LETS Update: Sustainability Appraisal Report

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The LETS Update project consists of five reports:
The Decision Makers Summary
The Scoping Phase Report
The Sustainability Appraisal Report
Working Groups A and B Report
Working Group C Report

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Executive summary

Background

In March 2005, the European Commission invited submissions for LIFE-Environment Preparatory Action Projects. The primary objective of the climate change theme was to provide background as well as the necessary data for an update to the Greenhouse Gas Emission Trading Directive (2003/87/EC). A secondary objective was an evaluation of the effects of the existing trading scheme. The Environment Agency for England and Wales led a successful project bid to undertake a technical assessment with the environmental protection agencies in Austria (Umweltbundesamt), Denmark (Miljostyrelsen/Danish Environment Protection Agency), Germany (Deutsche Emissionshandelstelle im Umweltbundesamt DEHSt) and Italy (Agenzia per la Protezione dell' Ambiente e per i Servizi Tecnici APAT) – the LETS Update project[1].

The LETS Update project has looked at the technical feasibility of expanding the European Union Emissions Trading Scheme (EU ETS) in future phases to cover additional sources of greenhouse gases and options for improving the design and harmonisation of the scheme. The project has involved two phases. A Scoping Phase was undertaken to prioritise the areas of greatest importance for more detailed study. AEA Technology took the leading role in undertaking this assessment for the project partners. In the Main Phase of the work programme, three Working Groups, comprising of experts from the partner organisations and external bodies, oversaw the technical assessment. This work was undertaken for the project partners by a consortium led by Ecofys.

Working Groups A and B considered the feasibility of including additional sectors and gases in the scheme. DEHSt did not participate in either of these groups. Working Group C considered a number of issues relating to the design and harmonisation of the trading scheme as a whole.

This report describes the Sustainability Appraisal that was carried out on the conclusions of all three working groups. The outcomes of the project will be used primarily to contribute to the European Commission's review of the EU ETS during 2006.

Expansion of the scheme to cover new sectors and gases

Working Group A and B considered the inclusion of the following sectors and gases in the EU ETS:

- Chemicals – CO_2 and non CO_2
- Aluminium – CO_2 and non CO_2
- Coal-mine methane
- Refrigerants – Hydro Fluoro-Carbons (HFCs).

The analysis suggested that of these, the chemicals sectors, aluminium and coal-mine methane might be suitable for future inclusion in an expanded EU ETS.

[1] The LETS Update project is funded by the EU LIFE programme.

Harmonisation and design of the scheme

Working Group C of the project researched three areas, selected in the Scoping Phase, for improving the design and harmonisation of the EU ETS. These were:

- the role of domestic offset projects in the future ETS
- the interaction between the EU ETS and other EU policies and measures
- improving the transparency of developing and assessing National Allocation Plans (NAPs).

Approach for the Sustainability Appraisal

The LETS Update project carried out a Sustainability Appraisal on the conclusions from the three working groups. This report presents the methodology and findings from the Sustainability Appraisal.

The Sustainability Appraisal of the Working Group A and B recommendations on potential sectors for inclusion was based on the European Commission's Impact Assessment Guidelines for policy proposals. A checklist of potential economic, environmental and social impacts was used to identify potential impacts which required assessment. These were mainly economic, and were assessed using a top-down macroeconomic, modelling approach and a bottom-up, sectorally-based approach.

Macroeconomic effects, impacts on competitiveness, employment and energy use were modelled using the General Equilibrium Model for Energy-Economy-Environment (GEM-E3) by the E3M Lab of the Institute of Communication and Computer Systems (ICCS) of the National Technical University of Athens. A baseline scenario assuming continuation of the EU ETS in its current form was compared against three scenarios which assumed expansion of the EU ETS to include the non-ferrous metals sector (of which aluminium is a sub-sector), the chemicals sector and coal mining. The scenarios were evaluated for both a 'low' and 'high' post-Kyoto target, of a 15 per cent and 30 per cent reduction in greenhouse gas emissions (GHGs) by 2020 from 1990 levels.

This 'top-down' modelling was complemented by a more bottom-up economic assessment for the coal-mining sector and parts of the chemicals sector responsible for nitrous oxide (N_2O) emissions using marginal cost curves and an illustrative carbon price for the EU ETS of ten Euros per tonne of CO_2 (€/t CO_2)to examine the impacts on the sectors. This bottom-up assessment was conducted by Metroeconomica.

The proposals put forward by Working Group C were of a more general nature, and so only a qualitative assessment of the potential economic, environmental and social impacts was carried out. This concentrated on identifying and assessing the nature of potential impacts on total GHG emissions and on the environmental integrity of the EU ETS, impacts on transaction and compliance costs and any changes in administrative burdens on Member State governments, competent bodies, or the European Commission.

Limitations of the Sustainability Appraisal

While the modelling undertaken for this Sustainability Appraisal goes some way to examining the economic, social (ie employment) and environmental effects (energy use and emissions), we recognise that the results have significant limitations. This is primarily due to the project timescale which meant that the objectives and approach for the appraisal had to be decided before the analysis on the feasibility of the potential sectors had reached its conclusions. The GEM-E3 model was selected as it provides general information on the main elements of a Sustainability Appraisal. It subsequently became clear that the most useful and appropriate modelling to complement this work would have been a sectorally-based analysis of the potential economic impacts, particularly on competitiveness. Specifically, we found that the chemicals and aluminium sectors which are most exposed to international competition will require this level of analysis before a decision is taken on inclusion.

The main limitation of using the GEM-E3 model for the analysis is the limited sectoral resolution of the model. Results are only available for the non-ferrous metals sector rather than the aluminium sector and for the chemicals sector as a whole rather than the ammonia, fertiliser and petrochemicals sub-sectors that were found feasible for inclusion. As the aluminium sector is much more energy intensive than other parts of the non-ferrous sector, this is recognised as a serious limitation of the analysis and we recommend that further work on the impacts on the aluminium sector is carried out before a decision is made on its inclusion in the EU ETS. Ideally this work will use a sectoral model. In the case of chemicals, the identified sub-sectors account for a significant fraction of energy use and CO_2 emissions, so the results provide a more useful indication of the impacts of inclusion. The results for nitric acid production and adipic acid production are based on a bottom-up assessment and are more reliable.

Economy wide impacts of expansion

Results from GEM-E3 suggest that inclusion of the non-ferrous sector or the chemicals sector in the EU ETS would lead to a very small fall in Gross Domestic Product (GDP) for the EU[1], of below 0.05 per cent. This is due to small falls in production and in the value added of these sectors upon inclusion in the EU ETS. In the case of the coal sector, GDP is forecast to increase slightly because production and value added in the coal sector rises on its inclusion in the EU ETS. The model shows that there is very little effect on employment on inclusion of any of the sectors.

Energy consumption increases when the chemicals or coal sector is included in the EU ETS; it also increases under a high Kyoto target when the non-ferrous metals sector is included. This is because all of these sectors offer relatively low cost abatement opportunities for non CO_2 greenhouse gases. The trading sectors take up these opportunities in preference to more costly CO_2 reduction opportunities. Consumption of fossil-based fuels (and hence energy consumption in general) is therefore not expected to reduce as much as in the current EU ETS scenario, where only CO_2 is included in the scheme.

2 The regional grouping in the version of the GEM-E3 model used is the ‘EU27’ (the current EU25 plus Romania and Bulgaria) rather than the existing EU25. The inclusion of Romania and Bulgaria within the region is not believed to have a significant impact on results.

Aluminium

Previous work on the impact of the EU ETS on the aluminium sector has looked at indirect effects from higher electricity prices rather than the direct effects of sector inclusion. This found that compared to energy intensive sectors such as cement and steel, which are already in the EU ETS, the aluminium sector was the most likely to experience the greatest financial impact. The aluminium sector is significantly more open to international competition[3] than the other energy-intensive sectors that are already in the EU ETS. This threat of international competition limits the pass through of costs by smelters, so that any increased production costs caused by the EU ETS are likely to be absorbed, lowering operating margins. The concerns identified in these studies were reiterated by the sector during stakeholder consultation in Working Groups A and B of this project.

The results from the modelling carried out in this study on inclusion of the non-ferrous sector suggest that with a high post-Kyoto target for the EU, inclusion in the EU ETS would lead to a less than one per cent reduction in the value added for the sector and in production levels. The reduction in value added for the aluminium sector could be higher than this average reduction across the sector due to its higher energy intensity, but it is not possible to estimate how much higher. A better indication of the magnitude of impacts on the aluminium sector could be gained through using a sectoral model of the aluminium industry, or using a more bottom-up economic modelling approach. Further analysis of this kind is necessary before making a decision on whether the aluminium sector should be included in the EU ETS.

Chemicals

The GEM-E3 model results suggest that on inclusion in the EU ETS, demand for chemical sector products will fall slightly, leading to a reduction in production, and a moderate fall in value added of 0.7 and 1.7 per cent for low and high post-Kyoto target scenarios respectively. Exports fall more significantly by six per cent under a high post-Kyoto target. These results suggest that while there may be some adverse impacts on the chemicals sector they are not so significant as to rule out inclusion in the EU ETS. It would be useful to carry out a further examination of economic impacts on the sector before a final decision is made on inclusion using more detailed sub-sectoral modelling or a bottom-up approach.

