorts of investments have long payback time and they complicate the realization of these sort of measures.

5.8 Key issues identified for LTAs at European level

Commonly identified problems or crucial elements in the implementation of the LTA were the commitment and engagement of personnel, adequate resources, and creation of structure for implementation and data management. These key areas and explanatory solutions are collected in Table 5-8.

Table 5-8: Key areas LTA implementation

Key area in implementation	Solutions
Commitment and engagement of personnel	• Commitment of top management is a strong sign to the organization of the importance of this issue • A well functioning internal communication • Training of the organization. • Performing an energy audit and involving company’s own personnel in carrying it out. The energy audit is also often considered to be internal training. • Continuity of action and a systematic approach will diminish initial resistance, as energy issues will be a permanent part of work. • Employee reward schemes • External rewards for best performing companies contribute to giving positive attention to the agreement issues and creating an interest for energy saving measures. • Combining energy issues with environmental issues create twofold motivation for energy saving, both cost and environmental benefit.
Adequate resources	• Possibility to use both own staff and external resources such as consultants or students • Externalised energy efficiency organization purely concentrating on energy issues is motivated and able to fully concentrate on energy issues • Allocate production staff responsibilities on energy management
Structure for implementation and data management	• Adequate resource allocation to energy management organisation • Persons responsible for energy efficiency actions at sites • Use of audit models • Utilise existing management systems, such as ISO 14001 or ISO 9001, when possible • Creation of structure for implementation and data management at company level • Use of industry branch approaches when available • Effective monitoring and documentation for energy efficiency and LTA

On the basis of the study results, the differences in LTA schemes affect also company actions in different countries. The comments of the Swedish companies reflected that the Swedish Eko Energy is more a “project” for energy efficiency measures in industry, rather than a full-fledged environmental agreement, which, by one company, has been regarded as quite appropriate, while another has been interested in a more systematic, structured and committed approach from the energy agency, as well as more support and assistance in the implementation.

Feedback was given also on the follow-up of the agreement, which lacked e.g. continuity and transparency when judging company performance. Also greater focus on processes and results instead of consumption data was demanded. So far the Swedish LTA did not encourage companies to high investments.

External reward for best performing company (Swedish LTA scheme) was highly appreciated by the company and it did also contribute to giving extra attention to the agreement and energy issues. The EKO Energi price has functioned as a trigger in creating an interest for energy saving measures.

Combining energy issues with environmental issues improves the motivation of the organization. It also creates motivation for energy saving, both cost and environmental benefit.

An interesting insight from the Swedish case studies is that also an energy intensive company outside an LTA scheme might have experienced similar benefits and development of energy/environmental issues. Thus lessons learned should be compiled from both LTA participants as well as from good-performers outside.

The comments of the Finnish companies expressed satisfaction with the LTA scheme and especially with support provided for implementation. Support of the Finnish energy agency Motiva was considered as crucial for successful LTA implementation. In addition to Motiva, industry federation as the third party was considered as reliable party in negotiations and in setting the effectiveness targets.

Some details concerning the scheme were already experienced as too bureaucratically in Finnish LTA. The audit process requires a lot of effort; it is very bureaucratic to apply for subsidies and carry out the analysis on plants. In Germany industrial branch associations have also a strong supportive role.

However, all companies were able to indicate several benefits of LTA, and these are listed below:

- Energy issues are understood better and looked more at as wholeness, not just as single and separate issues.
- Adding knowledge and expertise on energy issues.
- The investment need for achieving certain energy efficiency are known, as well as the reduction costs for CO_2.
- The knowledge on BAT has improved.
- The awareness of energy issues and motivation has remarkably increased.
- Improved integration of energy issues into the environmental report and environmental management system.
- Open cooperation and communication with the authorities, developing mutual trust between companies and the energy agency

To improve the LTA guidelines and efficiency of the agreement it was suggested that the scheme should include also other elements. Other required elements of the LTA according to the companies are listed below:

- Communication of advantages for joining the agreement
- Implementation support to the company when needed
- Ensuring co-operation with companies
- Highlighting of the good performers
- Utilizing best practice solutions and communicating this with all participating companies
- Creating networks for the participating companies
- Ensuring regularity in the reporting format
- Creating a forum for LTA stakeholder dialogue
- Continuity and predictability of the LTA scheme to enable investment planning
- Long-term commitment from both sides
- Goodwill and realism from the authorities when setting requirements
- Clearer communication of governmental expectations
- Clear advance approval of national plans by the EU as early as possible
- Resource efficiency into the monitoring process, not only the energy efficiency

6 Success factors for European LTAs – results of a stakeholder survey

A questionnaire on the possible use of LTAs at European level was developed and sent to the participating associations and other discussion partners in order to identify key factors influencing investment decisions as well as potential demands and incentives for industry to be included in a European LTA scheme. The questionnaire, referred to in the following as "LTA questionnaire", was sent to different discussion partners:

- Industrial associations: Experts from Cembureau, Cepi, Eurofer and Eurometaux as well as an expert from European Aluminium industry (referred to in the following as "aluminium expert/association").
- Companies: Aluminium and cement producing companies
- Expert from Novem

The results obtained in this survey are summarised in the following together with the key points raised by the stakeholders present at the workshop on LTAs held in Brussel on 8 July 2002.

6.1 Investment behaviour: key factors and barriers

The analysis of *key factors for investment decisions* points out that not only economic factors are taken into account, but also technology related factors like product quality and process safety are of high relevance. In general, *economic and technology related factors* are of *medium to high importance*. The most important factors are (by decreasing relevance): Payback time, investment costs, operating costs, product quality (especially cement and paper industry) and process safety.

The importance of *social and political factors* like public relations is estimated a little bit lower. Energy related factors are also of medium to major importance, but they are closely linked to operating costs. Some associations mention also "other factors" which play a major role for investment decisions such as "correspondence to staff and workers" (CEPI), "health" (Eurometaux) and other "technology related factors" like change of equipment, flexibility of the process (expansion possibility for other products) and human elements (ergonomy) (Eurometaux).

Barriers for investment decisions with medium to high relevance are: Investment priorities in view of limited financial resources, lack of general information concerning the application of new technologies, benefits of new technologies and especially the proof of operability, uncertainty of technical risks concerning production losses and especially concerning quality. According to Eurometaux, "other factors" of high relevance are "Conflicting attitudes of local and regional authorities".

Limited managerial resources, risks during changeover to a new technology as well as other management related problems (complexity of tasks, hierarchy, priority conflicts etc.) have only low relevance for investment decisions.

Conclusions: The analysis of the LTA questionnaire shows clearly that investment decisions depend strongly on cost factors, but non-monetary factors and barriers are also of high relevance. The LTA should therefore be shaped to address the specific factors. The following possibilities are given:

- Investment support for energy efficient to address monetary factors
- Improved information exchange on technology-related factors as application and benefits of new technologies
- Training on energy efficient technologies
- Support especially for demonstration actions to show operability and benefits of new technologies

6.2 Overall shaping of LTAs

Effectivity of LTAs compared to other policy measures: Compared to the effectivity of other policy measures as energy taxes, subsidies, regulation and emission trading, LTA measures are seen as most efficient policy instrument for emission reduction. The majority of persons questioned prefer LTA as part of a complex policy mix. Only Eurofer and Eurometaux state that LTA as standalone policy instrument would be of higher efficiency than in a policy mix (minor efficiency).

The assessment of other policy measures differs. In general, emission trading schemes (ETS) are assumed to be more effective than tax schemes, if well designed.

Incentives and sanctions: LTA schemes could include incentives or sanctions. In principle, sanctions are acceptable for nearly all respondents persons – depending on the type of sanctions - if companies do not fulfil their obligations. The respondents estimate effectivity of incentives as medium to major, whereas sanctions for firms lacking behind best practice are assessed very differently.

LTA participants: Partners to European LTA schemes could be individual firms or sector associations. Partly, LTAs are concluded with both firms and the related association (umbrella agreement with association and underlying agreements with firms). The respondents prefer in general LTAs with associations and firms.

National and European LTAs: A combination of European and national schemes is for most persons questioned a preferable option in view of limitations and strengths at both levels, regarding budgets and legislation for subsidies and the impact on transnational companies in a common market. The following comments on potential effects and advantages have been received:

- An exclusive European LTA scheme replacing national schemes is not workable, a European scheme needs “national foundation”. European and national schemes should be complementary.
- The national approach should ensure best adaptation to the national context, the European level should ensure common (minimum) rules and criteria.
- The harmonisation at European level is seen as major advantage of such a combination of both national and European LTAs.
- Only Eurofer expresses „strong reservations“ towards European LTAs, Eurofer states it would not be „politically feasible“, whereas a national LTA is seen to be very useful.

Benefits of a European LTA scheme in comparison to national schemes include mainly advantages compared to LTAs at national level with regard to European competitiveness, the development of a single market due to an uniform European approach and an improved information exchange within industrial sectors (especially confirmed from paper industry).

Conclusions: LTAs are estimated to have a high effectivity:

- LTA measures are viewed as most efficient compared to other policy measures, especially as part of a policy mix. Emission trading is also perceived as highly efficient.
- Sanctions included in LTA schemes are accepted by the majority, incentives are seen to be more useful.
- LTAs with associations and firms are preferred.
- European LTA should complete national LTAs. They should fix minimum criteria and rules.
- Benefits of European LTA concern mainly the development of a single market and the development of more extensive information networks within sectors

Therefore it can be concluded that potential European LTA schemes should be part of policy mix as flexible instrument and including incentives.

6.3 Demands to industry

Demands on industry can be divided in the following categories: Quantitative CO_2 targets, organisational change, change of investment criteria and other potential demands:

- *Quantitative CO_2 targets:* Whereas Eurometaux, the aluminium expert and company and Cembureau confirm that quantitative CO_2 targets would have advantages compared to other approaches, CEPI, Novem, Eurofer and the cement company do not agree. CEPI states, it would be confirmed, if the target would be specific. Absolute targets are under no conditions accepted. The danger of shifting production to countries outside Europe or Eastern Europe is seen as significant danger from most respondents.

  Most respondents do not agree on a combination with a certification according to ISO 14001 or EMAS. Certification should be voluntary (CEPI). Eurometaux, Cembureau and

Novem would approve a certification. Novem states that an increased coupling between LTA and certification is expected.

- *CO_2 or Greenhous Gases (GHG)?* Most respondents vote for GHG, only CEPI and Novem would prefer CO_2. Eurofer states that LTA based on GHG would increase the liqidity of future ETS scheme.
- *Organisational change at company level and industry level:* Energy management systems according to ISO 14001, EMAS or E2MAS would help to improve energy efficiency according to most of the respondents. Only the aluminium industry (the expert and the company) and Eurometaux do not agree because of the high costs. Therefore, most respondents would agree to include an implementation of energy management systems in a European LTA scheme.

To bind the eligibility to European research grants or to national subsidy schemes to the condition that the respective companies are party to an European LTA ore have EMAS certification is not accepted by most respondents.

Valid mechanisms to influence management decisions on energy efficiency are for most respondents: Sectoral energy efficiency monitoring and reporting as well as energy efficiency benchmarking.

- *Change of investment criteria and commitment to specific investments:* The average pay-back time accepted today for core business technologies is estimated by most respondents to be between 3 and 7 years. For energy saving measures, the pay-back time, which would be accepted, ranges between 2 and 5 years.

A demand to change of investment criteria would not be feasible for most respondents. Also change of investment criteria based on energy audits is not a preferable option.

- *Other relevant demands:* Other relevant demands are supported by most respondents. Exempt CEPI and Novem all respondents support the following options:
  - To foster RTD activities, for instance if combined with European RTD framework programmes
  - To foster take-up of new technologies for instance through early demonstration projects co-ordinated by the European industry association.
  - All respondents except Cembureau see a relevance to improve information exchange and networking.

The *results* can be summarised as follows:

- Quantitative CO_2 targets are accepted, if the target is expressed as specific quantity.
- Depending on sector, the reduction of CO_2 or GHG is preferred.
- A combination of LTA with ISO 14001 or EMAS certification is not agreed by the majority, only as voluntary measure. But nearly all respondents agree that energy management systems according to ISO/EMAS/E2MAS would improve energy efficiency.
- To bind eligibility of research grants or subsidies to certification is not accepted. Legal problems could arise.

- Valid mechanisms for energy efficiency are sectoral energy efficiency monitoring and energy efficiency benchmarking.

Potential European LTA scheme should therefore include specific targets and energy efficiency monitoring, but a combination with certifications should only be voluntary.