On the basis of the bottom-up modelling undertaken by this study, we would recommend that N_2O from nitric and adipic acid are considered for inclusion in the EU ETS as the economic impacts are not significant for either sector. In both cases, care would need to be taken in the allocation of allowances, due to the low marginal costs of abatement and significant reductions from ‘business as usual’ emissions which are available. Economic statistics from the bottom-up modelling indicate that the nitric acid and adipic acid sectors only have a low exposure to international competition. Using an illustrative equilibrium allowance price of ten €/t CO_2 eq, the adipic acid sector stands to benefit from participation in the EU ETS, given its very low (yet positive) marginal abatement costs. The nitric acid sector does not reap financial benefits from participation in the EU ETS, but the adverse impacts are not significant either.

3 As measured by the Organisation for Economic Co-operation and Development (OECD) openness ratio.

Coal

Overall, the Sustainability Appraisal leads to the recommendation that coal-mine methane should be included in the EU ETS with the caveat that safety concerns are addressed. The modelling results suggest that the economic impacts of inclusion would be positive and that the position of EU coal on the international market would not be jeopardised due to low abatement costs.

The results from the GEM-E3 modelling indicate that the coal sector benefits from the inclusion of coal-mine methane in the EU ETS. This agrees with the results from the bottom-up modelling. The benefits are due to low abatement costs that are offset by income from electricity generated from coal-mine methane. The sector could be a net seller of carbon permits to the market, so care would need to be taken in allocating allowances as the sector could potentially experience windfall gains and flood the market. The coal industry is predicted to expand if it is included in the EU ETS because the negative variable costs provide producers with the opportunity to reduce price, with the result that output increases.

Harmonisation and design issues

Domestic offsets

From an environmental point of view, the use of a domestic offset programme will have a limited direct effect, as emission reductions achieved in non-EU ETS sectors will result in credits sold into EU ETS sectors. As a consequence, emissions in the EU ETS sectors will increase compared to the emissions in absence of a domestic offset scheme. Only if discounting is applied, ie not all emission reductions of a project are converted into credits, will domestic offset projects result in extra emission reductions. There can be an indirect effect, however, when the carbon price incentive becomes available to other sectors and organisations, creating an increased awareness of and interest in emission reductions measures. This could lead to increased implementation of such measures, even beyond the realm of a domestic offset programme.

On the economic side, the additional flexibility for EU ETS participants of buying domestic offset credits will reduce compliance cost. The careful design of the approach should ensure that transaction costs are kept low. Lessons learned from existing programmes and comparable initiatives show significant potential for reducing transaction costs.

Social impacts of a potential domestic offset programme may include job creation in certain target sectors, for example the agricultural or forestry sector and providing services such as project development, monitoring and verification, etc. Other social impacts can include a reduction of fuel poverty in the case of residential projects or improved mobility in the case of transport projects.

It must be noted that the above assessment of impacts is based on a programme that meets the criteria for a domestic offset programme as formulated by Working Group C where:

- rules and procedures for verifying domestic offset credits are such that emissions sold into the EU ETS system are additional and certain
- the additional availability of potentially low cost compliance options for EU ETS participants is balanced with the need to maintain an incentive for in-house emission reductions by EU ETS participants.

The interaction between the EU ETS and other policies and measures

Better upfront coordination in the development of new policies and measures that affect greenhouse gas emissions can be expected to improve the effectiveness and efficiency of policies and measures. It is also likely to reduce transaction costs for government as well as the stakeholders targeted by the policies and measures as unintended overlaps can be avoided rather than addressed after implementation. The cost of using the checklist developed by this project to further improve the co-ordination of greenhouse gas policy formulation will be very limited.

No social impacts are expected for this policy proposal.

Improving the transparency of the EU ETS

The current lack of transparency surrounding the use of growth rates in the allocation process can lead to significant over-allocation. As such, it has the potential to have a high impact on both the environmental integrity of the EU ETS and the competitiveness between sectors, and especially between countries. The recommended tools to improve transparency, such as the reporting template and the (to be further developed) growth-rate algorithm will limit these impacts. According to a number of consulted competent authorities, the additional reporting efforts required in using these tools are not excessive.

However, the Sustainability Appraisal indicates that the work on sectoral policy pressures may be more costly, as the proposed methodology can not be applied in its current form, given the current modelling approaches in selected Member States. Therefore it is important that as a next step, the recommendation in Working Group C to further explore different alternative options and to further test the methodology in more Member States is taken forward.

It must be noted the problems with the use of the proposed methodology for assessing sectoral policy pressure are largely due to deficiencies in the current reporting under the Monitoring Mechanism. These deficiencies lead to inconsistencies in approaches used by Member States. As a result, substantial difficulties exist in assessing the effectiveness of policies and measures, the progress of different Member States towards their Kyoto/Burden Sharing targets and the contribution of different sectors to reaching those targets. This can have large impacts on both the environmental effectiveness of European climate change policy and the competitiveness of different industries.

The above issues might be best addressed, from a methodological point of view, by the development of an EU-wide model, using a common approach for all Member States, which allows for a modelling of the effectiveness of policies and measures. A preliminary, rough estimate of the development cost for such a model would be about one million Euros. It must be noted, however, that it is not clear whether Member States would be willing to use such a model (or its results) over their own models that have been especially developed to fit their national context and needs.

No significant social impacts of the above policy recommendations are expected.

1 Introduction

The EU ETS has been operating for a year. At this point there is a need to look critically at the system with a view to improving and developing the scheme for the longer term. The European Commission will be undertaking a review and, if necessary, presenting legislative proposals for an update of the scheme during 2006[4]. The environmental protection agencies for England and Wales, Austria, Denmark, Germany and Italy have carried out the LETS Update project under the EU LIFE Environment Programme to help inform the Commission's review of the scheme[5].

This report presents the conclusions of the LETS Update Sustainability Appraisal, including an assessment of the feasibility of expanding the scheme to cover new sectors and gases and ways to improve the design and implementation of the scheme. Given the proximity of the start of Phase II of the scheme (2008) there is not sufficient time to drive through legislative changes for the second trading period. For this reason, the conclusions of this report relate, in most part, to Phase III of the scheme, starting in 2013.

The LETS Update project consists of a Scoping Phase, which identified and prioritised key issues for more detailed study during the Main Phase of the work programme. This included a comprehensive review of available information on Phase I of the EU ETS and preparations by Member States for Phase II, and a criteria-based evaluation of a wide range of sectors currently not covered by the scheme to assess their suitability for inclusion in a future phase.

The Steering and Advisory Groups[6] selected the issues for further study in the Main Phase of the Work Programme, according to where the LETS Update project could provide the greatest contribution and bearing in mind other work being undertaken by Working Group 3 of the Climate Change Committee[7] and the Climate Strategies Network[8].

Three working groups carried out the Main Phase of the LETS Update work programme. Working Group A considered the feasibility of including CO_2 and non CO_2 emissions from chemical production (ammonia, fertilisers and petrochemicals) and methane (CH_4) from active coal mines. Working Group B considered the feasibility of including CO_2 and Per-fluoro Carbons (PFC) emissions from aluminium production and HFCs used in refrigeration. Working Group C considered a number of design and harmonisation issues, including the transparency of the preparation and assessment of National Allocation Plans, the interactions between the EU ETS and other EU policies and the potential for using domestic offset programmes. The Sustainability Appraisal presented in this report was carried out on the conclusions of the Working Groups.

4 Article 30 of the EU Emissions Trading Directive requires the Commission to present a report to the European Parliament by 30 June 2006.

5 The LETS Update project is funded by the EU LIFE Environment programme. Project number: LIFE05/ENV/UK/PREP/12.

6 See inside front cover for a list of people who have supported the LETS Update project.

7 WG3 is co-ordinated by the European Commission and consists of representatives of all EU25 Member States.

8 The Climate Strategies Network represented by Michael Grubb on the project's Advisory Group has undertaken studies on allocation issues for Phase II.

Each Working Group consisted of representatives of the partner organisations[9] and additional members invited to join the groups due to specialist knowledge in a relevant area[10]. The Working Groups steered the technical work, which was undertaken by the contractors, Ecofys and AEA Technology.

Conclusions from Working Groups A and B

Working Groups A and B[11] considered in detail the feasibility of inclusion, and devised route maps for the inclusion of the most promising sectors selected in the Scoping Phase:

- Chemicals – CO_2 and N_2O
- Aluminium – CO_2 and PFCs
- Coal-mine methane
- Refrigerants – HFCs.

The preliminary conclusions of Working Groups A and B, prior to the Sustainability Appraisal, were as follows:

- **Aluminium:** To include CO_2 emissions from primary aluminium production in Phase III of the EU ETS. PFC emissions from primary aluminium production should be included only if CO_2 emissions are included in Phase III. Inclusion of both gases would simplify emissions reporting and increase flexibility.

- **Chemicals:** To include CO_2 emissions from ammonia, fertiliser and ammonia and petrochemicals production and N_2O from adipic acid and nitric acid production in Phase III of the EU ETS. N_2O emissions could be included before Phase III.

- **Coal-mine methane:** Methane from active underground coal mines is recommended for inclusion in the EU ETS in Phase III. Important caveats are that for inclusion to be feasible Member States would need to work with government bodies to overcome current safety regulatory barriers to installing methane abatement equipment, and Member States would need to develop viable allocation methodologies.