6.4 Potential incentives for industry to be included in a European LTA scheme

Accompanying measures to LTA schemes can be: protection against other policy measures, marketing advantage, energy tax relief or subsidies.

- *Protection against other policy measures:* Because formal legal commitments to refrain from taxation or regulation are in conflict with constitutional law in EU member states, any such protection could only be in the form of promises made by EC. Such promises represent a relevant incentive for most respondents. Only CEPI and Eurometaux do not agree on this point.
- *Marketing advantage:* Marketing advantages are considered to be not attractive to medium attractive. Neither to target only those companies selectively, which are performing best according to a benchmarking, nor a mandatory labelling for companies unwilling to participate in a LTA find much support among the respondents.
- To change European public procurement rules in favour of companies participating in European LTA is agreed by most respondents except Novem, Cepi and Eurofer. Novem sees legal problems.
- *Energy tax relief:* Without an European energy tax or an European regulation regarding national tax schemes there is no direct way for European LTA to offer energy tax relief. Nevertheless, the EC could build such a system in combination with the national taxation. This is perceived as a significant incentive to European industry by all respondents. Advantages are thereby mainly seen for large companies with production in several European member states (e.g. through uniform performance requirements for receiving tax relief).
- *Relation to emission trading schemes:* There would be two possible options:
    - Industry concluding a LTA scheme could be exempted from potential European emission trading schemes.
    - The combination of LTA with Emission Trading Schemes (ETS) could include higher emission allowances within the ETS for those firms which are part of an LTA scheme. The emission allowance of the ETS would depend on the targets defined in the LTA and should be adapted depending on achievement of these targets.

  Most respondents would prefer option 2. Novem sees legal problems with option1 because of the distinction of participants and non-participants. Such ETS measures would be preferred, in which methods of LTA like efficiency monitoring play a role in setting baselines and following its annually progression. In general stakeholders, also at the Brussels workshop, emphasized the importance of linking ETS with LTAs.

- *Subsidies:* LTAs could be supported by the following measures:

  Investment support in general is seen to be medium to most relevant by most respondents. Thereby especially investment grants and long-term, low-interest loans are perceived as being effective except by Eurometaux and Novem. Only Eurometaux and companies from aluminium and cement industry considerd an accelerated depreciation to be relevant, whereas other associations and Novem estimate it to be of minor relevance. Low or zero rate VAT would play no major role, only for Eurofer it is of major relevance (for national LTA).

  Take-up of new energy efficient technologies: In this case answers differ:

  - Most respondents see a relevance for grants to monitoring and benchmarking (Al/Ce companies, Novem, Eurofer).
  - Combination of LTA with demonstration actions are supported also by industry (Aluminium/Cement) and Eurofer.
  - Operability tests are considered to be not that relevant, especially Cembureau and Eurometaux do not agree.

  RTD on new energy efficient technologies: Options could be:

  - Combination of LTA with RTD actions under the European RTD framework programme
  - Specific support for taking new ideas which are generated at company level to corresponding research institutions, in order to overcome a lack of industry’s own research resources
  - Organisational support to industry for management of contract research and for networking and co-ordination of long-term research projects

Answers differ dependent on sector: Whereas CEPI and Cembureau see only minor relevance for all options, Eurometaux and Eurofer as well as companies from cement and aluminium sector see medium to major relevance.

Results can be summarised as follows:

- Promises of EC concerning protection against other policy measures represent a relevant incentive for most respondents
- Energy tax relief or combination with emission trading schemes (higher emission allowances) are supported by most respondents persons. Legal problems are seen.
- Change of investment criteria in general or based on energy audits: not feasible for most respondents.
- Investment support is seen to be major to most relevant (investment grants, long-term, low-interest loans). Accelerated depreciation has only medium relevance, low or zero rate VAT has low relevance.

- To foster RTD activities and take-up of new technologies by early demonstration projects (e.g. with European RTD framework programmes) are relevant options. Major relevance have grants for monitoring and reporting, demonstration actions under EU RTD programme and grants for operability testing (depending on sector) have medium relevance:
- RTD actions, support for taking new ideas generated at company level and organisational support for contract research have in the mean value only medium relevance. The assessment is very sector dependent.
- Improvement of information exchange and networking is supported by most respondents
- No or low relevance: marketing advantage

Based on these results as well as on the results on key factors for investment decisions, the following conclusions can be drawn for a potential European LTA scheme:

- Different incentives are possible and would be accepted.
- A combination with ETS, energy tax relief and investment support are mostly preferred.
- Further relevant options would be the improvement of information exchange, support for research and demonstration actions.

6.5 Key issues identified for European LTAs

LTAs are assessed to be a flexible and very efficient policy instrument to reduce CO_2 emissions:

- Compared to other measures, LTAs can effectively affect every stage of the innovation cycle, this includes also qualitative factors and barriers relevant for investment decision. This is especially important because factors of high relevance for investment decisions are beside costs also technology related factors like product quality and lack of information concerning new technologies.
- LTAs can be combined effectively with different incentives and demands for industry which would have benefits for both contract sides. Of high relevance would be the combination with ETS, energy tax relief and investment support.
- Further supporting measures would be an improvement of information exchange, RTD support and others.

7 Proposal for LTAs at European level

Given the commitments taken by the European Union in the Kyoto protocol on the one hand and the need for more flexible and cost-effective instruments to achieve GHG emission reductions in the industrial sector on the other hand, a broad range of voluntary agreements have been concluded in different European countries in the last years. The challenge of climate change mitigation and energy efficiency, however, needs reinforced international co-operation given that these issues can't be solved unilaterally at national level anymore. Furthermore, in a European Union getting ever closer and disposing already of a high and increasing relevance in nearly all policy fields, the harmonisation of policy measures and the development of policy measures at EU level is an essential step in reaching common strategic targets especially on issues regarding the single market. This includes also LTAs.

In particular, the following *benefits* are expected *from European harmonised LTAs:*

- Above all the *prevention of market distortions* and the provision of a level playing field for transnational companies has to be mentioned. The harmonisation of LTAs at European level would have advantages compared to national approaches concerning the industrial competitiveness within the single market.
- The *qualitative impacts of LTAs* such as the improvement of intra-sectoral communication, the diffusion of information under an LTA and the promotion of an increased awareness on energy-efficiency would be even more substantial at EU level. LTAs can therefore especially be shaped to take into account the influence of non-monetary factors and barriers on investment decisions.
- Last but not least, the *long term approach of LTAs* involving a long term commitment between public and industrial actors would yield an additional impact on investment decisions when concluded at EU level.

In the current political context, the questions whether and how LTAs could be linked to the *EC initiative on emission trading* has to be scrutinised. Industry, on the one hand, has a strong preference for negotiated agreements offering flexibility to industry in contrast to mandatory emission trading schemes (ETS). In economic theory, on the other hand, emission trading is often seen as first-best instrument. Currently, however, industry and also national governments face insecurity since no concrete political guidelines on the planned ETS have been guaranteed and partly national LTA efforts are stopped (e.g. NL).

In the following, an outline for a European harmonised LTA is presented which is expected to yield also additional insights with regard to the ongoing debate on emission trading. For several issues, different alternatives are sketched and the pros and cons are discussed. Thereby ample use is made of the outcomes of the questionnaire on LTAs discussed in the previous section.

In the following, first the overall shaping of LTAs at European level is dealt with, then proposals for the participants and targets of the agreements are put forward and envisaged offers and sanctions as well as monitoring and reporting procedures are discussed.

7.1 Overall shaping of LTAs at European level

Since the existing LTAs in Europe are very heterogeneous, a harmonisation of these is certainly not an easy task. In the past and at present, national energy and other policies have led to a broad variety of situations in European member states. This presents, on the one hand, an obstacle to an EU-wide agreement including quantified targets. On the other hand, this makes an EU-wide approach necessary to ensure the competitiveness of European industry and a level playing-field. A solution which is e.g. also supported by CEPI could be a "two-level approach" or process: The framework defining the rules and measures (e.g. monitoring procedures) that apply for industry as a whole can be defined at EU level, while the quantified targets and detailed conditions should be defined at national level, taking into account the specific national situations. We propose therefore to launch a new *EC initiative on the conclusion of LTAs in Europe* which should take up as much as possible from the different national systems.

Both, an overlapping of inconsistent national and European LTA obligations and the exclusion of a European LTA participant from national obligations should be prevented. In any case, the subsidiarity principle has to be taken into account, so that national efforts and the European approach become really complementary. Through a nationally tailored approach best adaptation to the national context should be ensured, the European approach should guarantee common rules and a consistent approach.

An important issue for a European LTA scheme is thereby the possible *legal status of the agreement*. Thereby the following issues have to be considered:

On the one hand, a legally binding form of negotiated long term agreements would yield additional reliability for all contracting parties. LTAs at national level would also need to be legally binding when they are used to implement EC directives which create rights and obligations for individuals.

On the other hand, the majority of existing LTAs in European countries are non-binding (with the Netherlands as one exception) given that executive government agencies need to be empowered by the national law to sign LTA agreements with organised interests. This is necessary since through legally binding agreements the use of traditional public law instruments may be limited (they consequently fall under public law). Moreover, also industry associations need a mandate to conclude binding contracts on behalf of their member firms. Therefore, non-legally binding agreements are usually preferred although they are non-enforceable by the courts. These arguments hold also at the European level, where the

Commission as executive branch may not enter contracts under public law (be it with associations or other legal entities) unless explicitly empowered by member states.

One possible solution could be to combine (legally non-binding) European LTAs with legally binding regulations at European and/or national level to enforce the offers and sanctions provided to enterprises. On the industry side, legally binding contracts under private law between associations and companies could enforce burden-sharing and prevent free-ridership. However, these provisions would certainly bend LTAs away from the originally intended “light-handed regulation”.

Another relevant issue mentioned already above is the question whether and how *LTAs* could be *combined with other policy measures like emission trading or taxes*. Certainly, LTAs as stand-alone policy instrument on the one hand and ET on the other hand as two independent policy measures are rather incompatible since they aim at the same goal but by different means. Both instruments differ e.g. with regard to sanctions or flexibility, and they may create conflicting incentives when used in parallel. E. g. under a mandatory ETS, joining a LTA scheme is of little interest for companies, if there are not offered substantial (extra) incentives and even then they might prefer to buy certificates on the market rather to engage themselves in a process of energy efficiency increases.

Hence, the use of LTAs in addition to and without link to existing policy instruments should be avoided. Moreover, it is also rather unlikely that LTAs, an emission trading scheme or CO_2 taxes, if implemented as stand-alone policy instruments, could replace all other policy measures. As shown in setion four, a CO_2 tax would increase considerably the costs for industry and therefore undermine its competitiveness compared to companies outside the EU. This may lead to leakage effects which counterbalance the intended CO_2 emission reduction. These leakage effects are also likely to occur if emission prices in an ETS are high or if the primary allocation of certificates is done through auctions. On the other hand, in the case of free primary allocation, a scheme for the attribution of the certificates is needed.

Therefore, LTAs should be considered as part of a policy mix. Usually, they are linked to a stick & carrot approach and industry generally has a preference not to combine an LTA with stricter environmental regulations since an LTA is more like a gentlemen’s approach offering flexibility for industry. One should, therefore, be careful how to use and combine the LTA schemes with other existing policy measures and for each case, the pros and cons have to be assessed very critically as not to produce any counterproductive effects for industry. Since both energy taxation and emission trading are currently on the political agenda, possible combinations will be discussed in the following.

One further important issue not to be underestimated when shaping LTAs at EU level is the influence of *“qualitative impacts” on the investment decision process* in industry (“Psychology” of LTAs). Within the project, management decisions of individual companies have been considered as the key to implementing energy saving and CO_2 mitigation measures in industry. Consequently, an effective long term agreement scheme needs to be optimised concerning the impact on the management decisions and especially on decisions to invest in energy saving and new energy efficient technologies. Hereby, an improved information exchange is seen to be one of the key incentives which could be offered by an LTA scheme because the priorities of different investment decisions, available time and an improved dissemination of information are important factors influencing decisions almost as strongly as cost factors. These factors need first to be changed “in the head” of the concerned energy manager, and an additional motivation combined with an LTA participation such as “when you join the LTA, you are a winner” is seen as important as pure environmental reasons.

7.2 Participants to the agreement

So far as the signing parties to an agreement are concerned, different LTA designs are possible and will be discussed in the following. The main criteria for weighting one alternative against another are:

- administrative burden and costs both at EU/national and company level,
- efficient target setting process,
- reliability that the targets defined will be met.