- **Refrigeration:** The sector will already be subject to a range of mandatory emissions control measures as a result of the forthcoming EU regulation on F-gases. F-gas emissions from the refrigeration sector should therefore not be considered at this time for inclusion in the EU ETS. This recommendation should be reviewed when the regulation has been implemented for four years.

Only those sectors deemed potentially suitable for inclusion in the EU ETS, aluminium, chemicals and coal-mine methane, were taken forward for further analysis under this Sustainability Appraisal. Refrigeration was not covered under the Sustainability Appraisal, as it was not recommended for future inclusion under the EU ETS.

9 DESHt was a member of Working Group C only.

10 See the inside front cover for members of the Working Groups.

11 (April 2006) 'LETS Update: Working Groups A and B', Environment Agency for England and Wales.

This report outlines the Sustainability Appraisal findings. The approach taken for the appraisal is outlined in Section 2, together with the methodology used for the economic assessment which is the main focus of the assessment of the above recommendations. An overview of the results of the appraisal is given in Section 3, and the main economic, environmental and social impacts, for each of sectors considered suitable for inclusion, are given in Sections 4 to 6. Each of these sections begins with a summary of the overall implications of the Sustainability Appraisal for including the sector in the EU ETS. This is followed by more detailed results from the macroeconomic modelling and the results of a bottom-up economic assessment that was carried out for coal-mine methane and N_2O-emitting chemical sub-sectors. For the aluminium sector, the conclusions of recent studies assessing the indirect impacts of the EU ETS on the aluminium sector are also discussed (Section 4).

The conclusions from Working Group C

Working Group C of the LETS Update project researched three areas, selected in the Scoping Phase, for improving the design and harmonisation of the EU ETS. These were:

- the role of domestic offset projects in the future ETS
- the interaction between the EU ETS and other EU policies and measures
- improving the transparency of developing and assessing NAPs.

As part of the Sustainability Appraisal, a qualitative assessment of the key economic, social and environmental impacts of each of the areas researched was made, and is reported in Sections 8.2 to 8.4. Only a qualitative assessment is made, as the areas researched are broad suggestions for potential improvements to the EU, rather than detailed proposals. These sections conclude with an overall assessment balancing potential impacts on the environment, society and the economy.

2 Approach

2.1 Appraisal of policy proposals

The Commission issued its Sustainable Development Strategy in 2001[12]. This identified the principles and objectives of sustainable development – economic prosperity, social equity, environment protection and international responsibilities. In February 2005, the Commission published an initial stocktake and, subsequent to this, the European Council of June 2005 adopted stronger Guiding Principles for Sustainable Development. These were followed in December 2005 by a review of the strategy, which further developed it by setting out key actions for its effective implementation.

In order to contribute to an effective and efficient regulatory environment and to a more coherent implementation of the Sustainable Development Strategy the Commission has committed itself to perform an impact assessment of all major policy proposals. To this end, it has produced Impact Assessment Guidelines (SEC) 2005 791[13]. This involves a number of steps including definition of the problem, definition of objectives, development of main policy options, analysis of impacts, comparison of options and then monitoring and evaluation.

The proposals made by Working Groups A and B, to expand the EU ETS to include the aluminium, coal and chemicals sectors do not constitute a major policy proposal, rather they involve extending the coverage of an existing policy instrument. Some of the earlier steps in the impact assessment regarding definition of the problem and objectives are thus not relevant. It should be remembered that if these sectors remain outside the EU ETS, they and other non-ETS sectors would be targeted by other policies and measures to reduce emissions. The main alternative option to inclusion in the EU ETS is regulation and/or voluntary agreements, and the advantages and disadvantages of this for each of the sectors was considered in some detail in the final report of Working Groups A and B[14]. For the three sectors, aluminium, chemicals and coal, subject to the results of the additional analysis done in this report, inclusion in the EU ETS was considered the preferred option. The fourth sector, stationary refrigeration studied by Working Groups A and B, was not considered suitable for potential inclusion in the EU ETS, and is therefore not evaluated in this Sustainability Appraisal.

This Sustainability Appraisal used the framework suggested in the Impact Assessment Guidelines to examine the additional impacts of inclusion of these sectors in the EU ETS. It does not attempt to examine the impacts of the EU ETS as a whole[15].

12 (2001), 'A Sustainable Europe for a Better World: a European Union Strategy for Sustainable Development', European Commission, COM (2001) 264 Final.

13 European Commission, (2005), 'Impact Assessment Guidelines', (sec) 2005 791.

14 (April 2006), 'LETS Update: Working Groups A and B', Environment Agency for England and Wales.

15 The economic impacts of implementing an EU wide trading scheme versus meeting targets nationally were examined in 2000 using the PRIMES and POLES energy models, see P Kapros and L Mantzoz, (2000), 'The Economic Effects of EU-Wide Industry-Level Emissions Trading to Reduce Greenhouse Gases, Results from the Primes Energy-system Model', NTUA, and (2000), 'Preliminary Analysis of the Implementation of an EU-Wide Permit Trading Scheme on CO_2 Emissions Abatement Costs, Results from the POLES Model', Institute for Prospective Technological Studies.

The proposals put forward by Working Group C were of a more general nature, and so only a qualitative assessment of the potential economic, environmental and social impacts was carried out. This concentrated on identifying and assessing the nature of potential impacts on GHG emissions and on the environmental integrity of the EU ETS, impacts on transaction and compliance costs and any changes in administrative burdens on Member State governments, competent bodies, or the European Commission. The results of this analysis are presented in Section 8.

2.2 Initial assessment of impacts

The Commission's guidelines recommend using a screening approach to assess potential economic, environmental, and social impacts of the policy in order to prioritise further assessment. The results of this exercise are shown in Tables 1 to 3. The key elements which emerge from the screening for further analysis and the methods used to assess them, and references to the sections describing the results of these assessments are summarised in Table 4.

An assessment of macroeconomic effects, impacts on competitiveness, employment and energy use have been assessed through the use of a macroeconomic model called the GEM-E3 (see Section 2.3 and Annex A). This was complemented for coal mining and parts of the chemicals sector (responsible for N_2O emissions) by a more bottom-up economic assessment, which used marginal cost curves and an illustrative carbon price for the EU ETS to examine the impacts on the sectors (see Section 2.3). The results of the bottom-up economic assessment are reported in Annex B and summarised in the relevant sector chapters. This additional economic analysis was carried out for N_2O emissions from the chemicals sector, only two specific parts of the chemical sector are involved (adipic acid and nitric acid production) and the more broad brush macroeconomic modelling does not allow modelling of these sectors in a disaggregated way. In the case of the coal sector, it was considered necessary to examine the impacts that the different structure of the industry across Member States might have on the way the sector responded to inclusion in the EU ETS.

The administrative costs to business and burdens on public authorities were considered in the earlier assessment of inclusion of the sectors in the EU ETS. The conclusions of this assessment were general to all three sectors and are summarised in Section 3.

Table 1 | Economic impacts

Impact on	Initial assessment	Further assessment required in this appraisal?
Competitiveness, trade and investment flows	Competitive position with non-EU industry rivals is key concern for some sectors (eg for aluminium).	Assess further using macroeconomic modelling.
Competition in the internal market	Effect on EU competition policy and functioning of internal market should be no greater than for existing EU ETS system.	Consider whether different structures of industry across Member States (MSs) could have an impact using a qualitative assessment.
Operating costs and conduct of business	Will be some transaction costs, but firms already in EU ETS already bear these.	Operating costs were considered in main analysis of sectors; conclusions are summarised in Section 3 of this report.
Administrative costs on businesses	Will be some additional administration costs, but current EU ETS participants already bear these. The firms in the chemical, aluminium and coal sector are not small or medium enterprises (SMEs) so no need to consider impacts on SMEs specifically.	Administrative costs were considered in main analysis of sectors; conclusions are summarised in Section 3 of this report.
Property rights	Not relevant	No
Innovation and research	Inclusion in the EU ETS should promote research and development into new technologies, carbon abatement options, and promote greater resource efficiency.	No
Consumers and households	Could be some impact on prices of goods for consumers if prices of goods in affected sectors increase.	Macroeconomic modelling will consider this element in a general sense.

Table 1 | Economic impacts (continued)

Impact on	Initial assessment	Further assessment required in this appraisal?
Specific regions or sectors	Proposal is targeted at three sectors (aluminium, chemicals and coal mining). Other energy-intensive industries are already included in the EU ETS. Impacts of inclusion of the three sectors will vary regionally depending on location of industry sectors, but in general no particular regions expected to be impacted on significantly above others.	No
Non-EU countries and international relations	No additional effects on trade policy and international obligations, foreign policy, development policy above those identified for the EU ETS.	No
Public authorities	Expansion of EU ETS scheme will have some resource implications for public bodies administering the schemes, but unlikely to be great in comparison to existing budgets for current EU ETS.	Burdens on public authorities were considered in main analysis of sectors; conclusions are summarised in Section 3 of this report.
The macroeconomic environment	Potential impacts on overall economic growth and employment; may be knock-on effects for the rest of the economy from changes in the sectors. For example, changes in the coal sector may affect the price of electricity, which will in turn have impacts on other sectors of the economy.	Use macroeconomic modelling to examine effects.

Table 2 | Environmental impacts

Impact on	Initial assessment	Further assessment required in this appraisal?
Air quality	Reduction in emissions of CO_2 would be accompanied by reduction in energy use and/or use of low-carbon energy sources. This should lead to a reduction in emissions of fuel combustion-related emissions, many of which contribute to poor air quality.	No further analysis considered necessary at this stage.
Water quality and resources	No direct effect. Inclusion in EU ETS could lead drive to generally more resource-efficient production, which could include reduction in water use, less discharges to water, but likely to be very process specific. Reduced emissions of combustion-related pollutants (see Air Quality (above)) could also lead to an improvement in the quality of water bodies, through reduced deposition of pollutants.	No
Soil quality or resources	No direct effect. Reduced emissions of combustion-related pollutants (see Air Quality (above)) could also lead to reduced acidification of soils, through reduced deposition of acidic pollutants such as SO_2.	No
The climate	Primary aim of policy is to reduce cost-effectively emissions of greenhouse gases, so this is a key impact to assess.	Use macro-economic modelling and bottom-up assessment to look at cost of achieving greenhouse gas reductions.

Table 2 | Environmental impacts (continued)

Impact on	Initial assessment	Further assessment required in this appraisal?
Renewable or non-renewable resources	Inclusion of the coal sector in the EU ETS will influence use of this non-renewable resource.	Examine impacts on coal use in macroeconomic modelling.
Biodiversity, flora, fauna and landscapes	No impacts foreseen.	No
Land use	No impact foreseen.	No
Waste production/generation/recycling	No increase in waste production foreseen. Recycling of aluminium is already attractive as it is a much less energy-intensive process than primary production so inclusion of the sector in the scheme is unlikely to increase recycling rates.	No
The likelihood or scale of environmental risks	Some potential concerns have been expressed by stakeholders over increased use of mine methane. Inclusion of this sector in the EU ETS should not be allowed to affect health and safety considerations.	Explore interaction between health and safety requirements and utilisation of mine methane further. See Section 6 for discussion.
Mobility (transport modes) and the use of energy	Reduction of CO_2 emissions in a cost-effective way is an aim of the policy and is likely to be achieved partly through reductions in energy use and partly through fuel switching to low carbon generation technologies.	Changes in energy use are examined in the macro-economic modelling carried out to examine competitiveness issues.
The environmental consequences of firms’ activities	The policy should lead to production becoming less energy intensive.	No
Animal and plant health, food and feed safety	No impacts.	No

Table 3 | Social impacts

Impact on	Initial assessment	Further assessment required in this appraisal?
Employment and labour markets	If entry into the EU ETS adversely affects the international competitiveness of the sector, then there could be employment effects.	Use macroeconomic modelling to examine.
Standards and rights related to job quality	No impacts.	No
Social inclusion and protection of particular groups	No impacts.	No
Equality of treatment and opportunities, non-discrimination	No impacts.	No
Private and family life, personal data	No impacts.	No
Governance, participation, good administration, access to justice, media and ethics	No impacts.	No
Public health and safety	No direct public heath impacts. There may be some indirect effects as the policy aims to help prevent climate change, which is associated with a number of potential impacts on public health.	No
Crime, terrorism and security	No impacts.	No
Access to and effects on social protection, health and educational systems	No impacts.	No

Table 4 | Key impacts identified through initial screening

Impact	Methodology used to assess impacts in this appraisal	Results of assessment
• The macroeconomic environment • Impacts on consumers and households through increased prices • Use of energy • Employment	Macroeconomic modelling of inclusion of each sector (see Section 2.2).	Section 3
• Competitiveness, trade and investment flows • The climate – changes in emissions of green-house gases	Macroeconomic modelling of inclusion of all three sectors (see Section 2.2). Bottom-up economic assessment of coal sector and chemical processes emitting N_2O (see Section 2.3 for details).	Sections: 4 (aluminium) 5 (chemicals) 6 (coal)
• Operating costs and conduct of business • Administrative costs on businesses • Burdens on public authorities from implementation	Qualitative assessment in Working Groups A and B report previously.	Section 3
• Environmental risks (safety issues in coal mining) • Competition in the internal market (coal sector)	Qualitative assessment	Section 6 on coal sector

2.3 Macroeconomic modelling of inclusion of the sectors

2.3.1 GEM-E3 model

Macroeconomic modelling of the inclusion of the three sectors in the EU ETS was examined by the National Technical University of Athens using the GEM-E3. The world version of the model, which includes 21 world regions linked through endogenous bilateral trade, and 19 productive sectors of the economy was used (Table 5). The model computes simultaneously the competitive market equilibrium and determines the optimum balance for energy demand/supply and emissions/abatement. It is specifically designed to be used for the appraisal of energy and environment policies. A brief description of the functioning of the model is in Annex A[16].

From the list of world regions, it can be seen that the EU is represented in this version of the model by the EU27 (the EU25 plus Romania and Bulgaria) rather than the EU25. The inclusion of Romania and Bulgaria in the EU grouping is believed by the modelling team to have only a minor impact on the results for the EU region, and no significant change in results would be expected for the EU25 alone.

Table 5 | World regions and productive sector breakdowns used in model for this study

World regions	
Canada	Sub-Saharan Africa
USA	Middle East
Australia, New Zealand	South-East Asia Dynamic Economies
Japan	South Asia
EU27	India
Other European OECD countries	China
Former Soviet Union	Mexico and Venzuela
Middle Africa	Brazil
South Africa	Indonesia
North Africa	Latin America
Sectors	
Agriculture	Transport equipment
Coal	Other equipment goods
Oil	Other manufacturing oridycts
Gas	Construction
Electricity	Food industry
Ferrous metals	Trade and transport
Non-ferrous metals	Textile industry
Chemical products	Other market services
Other energy intensive	Non-market services
Electronic equipment	

16 A full description of the GEM-E3 model is available at www.gem-e3.net/. See also Annex A

The world version of the model was chosen over the European version as it allows the separation of the metals sector into ferrous and non-ferrous metals; it also allows more accurate representation of trade, which was considered important given the concerns over the international exposure of the aluminium industry. The level of disaggregation of the sectors in the model is not ideal for the purposes of this study, but is the greatest possible within the model, as more disaggregated international trade statistics are not available. The aluminium sector accounts for just over 20 per cent of non-ferrous metals production (by volume), about a third of direct (process and combustion) CO_2 emissions and about 50 per cent of end use energy demand within the sector (including electricity use). The use of the non-ferrous sector to represent the aluminium sector in the analysis is thus a very coarse approximation. Similarly the 'chemical products' sector in the model is much broader than the portion of the chemicals sector actually proposed for inclusion in the EU ETS.

While the modelling undertaken for this Sustainability Appraisal goes some way to examine the economic, social (ie employment) and environmental effects (energy use and emissions) of inclusion of these sectors, we recognise that the results have significant limitations. This is primarily due to the project timescale which meant that the objectives and approach for the appraisal had to be decided before the analysis on the feasibility of the potential sectors had reached its conclusions. The GEM-E3 model was selected as it provides general information on the main elements of a Sustainability Appraisal. It subsequently became clear that the most useful and appropriate modelling to complement this work would have been a sectorally-based analysis of the potential economic impacts, particularly on competitiveness. It is clear that for the chemicals and aluminium sectors which are most exposed to international competition, this more detailed level of analysis should be undertaken before a decision is taken on inclusion.

2.3.2 Scenarios modelled

Four main scenarios were modelled (names in brackets indicate the name used to refer to the scenario in the rest of the report):

- Continuation of the EU ETS as currently operated (current EU ETS)
- Inclusion of the non-ferrous metals sector in the EU ETS (current EU ETS + non-ferrous)
- Inclusion of the chemicals sector in the EU ETS (current EU ETS + chemicals)
- Inclusion of the coal sector in the EU ETS (current EU ETS + coal).

A number of key assumptions were required to run the model, for example on post-Kyoto targets and the use of the Clean Development Mechanism (CDM) and Joint Implementation (JI) by all Annex B countries[17], and the future overall cap for the EU ETS. These are shown in Box 1. The choice of assumptions is not intended to form a forecast of future action, but to provide a realistic backdrop against which inclusion in the EU ETS can be assessed. The stringency of post-Kyoto targets for both the EU and other Annex B countries was considered to be of key importance and therefore each of the scenarios was run with both a low post-Kyoto and a high post-Kyoto target.

[17] Annex B to the Kyoto Protocol lists countries that have adapted mandatory emissions targets for the period 2008–12.

The modelling under the Sustainability Appraisal was not aimed at assessing absolute reductions, but about relative changes compared to other scenarios, outlined in this section. This relative change approach minimises the impact of specific assumptions on the overall results.

The two scenarios that were run for comparison were:
- a reference baseline which assumes no targets post-Kyoto and thus has no constraints on emissions post-2010 (no targets baseline)
- an ‘all trading scenario’ where all parts of the economy are allowed to trade and which effectively determines the most cost-effective way of meeting targets (all trading).

When the three sectors of interest are not in the EU ETS the only constraint set on their emissions post-2010 is that they may not rise above those in the reference baseline. In reality, it is likely that these sectors would be the subject of other policies and measures, and the results are therefore a ‘worst case’ assessment of the impacts for the sectors.

The overall results for the EU economy of inclusion of the sectors are shown in Section 3. The results for each of the sectors are discussed in Sections 4 (aluminium), 5 (chemicals) and 6 (coal mining).