Thereby, the following phases have to be considered:

- Negotiation phase
    - Negotiation at sectoral level
    - Negotiation at company level
- Implementation phase
    - Implementing
    - Reporting
    - Monitoring
    - Sanctioning (if necessary)

Certainly, the administrative effort strongly depends on how many parties there are to an agreement. This provides a strong argument in favour of concluding individual agreements only with a limited number of large companies. On the other hand, without individual contracts - LTAs being concluded only at sectoral level – the danger of free-riding is high and also the possibilities of sanctioning are very limited. According to Novem, the experience in the Netherlands is that LTAs are most successful if a strong branch organisation exist which is able to coordinate the LTA efforts and to influence individual companies. Otherwise, the LTA process is in general much less efficient.

It is therefore proposed to use a combination of sectoral agreements and individual agreements with the largest companies within the sector. The largest companies should be chosen so that together they cover at least 80 % of the total energy consumption of the sector.

For the choice of the contracting parties, different constellations are possible, the three most realistic ones, however, being the following:

1. Umbrella agreement between the EC and European associations in the energy-intensive sectors and sub-agreements between the European associations and individual large (often transnational) companies.

2. Umbrella agreement between the EC and European associations in the energy-intensive sectors and sub-agreements between the national governments/national energy agencies and individual national sites of large companies.

3. European framework (e.g. in form of a directive or guidelines) for national LTA schemes, involving national governments/national energy agencies and national associations/individual national sites of large companies

In the *first choice*, the associations would have to negotiate and handle, according to first estimates, 200 to 500 individual agreements within the five energy-intensive sectors involved in this study. The associations would be the primary contacts for the Commission, responsible for the compliance of the contractual obligations for themselves and for the companies who have concluded a separate agreement with them. These would allow also for flexible negotiations at the association level on the burden sharing within the sector.

The feasibility in this case depends on the ability of the associations to achieve agreements on behalf and with their members, on the ability for collective action at European level as well as on the administrative and financial efforts needed for the negotiation, conclusion and implementation of the agreement. The EC would only supervise the contractual obligations of the associations.

In the *second case*, the administrative and financial resources of the national governments as well as the expertise of the national energy agencies could be used. However, a three-level-approach between the EC, member states and the associations would subdivide the negotiation and implementation phase and thus yielding higher administrative efforts. The Commission would have the supervisory role towards the obligations of the associations who, on their part, would take the overall responsibility for the data collection and the compliance of targets. Particular attention has to be paid as to ensure a consistency between the sectoral goal defined at European level and the site specific goals at national level. A prerequisite for such a consistency would be to develop uniform requirements for national energy audits. It would also certainly be helpful to create a European Agency, funded by the Commission, to co-ordinate the national executive authorities. In this constellation, the feasibility therefore mainly depends on the clear definition of tasks, responsibilities and interactions between all parties.

The *third case* would offer the member states the necessary flexibility to adapt the LTA scheme to the national policy mix thereby taking into account existing taxes, laws, regulations and subsidy schemes. At the same time, minimum quality standards for agreements and transparent procedures across the EU could be ensured. Since a harmonisation of offers and sanctions at EU level could take some time, European harmonised framework conditions concentrating on the following main issues should guarantee a consistent European approach:

- clearly defined targets using common definitions, units and approach,
- clearly defined business-as-usual scenarios establishing a clear baseline in each EU Member state,
- a unified and reliable monitoring system,
- sanctions for non-complying firms,
- dissemination of best practices,
- provisions against competition distortions.

In all three cases, additionally informal agreements between the associations and SMEs within the sectors could be concluded since the negotiation of individual targets as well as the monitoring and reporting efforts for the small companies are not in balance with energy savings and are not cost-effective. These agreements would include other incentives, especially the promotion of information networks or easier access to European funds for information centres.

One important issue to be discussed for all constellations is the ***exact role for the Commission*** in European LTAs since it is difficult for the Commission to be a party itself in the agreement due to legal reasons mentioned above: How far should an European harmonised LTA scheme be shaped and should this be done by using a directive or a guideline? Different cases are possible, among them e.g. the following:

- A *common EU framework* with minimum criteria for LTA participation would be especially preferable in the case of an ETS allowing for a combination with LTAs.
- However, it could also be thought of to adapt a *directive* setting a common EU frame, but not regulating all specifics at national level, like e.g. in the case of energy performance regulations for the building sector, another policy field with many country particularities.
- European regulations should allow for national specifics and the specific adaptation of the LTA to the national policy mix (e.g. different targets in each country). An overview of the success factors of existing national LTAs could hereby be included. Moreover, common European guidelines for energy audits and requirements for quality standards would be welcome.
- In any case, the flexibility of the LTA approach should be guaranteed.

7.3 Targets of agreement

Whether a focus on GHG or on CO_2 emissions would be preferable strongly depends on the sector; the paper industry, e.g., would prefer CO_2 emission reduction targets. According to the results of the LTA questionnaires, however, most but not all sectors would prefer an LTA scheme focussing on all greenhouse gases, not only on CO_2 emissions. Especially in case the LTA scheme would be coupled with a future emission trading scheme, a focus on GHG in general would increase the "liquidity" of companies.

Hereby the following basic alternatives for target setting can be distinguished:

- absolute targets (in Mt CO_2 equivalents for each sector),
- relative targets (in Mt CO_2 equivalents per unit of output),
- qualitative targets at sectoral level, referring to on-site energy audits,
- combination of qualitative and quantitative targets.

Absolute quantitative targets are hardly acceptable for industry, since under uncertain production growth competitiveness may be severely affected. In the LTA questionnaires, the associations state that targets should rather be production related. In the context of an increased global competition, quantitative targets should take into account social and economic aspects and provide compensation. Otherwise a shift of production to East European countries and countries outside Europe (e.g. Asia) is to be feared.

Therefore *ambitious relative targets* supported by effective accompanying measures should be set which allow to achieve at average growth rates substantial absolute abatements. For the definition of relative targets several alternatives are possible:

- t CO_2 equivalents /unit of output (or alternatively per value added),
- energy consumption/unit of output (or alternatively per value added).