Box 1: Key assumptions used to define the model

Post-Kyoto targets

The only indication of potential Post-Kyoto targets for the EU has been the Council conclusions[18] which suggested that 'reduction pathways by the group of developed countries in the order of 15–30% by 2020 and 60–80% by 2050 compared to the baseline envisaged in the Kyoto Protocol should be considered'. Two targets were therefore considered for the EU:

- 15% reduction from 1990 levels by 2020
- 30% reduction from 1990 levels by 2020.

For other Annex 1 countries which have ratified the Kyoto Protocol, their 2020 targets were set so as to require an equivalent effort to the EU, ie an additional reduction of 7% and 22% of 1990 emissions between 2010 and 2020. For example, a country with a Kyoto target of -5% in 2010 will have targets of -12% and -27% in 2020. As the US has not ratified, it is given a target in 2010 of a 7% reduction from 1990, this target corresponds to a 17% reduction in Greenhouse Gas (GHG) emission intensity.

Cap for EU ETS sectors

Current EU ETS sectors

An allocation/Cap for the current EU ETS sectors (CO_2 emissions only) in 2020 has been derived based on the current NAP allocations for Phase I and a judgment on how this will evolve to 2010 in the future, based on assessments of the impact of additional policies and measures currently proposed by MSs for industry. By 2010, the cap was assumed to have tightened to 1,979 Mt CO_2 eq for the current EU ETS sectors, and by 2020 to 1,823 and 1,500 Mt CO_2 eq respectively in the low and high post-Kyoto target scenarios. The use of company level CDM which might be expected was estimated as 100 and 200 Mt CO_2 eq per year in 2020 in the low and high post-Kyoto target scenarios respectively.

Expansion to new sectors

When additional sectors are added in, the EU ETS cap is adjusted so that the overall percentage reduction required for the EU ETS sectors remains the same.

Use of CDM and JI

A limit has been set on the amount of CDM to be used to meet EU targets (ie implicitly stipulating the amount which must be achieved through domestic action). An additional amount of company level CDM is assumed to be used by companies within the EU ETS. Non-EU Annex B countries are allowed to use CDM and JI. The CDM hosting regions are Brazil, China, East Asia, India, Latin America, Mexico and Venezuela. For the EU27 it is estimated that 100 Mt CO_2 eq per year of CDM credits are available in 2010. This is based on assessments of countries' plans for the use of CDM to meet Kyoto targets. In 2020, 200 and 500 Mt CO_2 eq were assumed to be available for use in the low and high post-Kyoto target scenarios.

Allocation of permits

Within the model, all permits are allocated using a grandfathering approach.

[18] 6693/05 (Presse 40) (OR. fr) PRESS RELEASE 2647th Council Meeting, Environment, Brussels, 10 March 2005, Main results of the Council.

2.4 Bottom-up economic modelling

The methodology used to assess the financial impact on the coal, nitric acid and adipic acid sectors of participating in the EU ETS is based on the approach used by the United States (US) Environment Protection Agency (EPA) for Regulatory Impact Assessment[19]. This estimated a number of impacts in the short and long term and assesses whether they are significant (Table 6). The analysis used sector-specific marginal abatement cost curves and an equilibrium price of allowances to estimate the effects of inclusion in the EU ETS. Full details are given in Annex B. Results from the macroeconomic analysis giving the price of carbon were not available before the analysis was undertaken, and so an illustrative price of ten €/t CO_2 eq was assumed. The price of carbon predicted by the GEM-E3 model under a low post-Kyoto target is shown in Table 7. This shows that the value assumed for the bottom-up modelling is consistent with the range forecast by GEM-E3.

Table 6 | Impacts assessed in the bottom-up economic modelling

Short-run analysis	Long-run analysis

• Change in market price
• Short run change in output
• Change in gross margin
• Maximum potential impact:
  • Revenue ratio
  • Cost to profit ratio
• Minimum potential impact:
  • Revenue ratio
  • Cost to profit ratio
	• Long run change in output
	• Firm closures:
	  • Maximum
	  • Minimum

Table 7 | Carbon prices (€/t CO_2) in the EU ETS sectors in GEM-E3 scenarios in 2015

	Current EU ETS	EU ETS+non-ferrous	EU ETS+chemicals	EU ETS+coal
Low post-Kyoto target	7	7	6	6
High post-Kyoto target	13	13	11	11

19 US EPA (1999) and Dole (2001). D Dole, (2001), 'Measuring the Impact of Regulation on Firms, Working Paper 01–03', National Centre for Environmental Economics, US Environmental Protection Agency, Washington, DC.

3 Overall impacts on EU25 economy

3.1 Changes in key economic parameters

Figure 1 shows the changes in key macroeconomic parameters forecast by GEM-E3 for the EU27 (EU25 plus Romania and Bulgaria). The inclusion of Romania and Bulgaria in the EU grouping is believed by the modelling team to have only a minor impact on the results for the EU region, and no significant change in results would be expected for the EU25 as compared to the EU27. Sector specific results are discussed in Sections 4 to 6.

The scenarios modelled were:

- continuation of the EU ETS as currently operated (current EU ETS)
- inclusion of the non-ferrous metals sector in the EU ETS (current EU ETS + non-ferrous)
- inclusion of the chemicals sector in the EU ETS (current EU ETS + chemicals)
- inclusion of the coal sector in the EU ETS (current EU ETS + coal).

Each of these scenarios was modelled under low and high post-Kyoto targets for 2020 of a 15 and 30 per cent reduction in greenhouse gas emissions from 1990 levels.

Impact on GDP

Results from GEM-E3 suggest that inclusion of the non-ferrous sector or the chemicals sector in the EU ETS would lead to a very small fall in total GDP for the EU27 of about 0.02 per cent on inclusion of the non-ferrous sector and of up to 0.04 per cent on inclusion of the chemicals sector, depending on the stringency of the EU post-Kyoto target. This is due to small falls in production and in the value added of these sectors when included in the EU ETS. In the case of the coal sector, GDP is forecast to increase between 0.01 and 0.1 per cent. This is a result of production and value added in the coal sector rising on its inclusion in the EU ETS. Due to the availability of substantial low-cost abatement opportunities, the coal sector is able to sell permits, and this revenue reduces the price of coal, thus increasing demand and production. This effect suggests that if coal were to be included then care would need to be taken in setting the allocation of permits for the system.

Impacts on employment

The model shows that there is very little effect on employment on inclusion of any of the sectors. Inclusion of the non-ferrous and chemicals sector leads to increases of 0.002 to 0.003 per cent and 0.005 per cent to 0.006 per cent respectively, whereas inclusion of the coal sector sees a small reduction in employment of 0.006 per cent under a high post-Kyoto target.

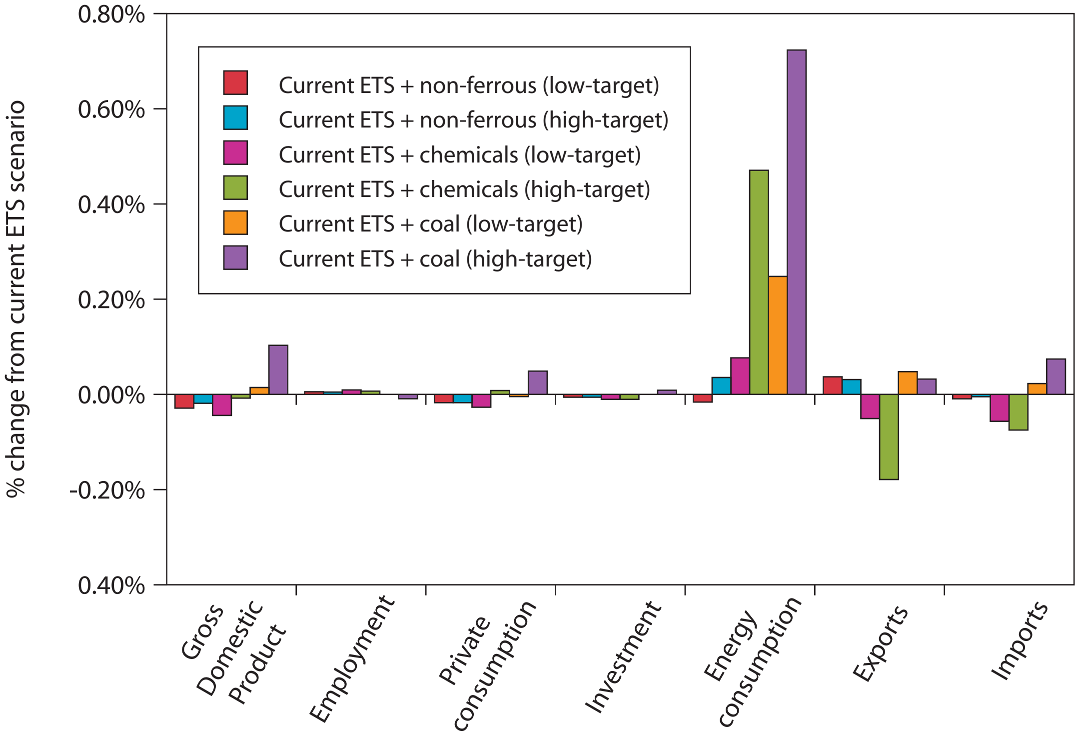
Impacts on private consumption

Impacts on private consumption follow the same pattern as changes in GDP, although they are only about half the magnitude of changes in GDP.

Impacts on investment

These are very small. As for GDP, inclusion of the non-ferrous and chemicals sector leads to a small decrease in investment (of 0.002 per cent and 0.004 to 0.005 per cent respectively). Again, this is related to the loss of value added in these sectors when they are included in the EU ETS. Investment shows a small increase (of 0.006 per cent) upon inclusion of the coal sector in the EU ETS, due to the increase in value added in this sector.

Figure 1 | Changes in key economic parameters in 2020 (from the 'Current EU ETS' scenario)



Energy consumption

Energy consumption increases when the chemicals and coal sectors are included in the EU ETS. This is because these sectors offer relatively low cost abatement opportunities for non CO_2 greenhouse gases. The trading sectors take advantage of these opportunities when the sectors are introduced into the EU ETS. Not such a great reduction in CO_2 emissions is required and hence consumption of fossil-based fuels (and hence energy consumption in general) does not reduce as much as in the current EU ETS scenario, where only CO_2 is included in the scheme. The effect is exaggerated for the chemicals sector, partly as discussed earlier because the chemicals sector in the model is much broader than the sub-sectors suggested for inclusion and partly because the model only allows for none or all of the non CO_2 GHGs within a sector to be in the EU ETS. This means that in addition to N_2O emissions reduction opportunities, HFC reduction opportunities are available and are utilised when the chemicals sector is included in the model. This effect can also be seen by looking at the changes in GHG emissions when sectors are included in the scheme.

An increase in energy consumption is also seen on inclusion of the non-ferrous metals sector, under a high Kyoto target; reflecting opportunities for abatement of PFCs in the aluminium sector within the model[20].

20 The more detailed sectoral analysis carried out in preceding work (LETS Update: Final Report for Working Groups A and B, April 2006) suggested that PFC reduction opportunities were limited, suggesting that the marginal cost abatement curve used in model may need updating.

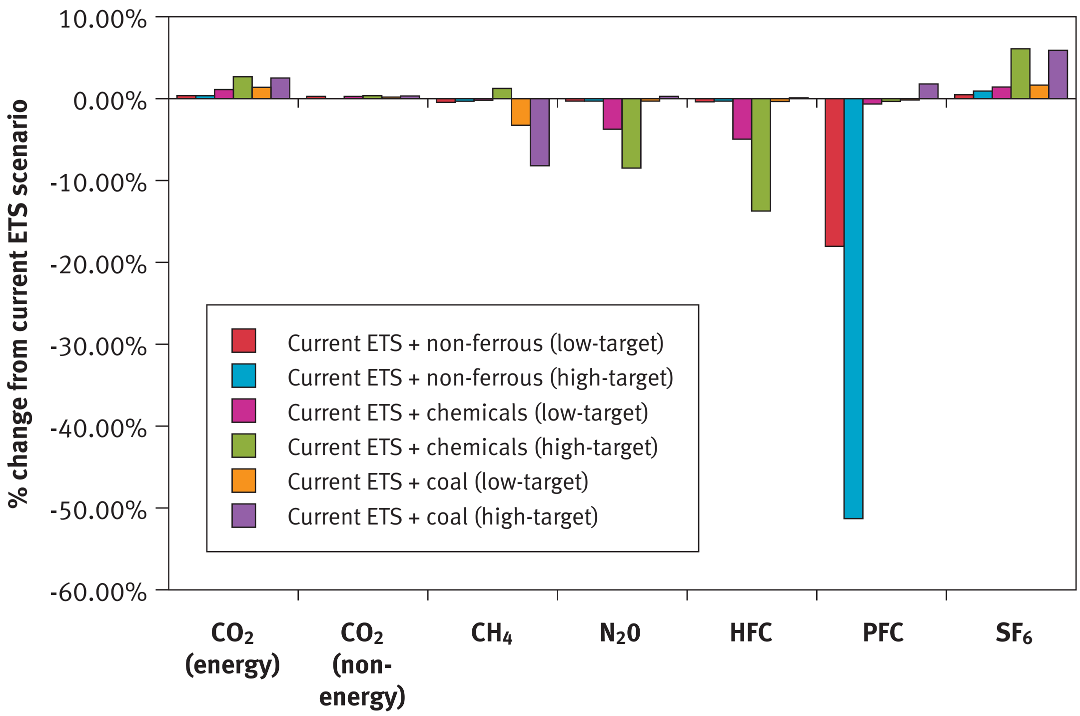
3.2 Changes in greenhouse gas emissions

The overall reduction in GHG emissions is the same in each scenario as the model ensures that the post-Kyoto target for the EU is met. However the pattern of abatement is different in each (Figure 2). As discussed above, the introduction of non CO_2 GHGs to the trading scheme brings in relatively low cost abatement options. This increased flexibility means that the non CO_2 GHG emissions decrease for scenarios where chemicals, non-ferrous metals and coal are included, and energy-related CO_2 emissions increase on the introduction of each of these sectors. The largest percentage decrease in PFCs occurs when the non-ferrous sector is included, though this effect is less significant than it looks as PFCs are a very small proportion of total EU25 GHG emissions in terms of overall carbon equivalent emissions.

3.3 Administrative costs for public authorities

The inclusion of the chemicals, aluminium and coal-mining sectors in the EU ETS would result in a range of associated costs for public authorities, industry and the European Commission. Such administrative costs need to be considered when assessing inclusion into the scheme. The overall conclusions of Working Groups A and B are that expansion of the EU ETS to the proposed sectors would have some budgetary implications for public bodies administering the schemes, but it is unlikely to be great relative to current EU ETS costs as emissions from these sectors come from a limited number of large point sources.

Figure 2 | Changes in emissions in 2020 for all sectors in the EU25
(from the 'Current EU ETS' scenario)



Public authorities most affected by an expansion of the EU ETS will be the competent authorities. The LETS Update project partners included the competent authorities for the EU ETS in four Member States (Austria, Denmark, Germany and the UK), and the project team considered the impacts on competent authorities when assessing each sector for suitability for inclusion. The overall conclusions from Working Groups A and B are that expansion of the EU ETS to cover the chemicals, aluminium and coal sectors would have some budgetary implications for public bodies administering the schemes, but it is unlikely to be great in comparison to the budgetary demands of the current EU ETS sectors. Emissions from the three sectors come from a limited number of large point sources (between 300 and 400 sites[21] for all three sectors compared to over 11,000 installations currently in the EU ETS) and thus the number of extra EU ETS participants should be manageable.

Administrative costs to the trading scheme's competent authorities will include the determination of credit allocation, and requirements for permitting and registration. The competent authorities will also need to verify emission estimate parameters, for example, for the aluminium PFCs this would be the amount of aluminium produced, and the anode effect in minutes per cell day.

Monitoring and reporting guidelines will need to specify the necessary tier approach that site operators will be required to use, and competent authorities will need resources to approve emissions calculation methodologies. Under the EU ETS, this requirement is outlined in Section 4.2.2.1.4 of the monitoring guidelines. Operators are required to use the most accurate methodology unless it is shown to the satisfaction of the competent authority that the highest tier approach is technically not feasible or will lead to unreasonably high costs.

In the mining sector, new methane combustion plant would need to be approved by the Member States' mining authorities. Germany and the UK have raised this as a potential barrier to meeting commitments under the EU ETS, and Member States would need to work with mining authorities to coordinate approval procedures to minimise delays. Thus there could be some additional resource demands on mining authorities if coal-mine methane was included in the EU ETS.

3.4 Administrative and operating costs on businesses

There are two types of day-to-day costs which businesses are exposed to:

- Administrative costs of the scheme
- Resource costs of meeting scheme requirements.

Administrative costs

Administrative costs borne by industry will include payment of fees for the trading permit, scheme subsistence and emissions verification. These are minimised due to the comparatively small number of operators in the sectors proposed, and also through co-operation through strong trade association bodies. Firms already in the EU ETS have managed under these additional administration costs and some businesses affected by the proposed scheme expansion are already under the EU ETS for energy generation-related emissions, and have already adjusted to the additional costs. Smaller businesses will be hit harder by administration costs, but the majority of businesses in the chemicals, aluminium and coal sectors are the larger major industry players.

21 (April 2006), 'LETS Update: Working Groups A and B', Environment Agency for England and Wales.

Costs of meeting the scheme requirements

In addition to administration costs, businesses will need to cover other costs, which will be incurred during preparations for participating in the scheme. These might include:

- the purchase of measurement equipment, particularly if operators need to move to a higher Intergovernmental Panel on Climate Change (IPCC) emissions methodology estimation tier for example, Tier 2 to 3b
- installation of monitoring software for example, for aluminium, software for recording the different parameters on which anode effect frequency and duration are recorded
- training plant operators to effectively manage a monitoring and reporting system.

Implementation of management systems to ensure a systematic approach to monitoring and reporting may also be an additional cost, which could be marginal if necessary systems are already in place.

4 Aluminium sector

4.1 Summary for sector

The aluminium sector is very electricity intensive and therefore is already indirectly affected by the EU ETS through the effect that the inclusion of the power supply sector has on electricity prices. LETS Update looked at expansion of the EU ETS to include CO_2 and PFC emissions from the primary aluminium industry in Phase III of the trading scheme.