The use of t CO_2 equivalents/unit of output seems preferable under the premise that the major policy goal is currently the reduction of greenhouse gas emissions. However, since companies can not be held responsible of the national electricity generation mix, the valuation of electricity should be done using the average European carbon intensity of electricity production.

The targets may be derived either taking the current situation as starting point (e.g. as relative change of emission intensity defined as t CO_2 equivalents/t output). Or alternatively, the targets could be derived from *process specific benchmarks*.

In a first step, such benchmarks could be proposed at sectoral level based on the use of best available technologies or alternatively on the definition of best practice, e.g. on the definition of the top-of-the world in terms of energy efficiency like in the benchmarking agreement in the Netherlands. If the sector has an identifiable number of energy intensive processes, then the benchmarks can be defined for single processes in t CO_2 equivalents per t of product. This means that within a sector different principal processes have to be identified and defined. For example in the copper sector, these could be primary and secondary anode copper, cathode copper and different copper products. For these individual principal processes, the benchmarks could be defined in t CO_2 equivalents per t of product. Possibly, correction factors could be applied to account for the effects of plant capacity or product quality (e.g. in pulp and paper).

If the products are rather heterogeneous, this approach becomes difficult if not impossible. Then the definition of relative targets in terms of t CO_2 equivalents per M€ of value added may be the only solution.

Given the influence of investment cycles, limited retrofit capacities and other barriers to innovation, the target level should not necessarily correspond to the BAT/best practice level, but could also be defined as a percentage of gap closure between today's performance and BAT/best practice. Such an approach could also be used for the definition of company targets, however, this should preferably be the responsibility of either the associations or the national government/energy agencies taking also into account the process- or production-line-related differences within one sector and regarding individual site related factors.

Additionally, *qualitative targets* have proven a promising option to increase energy-efficiency (cf. the Danish experience) and a combination of both quantitative and qualitative targets could be envisaged. When operating with qualitative targets at sectoral level, *energy audits* play a key role aiming at the development of an energy conservation plan by the company. Here the potentials for energy savings and feasible energy efficiency measures (with economic viability) are investigated to enable the company to find individual site-specific, most cost-effective solutions. An action plan at sectoral level on how the sector is going to increase its energy-efficiency based on the energy audits as well as an information exchange within one sector regarding the specific measures can be an additional qualitative target.

A related requirement could be that investment criteria (e.g. payback time) are changed for energy efficiency investments identified in the energy audits. But the question is how this can be controlled by the authorities. Furthermore, this is not estimated to be of major usefulness (cf. section 6).

Furthermore, the implementation of an *energy management system* (building on EMAS, E^2MAS or ISO) could be part of the qualitative targets included in the LTA scheme, since this is considered by a majority of the associations as being helpful for improving energy efficiency. The majority agrees to include an implementation of energy management systems in a European LTA scheme. However, this should not necessarily be the ISO 14 001 or EMAS system and a strict coupling of LTA with ISO or EMAS certification is not approved by most associations involved.

Independently of the targets retained, it is important to define *regular milestones* to see whether the targets have been achieved so far and can be achieved in the future or whether adjustments are necessary.

7.4 Incentives for participation

A wide range of incentives can in principle be offered to participants in European LTAs. In particular, the following types of incentives deserve attention:

- tax incentives,
- incentives related to emission trading,
- easier access to environmental permits,
- subsidised audits,
- investment support,
- RTD support,
- information network,
- Further accompanying measures.

Since effective LTAs depend on the embedding in a consistent policy package, the establishment of harmonised European approaches for those policy measures linked to a European LTA is strongly desirable to avoid competitive distortions. This holds in particular for energy taxes and emission trading allowances which will be discussed first in the following.

7.4.1 Tax incentives

Concerning *tax incentives*, the harmonisation of the European tax system would play a major role. An older EC proposal for a *Directive restructuring the Community framework for the taxation of energy products (1997)* has foreseen to develop an overall tax system for the taxation of energy products, thereby improving the functioning of the internal market as well as encouraging environmentally friendly behaviour. This directive has been recently revived in the Council under the Spanish presidency who has proposed new minimum tax rates for certain products and a long list of exemptions to get the required unanimous agreement which couldn't, however be reached by now. In March 2002, EU leaders had agreed on a summit in Barcelona they wanted a proposal on energy taxation by the end of the year and a high level group of experts has been charged with sorting out disagreements such as tax rebates for energy intensive industries.

If the taxation of energy products could be harmonised at European level, tax exemptions for energy intensive companies participating in a European LTA could be offered as incentive. On the other hand, if a substantial proposal for LTAs is put forward, this could help finding a consensus on granting tax exemptions for energy intensive industries.

According to the results of the LTA questionnaires, an energy tax relief would be a strong incentive for an LTA participation. The associations emphasize that any energy cost reduction would be a relative incentive. Moreover, further harmonisation at EU level and the establishment of uniform requirements for all European countries are of major relevance especially for large companies with production in several European member states.

As long as no harmonisation of energy taxation at EU level is decided, the endowment of the Commission with a supervisory role regarding national tax exemptions as forms of state subsidy is a potential starting point for LTA negotiations at EU level. In this respect, the

New Community guidelines on state aid for environmental protection adopted in February 2001 determined the conditions under which MS may grant firms aid to promote environmental protection: Aid may be justified in some cases where it provides a temporary second-best solution or serves as an incentive to firms to improve on standards or to undertake further investments – only in the absence of harmonisation at European level. Moreover, tax reductions or exemptions may be justified when they are conditional to the conclusion of negotiated agreements under specified conditions. Hence, even in the current situation national tax exemptions for participants supervised and allowed by the Commission could be an incentive.

Furthermore, a promise made by the EC to refrain from further European ECO-taxation would presumably be a relevant incentive for industry.

However, this has to be in line with the *European court decision for the use of tax rebates* regulating when a state subsidy is in accordance with European law or not. The privileged treatment of LTA participants, compared to companies from other industrial sectors, not covered by a LTA, may therefore lead to legal problems. This is also true for further incentives mentioned below.

7.4.2 Incentives related to emission trading (ET)

In October 2001, the European Commission has submitted a proposal for a *Directive establishing a GHG emission trading scheme*. It is stated there that existing environmental agreements should be adapted to include the ET scheme. It is therefore possible to combine this ET scheme with a European LTA. In particular, two options can be envisaged:

a) Participants of LTA schemes could be *exempted* from ET scheme (opt out possibility).
b) The primary allocation of emission allowances under the ET scheme could be linked to an LTA. Participants in the LTA would then be *allocated emission certificates free of charge or at reduced rate*.

According to the results of the LTA questionnaires, both options could be accepted by industry, but option b) would be preferred. Furthermore, the exemption from ET (option a.)) would potentially lead to legal problems because of the division into participants and non-participants[2].

The allocation of emission allowances free of charge is also foreseen by the proposal for the period 2005-2007. However, the commission leaves to the member state to establish an appropriate procedure for the allocation of emissions. Furthermore, both environmentalists and economists question, whether the free allocation of emission allowances leads to efficient results.

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[2] In principle, another option could also be to implement an LTA scheme as leading policy measure and the ETS as “sanction” for those LTA participants who don’t meet their targets.

But if in counterparty, industry agrees both on relative efficiency targets and appropriate monitoring and benchmarking procedures, this can provide a sound basis for the allocation of certificates and help to increase the acceptance of free allocation in politics and the wider public.

In order to have a workable scheme which provides few incentives for “gaming”, it is proposed to allocate the emission certificates based on the relative targets established for the LTA. These targets should be established based on world-wide benchmarks as already done under the current Dutch LTA scheme or using the results established in section 4. For deriving the absolute number of emission certificates allocated free of charge or at reduced rate in the primary allocation, the benchmark efficiency target should be multiplied by the production output under expected growth rates.

Through this combination of an ET scheme with LTA the advantages of the flexibility and the price mechanism in the ET scheme can be combined with key advantages of the LTAs including information sharing and monitoring, which enables subsequently the determination of adequate baselines.

7.4.3 Better access to environmental permits (i.e. environmental regulations)

A *better access to environmental permits* as practised in the Netherlands is sometimes seen as an appropriate incentive. This may be achieved especially by support from the national energy agency e.g. in the writing of energy conservation plans or advice on energy conservation plans to the environmental authorities. Since non-participants would have the same obligations but without receiving any supporting activities, this would therefore not result in lower environmental quality standards.

7.4.4 Subsidised audits

With regard to providing *audits* at reduced cost or even free of charge *as an incentive*, the administrative and financial effort for detailed energy audits for all companies concerned should not be underestimated. Therefore certainly no audits free of charge could be offered to all participants. But a cost sharing scheme could be envisaged, providing especially smaller companies access to energy consultancy services at reduced rate. Uniform requirements for the audit procedures are necessary to guarantee equal treatment between the participants as well as a comparability of measures at least within one sector. Hereby the foundation of a European Energy Agency would certainly be helpful to co-ordinate the national authorities, but otherwise also the existing network of national energy agencies could be used.

According to the LTA questionnaires, however, the associations are undecided whether to support an inclusion of energy audits into an LTA scheme. Further discussions on this issue are required to yield additional insights on how to adjust the audit incentive to an European LTA scheme.

7.4.5 Investment support

A support to investments could take one of the following forms:

- *Investment grants* for energy efficient equipment change or long-term, low-interest loans for investments. This is considered to be a measure of major relevance for industry. However, budgetary constraints at European and national level have to be taken into account.
- *Accelerated depreciation* for investments on energy efficient equipment (combination with profit tax). This is more seen as a complimentary measure.

7.4.6 RTD support

The LTA could in principle be combined with support under the *European RTD framework programme*. However, an easier access to European research grants can also lead to legal problems, notably when discriminating non-participants.

On the one hand, the results of the LTA questionnaires show only medium relevance for related questions depending on the sector considered. On the other hand, according to the questionnaires, the lack of information concerning application potential, operability etc. of new energy efficient technologies are seen to be of major relevance, therefore the support especially for the take-up of new energy efficient technologies should be included into the LTA measures. Hereby different options are possible:

1) Take up of new energy efficient technologies:
   - Grants for monitoring and benchmarking are of special interest for industry
   - Combination of LTA with demonstration actions and operability tests are also supported by most industry sectors.
2) RTD on energy efficient technologies: RTD actions in combination with an LTA is assessed very differently in the LTA questionnaires, depending on the sector.

7.4.7 Information network

The results of the LTA questionnaires show that a lack of information concerning energy efficient technologies is one major barrier for new investments in these technologies. Industry would support approaches which could improve the information exchange within the sector. The following options would contribute to strengthen the information exchange within Europe and within the individual sectors:

- Establishment of an information and support network at EU/sectoral/national level – especially for the smaller companies:
  - Giving support to the companies
  - Informing companies about the best already realised energy efficiency measures on the market

  - Technical assistance
  - Information services
  - Adequate training schemes
- Promotion of intra-sectoral information exchange and networking pooled at the branch organisation is relevant. Concepts have to be developed focussing on accelarating and facilitating technology transfer to industry. This could include administrative, financial or personnel support to establish a “technology transfer department” within the sectoral associations. This department could give e.g. support to companies by information on relevant energy efficient technologies, their application and benefits, by giving contacts to other experts and by developing new concepts of information exchange (see e.g. database below).
- Development of an innovative European database concept including the promotion of national databases of energy saving measures undertaken in industry and new energy efficient technologies (IPPC directive), leading to an independent estimation of sectoral technical and economic potentials (cf. Icarus/IKARUS). The database concept to be developed should be based on a user friendly system in order to provide information on energy efficient technologies especially for interested companies. It should focus on problem oriented solutions. Information on technologies should be given separately for different sectors and applications in contrast to already existing databases, which do not differentiate technologies by their applications. If possible, information on application potential, operation experiences and/or testing results, benefits and disadvantages, cost estimates or potentially also information on developers or suppliers of such equipment could be included.

7.4.8 Further accompanying measures

Several possibilities may provide additional benefits:

- EC offering direct marketing advantages in an LTA scheme. According to the LTA questionnaires this is only considered as attractive if there is a small number of participants. An interesting approach in this case could be to build here on the E^2MAS initiative. Most associations estimate the relevance of marketing advantages as only minor.
- *Changing European public procurement* rules with preferential treatment for participants would probably lead to legal problems and is not advocated by associations according to the LTA questionnaires.