Previous work on the impact of the EU ETS on the aluminium sector has looked at indirect effects from higher electricity prices rather than the direct effects of sector inclusion. This found that compared to energy-intensive sectors such as cement and steel which are already in the EU ETS, the aluminium sector was the most likely to experience the greatest financial impact; even though the impact of the EU ETS was limited to indirect costs only. The aluminium sector is significantly more open to international competition (as measured by the OECD openness ratio, see Box 2) than other sectors such as the iron and steel sectors which are already in the EU ETS, and this threat of international competition limits the pass through of costs by smelters. Any increased production costs caused by the EU ETS are thus likely to be absorbed, lowering operating margins. The concerns identified in these studies were reiterated by the sector during stakeholder consultation over the potential inclusion of the sector in the EU ETS.

The GEM-E3 model used to examine the macroeconomic effects of expanding the EU ETS for this Sustainability Appraisal does not allow the aluminium industry to be modelled as a separate sector as disaggregated international trade statistics are not available. The greatest level of disaggregation which can be achieved is the non-ferrous metals sector. The aluminium sector accounts for almost a fifth of non-ferrous metals production (by volume), about a third of direct (process and combustion) CO_2 emissions and about 50 per cent of end use energy demand within the sector (including electricity use)[22]. It is significantly more energy intensive than other parts of the non-ferrous metals sector. The use of the non-ferrous metals sector to represent the aluminium sector in the analysis is thus a very coarse approximation and is a serious limitation of the modelling work carried out.

The GEM-E3 model was used to compare macroeconomic indicators for the non-ferrous sector under two scenarios:

- Current EU ETS – there is no expansion of the EU ETS, ie the EU ETS applies only to sectors currently (in Phase I) in the EU ETS and only to CO_2 emissions from those sectors. A reduction is required in emissions from the EU ETS sectors. The only constraint placed on emissions from the aluminium sector is that they may not rise above those in the reference base case where no emissions targets are set post-Kyoto.
- Current EU ETS + non-ferrous – the EU ETS is expanded to include the non-ferrous metals sector.

The modelling represents a worst-case appraisal of the impacts on the non-ferrous metals sector of inclusion in the EU ETS in the sense that if it remains outside the EU ETS, emissions are unlikely to be allowed to be totally unconstrained, as they would be the target of other policies and measures.

[22] PRIMES data for 2000 and LETS Update Scoping Report, Environment Agency for England and Wales April, 2006.

The GEM-E3 model results show that inclusion of the non-ferrous metals sector in the EU ETS leads to reduced demand for non-ferrous metals (as a result of higher prices) which leads to a small (less than one per cent) reduction in production levels and in value added for the sector, even under a high post-Kyoto target. Work during the development of the model scenarios suggested the results are quite sensitive to the stringency of the EU post-Kyoto target compared to other Annex B country targets, and the flexibility of both these countries and the EU to use mechanisms such as JI and CDM. This is to be expected given the relatively high exposure to international competitiveness of these sectors.

Sectoral emission reductions are significantly higher than those forecast if the sector remains outside the EU ETS. However, the reductions forecast for PFC emissions seem high given the proposed adoption of best available technologies in a 'business as usual' future, suggesting that this business as usual development is not taken into account in the reference baseline for the model.

For the non-ferrous sector as a whole the small adverse impacts on the sector of inclusion in the EU ETS do not appear so significant as to warrant not considering inclusion. However, it is not possible to say by how much the results at the sub-sector level of primary aluminium production would vary from these 'average' results for the sector as a whole, given the more energy-intensive nature of aluminium production compared to other non-ferrous metals. A better indication of the magnitude of impacts on the aluminium sector could be gained through using a sectoral model of the aluminium industry[23], or using a more bottom-up economic modelling approach. Further analysis of this kind would be useful before making a decision on whether the aluminium sector should be included in the EU ETS.

4.2 Results from macroeconomic modelling

Sector coverage

The GEM-E3 world model used for the macroeconomic impact assessment can only disaggregate sectors down to the level of ferrous and non-ferrous metals. The Sustainability Appraisal results are presented for non-ferrous metals[24]. This means the results in this section must be interpreted with caution as aluminium is only one of a number of sub-sectors of the non-ferrous metals sector in the GEM-E3 World model used here. The other non-ferrous metal sectors will experience some similar behaviour to aluminium as they are also exposed to international competition in the markets they trade under, but they are much less energy intensive (per tonne of metal produced) than aluminium. Although aluminium production accounted for only a fifth of sectoral production in 2000 (in tonnes), it accounted for about 50 per cent of end use energy demand and a third of CO_2 emissions.

Economic indicators

Modelling with GEM-E3 suggests that expanding the EU ETS to include PFC and CO_2 emissions from the non-ferrous metals sector would have some small adverse macroeconomic impacts on the sector. Figure 3 summarises the changes in economic indicators on expanding the current EU ETS to include the non-ferrous metals sector. The 'low' and 'high' scenarios denote low and high EU post-Kyoto targets (see Box 1).

23 It might be necessary to develop such a model; ideally it would need to model the industry globally.

24 This would be more disaggregated than the GEM-E3 Europe model which can only split down to 'Metals'.

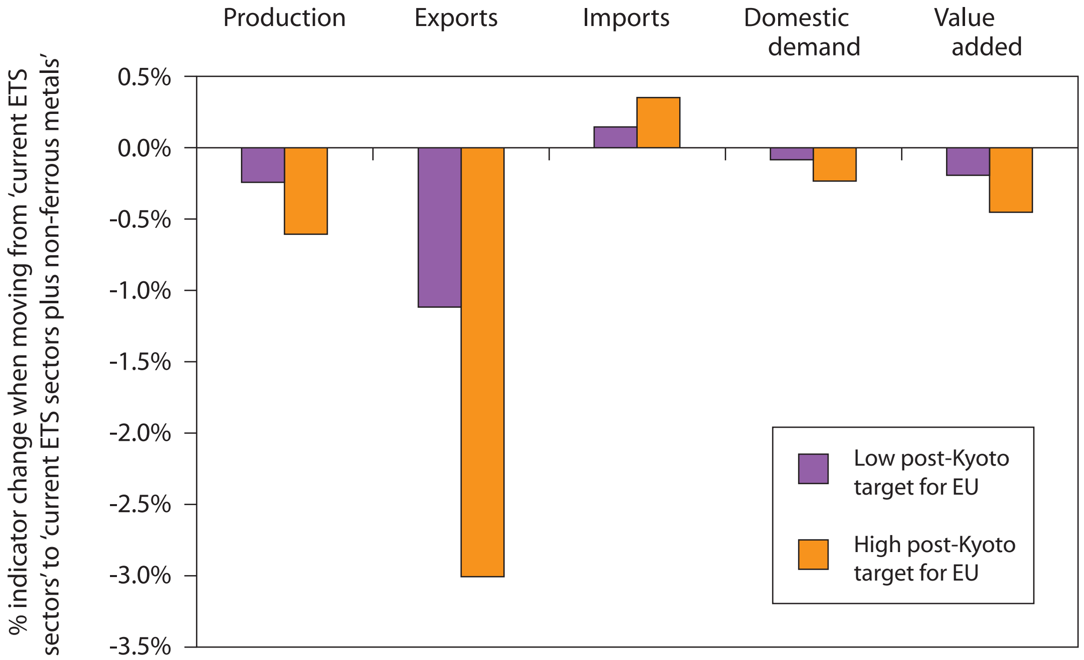
On inclusion in the EU ETS, value added in the non-ferrous metal sector falls by 0.2 per cent and 0.5 per cent in 2002 for low and high post-Kyoto emissions target scenarios respectively. Production levels also fall by a similar amount, with the EU seeing a larger decline in production than other world regions.

There is a greater percentage reduction in exports (1.1 per cent and 2.9 per cent under the low and high post-Kyoto emissions targets for the EU25), but as exports are only a small fraction of production, the reduction is not significant in mass terms. For example EU25 exports of aluminium were only two per cent of total production in 2004 (Table 8).

Table 8 | Tonnage of primary aluminium imports, production and exports for the EU25 in 2004[25]

	Aluminium (tonnes)
Imports into EU25	2,599,265
EU25 Domestic production	1,922,018
EU25 Exports (2% of production)	39,668

Figure 3 | Change in economic indicators for non-ferrous sector when CO_2 and PFCs are included in the EU ETS. Percentage change shown for the move from a 'current EU ETS sectors' to a 'current EU ETS sectors plus non-ferrous' trading scenario.