7.5 Sanctions

Sanctions are generally regarded as being necessary for an effective LTA and also the results of the LTA questionnaires point out that all associations would accept sanctions, - “depending on the type of sanctions” -, if firms do not fulfil their obligations. The effectivity of sanctions, however, is generally estimated to be lower than the effectivity of incentives provided to industry. Different mechanisms can be envisaged for sanctioning companies by submitting them to non-preferential treatment (e.g. in energy taxation or allocation of emission certificates) or by excluding them from the additional benefits of an LTA scheme such as subsidised audits or RTD support. Such an exclusion would take place e.g. when

- quantitative targets are not met,
- no annual monitoring results are given,
- no energy conservation plan is provided (in case of audits) or
- energy efficiency measures are not implemented (in case of audits).

7.6 Monitoring and reporting procedures

Uniform, reliable monitoring and reporting procedures are a necessary measure to be included into an European LTA scheme. Monitoring and reporting procedures should be standardised to guarantee both transparency and a reliable comparability of national and sectoral/industrial statistics but confidentiality aspects have to be respected at the same time. Thereby it is not sufficient to require reporting according to EMAS or ISO 14000ff standards since these are too vague.

Among others, the reporting procedures have to provide guidelines on:

- the treatment of on-site CHP,
- the treatment of energy contracting solutions,
- the valuation of biofuels and waste fuels,
- the treatment of intra-firm deliveries (not necessarily appearing in official production statistics),
- the consistency with national and European production and energy statistics.

In order to minimise administrative efforts, reporting should be done only by the big companies and moreover be part of other existing information and management systems so that information should not be produced each time separately. The roles of all relevant actors have to be clarified. The installation of an independent bureau of verification at EU level would be helpful, but is probably difficult to realise for budgetary reasons.

The predefined milestones should be regularly evaluated in case adjustments of the system are necessary. Furthermore, every year the absolute effects of the relative targets should be calculated with reference to the Kyoto targets.

8 Final remarks and outlook

The previous chapters have provided a wealth of material on the evaluation of existing LTAs and based on these findings, a proposal for the European harmonised LTAs has been developed. The key outcomes of the study can be summarised as follows:

Existing LTAs:

- Most agreements to date have been not very ambitious
- Schemes with quantitative targets at sectoral level and schemes without such targets have to be distinguished.
- Within negotiated agreements at company level more precise targets and measures can be negotiated than in sectoral level agreements.
- In current LTA schemes, control and sanctions are a key issue for enforcing quantitative schemes.

Potentials for energy-efficiency improvements:

- Data availability is a key restriction for assessing these potentials.
- Already in the reference development, without LTA, specific emissions are expected to decrease substantially.
- Whether absolute emission reductions occur, strongly depends on the expected economic growth rates.
- Modelling results show that under a LTA, as under any other policy instrument, only limited additional emission reduction potentials are available at reasonable costs. Because under LTA also *qualitative factors of investment decisions* can be influenced, a higher emission reduction potential could be reached in reality by effectivley supporting investment decision of industry.
- Emission reduction under a LTA is much cheaper for energy intensive industries than if an emission tax would be applied, which would yield the same emission reduction level. Also emission trading schemes will lead to higher costs for industry than LTAs - except the unlikely case that the industries receive abundant emission certificates for free.
- Therefore, LTAs are expected to have much less detrimental effects on the competitiveness of European industry than other policy instruments achieving the same emission reduction targets.
- Identification/Agreement on the baseline is a key issue for negotiations.

Company case studies:

- The companies have signed a broad variety of LTAs.
- The companies‘ experiences with the LTAs vary considerably.
- The LTAs have increased in all cases the awareness on energy efficiency.
- The LTAs have contributed to a more systematic approach to energy efficiency, including reporting and monitoring mechanisms.

- Information exchange between companies on energy efficiency is fostered by some LTA schemes.
- Several companies raise the issue of previous energy efficiency efforts as a key issue as they fear their efforts might not be considered in case of future regulations.

Expert interviews on LTA and key factors and barrires of investment decisions

- LTAs are estimated to have a high effectivity compared to other policy measures, especially as part of a policy mix. This is because they are expected to affect every stage of the innovation cycle.
- Sanctions included in LTA schemes are accepted by the majority, incentives are seen to be more useful.
- European LTAs should complement national LTAs. They should fix minimum criteria and rules. They are especially beneficial in view of the development of the single market and the development of more extensive information networks within sectors
- Potential European LTA schemes should include specific targets and energy efficiency monitoring, but a combination with certifications should only be voluntary.
- LTAs can be combined effectively with different incentives and demands for industry. which would have benefits for both contract sides. Of high relevance would be the combination with ETS, energy tax relief and investment support. Further supporting measures would be an improvement of information exchange, RTD support and others.

Proposal for sectoral LTAs at European level:

- Different constellations are possible for European harmonised LTAs, depending on the administrative burden and the efficient target setting process.
- European framework (e.g. in form of a directive or guidelines) for national LTA schemes, involving national governments/national energy agencies and national associations/individual national sites of large companies seems currently the most workable alternative
- Ambitious relative targets should be set, hereby also process specific benchmarks could be thought of
- A broad variety of different incentives should be offered to LTA participants, thereby harmonised European approaches for those participating in the LTA scheme would be desirable. A tax rebate in the context of a European harmonised energy taxation would be a strong incentive. But also subsidised audits, investment and RTD support and information networks deserve attention. On the relation to emission trading see below.
- Sanctions are necessary and one should envisage to sanction companies by submitting them to non-preferential treatment (e.g. in energy taxation or allocation of emission certificates) or by excluding them from the additional benefits of an LTA scheme such as subsidised audits or RTD support.

- Uniform, reliable monitoring and reporting procedures are a necessary, common standards are thereby needed, defining e.g. the treatment of on-site CHP. Reporting procedures according to EMAS or ISO 14000ff standards are too vague

Linkage of LTAs to emission trading:

- Number of industry representatives still have strong reservations against mandatory emission trading schemes and prefer LTAs as an alternative.
- If the current proposal for emission trading is implemented, then the number of certificates allocated to the Energy intensive industries and the allocation procedures are crucial issues.
- Auctioning as procedure for primary allocation will lead to competitive disadvantages similar to a tax scheme.
- Free allocation on the other hand, requires widely accepted allocation rules. Here, the conclusion of LTAs can contribute to developing a consensual and transparent allocation scheme.
- Furthermore, GHG emissions not covered by the ET scheme should be subject to LTAs.

On the issue of combining LTAs with emission trading and on the coverage of non CO_2 emissions through LTAs however further research is required.

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