Source: GEM-E3

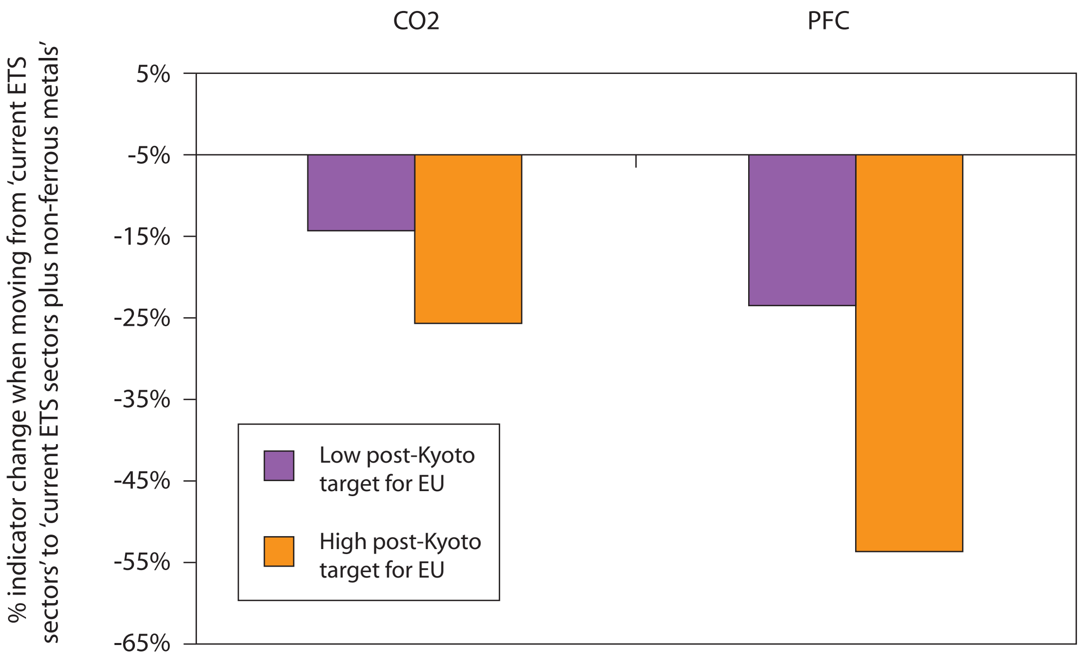
[25] Figures are for production and trades of unwrought, non-alloy aluminium for EU25 countries. This is considered the best reflection of the primary aluminium market given the data available. Trade figures exclude intra-EU25 trades.

Emissions

GEM-E3 reports significant emission reductions from including non-ferrous metals in the EU ETS. Under low and high post-Kyoto emission targets, PFC emissions are reduced by 23 per cent and 54 per cent respectively; and CO_2 emissions by 14 and 25 per cent (see Figure 4). These reductions are greater than the modelled decrease of 3 per cent and 14 per cent that occur in the sector if it is outside the EU ETS.

While the European Aluminium Association (EAA) suggest there is more potential for PFC abatement than for CO_2, the 54 per cent reduction in PFCs seems high, particularly given the proposed adoption of best available technologies in a 'business as usual' future. This suggests that this business as usual development may not be taken into account in the reference baseline for the model, and PFC reductions may be overestimated in the model.

Figure 4 | Change in emissions for non-ferrous sector when CO_2 and PFCs are included in the EU ETS. Percentage change shown for the move from a 'current EU ETS sectors' to a 'current EU ETS sectors plus non-ferrous' trading scenario.



Source: GEM-E3

Comparison of the ferrous and non-ferrous metals sectors

One of the materials with which aluminium competes in some products is steel. The iron and steel (ferrous) sector is already included in the EU ETS, and the model was used to compare the effects for the ferrous and non-ferrous sector of inclusion in the EU ETS. As indicated above, results from this comparison are only valid for the non-ferrous sector as a whole.

Figure 5 and Figure 6 show the changes in economic indicators for the ferrous and non-ferrous sectors on inclusion in the EU ETS and for an 'all trading' scenario. In both cases the changes are relative to a reference baseline scenario where there are no post-Kyoto targets and no EU ETS. The 'all trading' scenario assumes that all sectors of the economy can effectively trade with each other, and presents the optimal, in terms of least cost, solution for meeting the post-Kyoto targets.

Figure 5 | Change in economic indicators from the no targets baseline to the 'all trading' and 'inclusion of non-ferrous in EU ETS plus current EU ETS sectors' scenarios, for a low post-Kyoto EU target

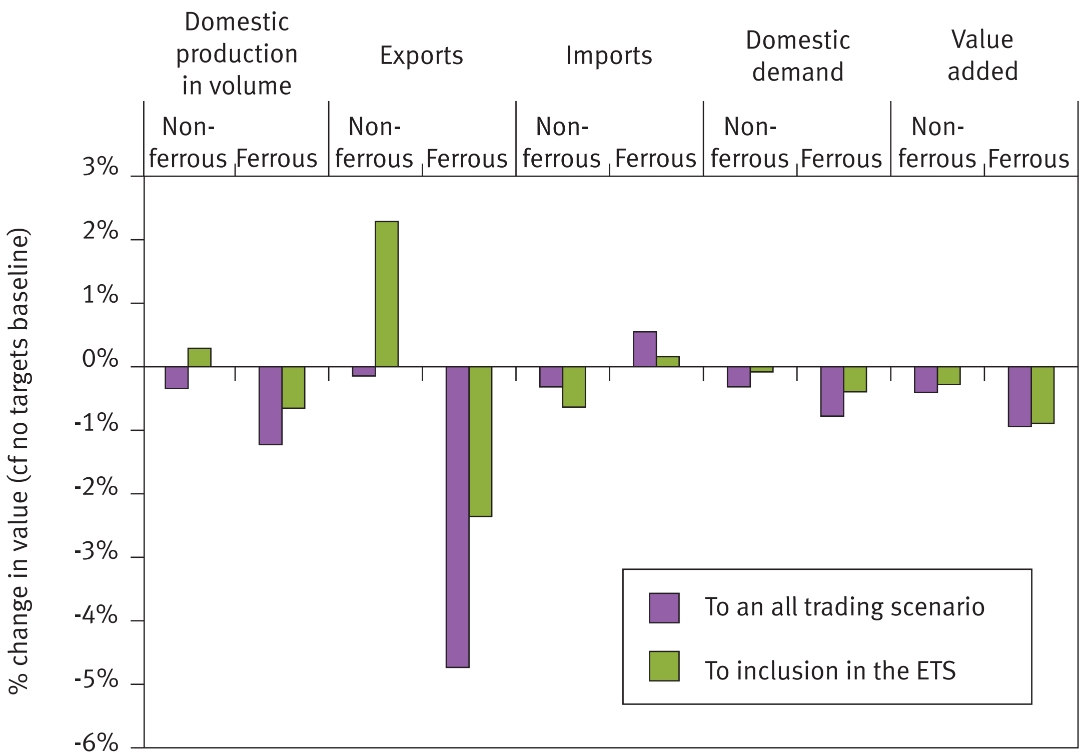


Figure 6 | Change in economic indicators from the targets baseline 'all trading' and 'inclusion of non-ferrous in EU ETS plus current EU ETS sectors' scenarios, for a high post-Kyoto EU target

Under a low post-Kyoto target, the impacts (compared to the reference scenario) for the ferrous sector are more adverse (or less beneficial), than for the non-ferrous sector, under both an 'all trading' scenario and an 'inclusion in the EU ETS' scenario. Under an 'all trading' scenario, value added and domestic production fall in both sectors, but the reduction is greater for the ferrous sector. On inclusion in the EU ETS, production increases (compared to the baseline) for the non-ferrous sector but falls for the ferrous sector. Value added falls for both sectors, although again the drop is greater for the ferrous sector. The situation is broadly the same under a high post-Kyoto target, with the same pattern of impacts between the two sectors.

4.3 Other modelling of the aluminium sector

Review of literature on indirect costs of EU ETS

Aluminium smelters are very power-intensive, with power costs comprising up to a third of total production costs. They are therefore highly exposed to the indirect costs of the EU ETS via electricity supply.

Oxera was commissioned by The Carbon Trust to study the impact of the EU ETS on the competitiveness of a sample of UK industry sectors[26]. The other report reviewed in this section is by Reinaud[27] and published by the IEA. The Oxera study had a UK focus; Reinaud's was an EU-wide analysis and the emission reduction approaches in each were different. Nonetheless, in both studies, of all the sectors[28] modelled, the aluminium sector was clearly the most likely to experience the greatest financial impact; even when the impact was limited to indirect costs. The other sectors modelled (cement, newsprint and steel) participate in the current EU ETS and were thus exposed to both direct and indirect costs. This implies that for aluminium the financial impact of participating in the EU ETS could worsen, when direct costs must also be borne. The results of the macroeconomic modelling above addresses the discussion on direct costs of inclusion.

In general, the degree of non-EU competition faced by participants in their respective markets was one of the key determinants of the financial impact of the EU ETS. Not only are competitors outside the EU free from the marginal cost increases associated with complying with a carbon emission limit, but also their presence limits the extent to which firms in the scheme can pass on the cost increases to customers. This is particularly true in the case of the highly open aluminium sector, despite being characterised in the reports reviewed as an oligopoly. The aluminium sector's ability to influence price is severely restricted.

Another key determinant is the own-price elasticity of demand. The more responsive demand is to price changes, the greater the financial impact of the EU ETS. Examples from Oxera and Reinaud are given in the following paragraphs to give insight into how much demand for EU aluminium decreases when smelters increase the price of aluminium. However, other things being equal, the estimated price elasticity for primary aluminium suggests that aluminium smelters could, in theory, pass costs on to customers without significantly affecting demand and total revenue. As noted above, the threat of international competition severely limits pass through by smelters. Increased production costs are thus likely to be absorbed, resulting in lower operating margins. If, as a result, fixed costs (including an adequate return on investment) are no longer covered, smelters could shut down or relocate.

Oxera reported that indirect costs of the EU ETS on the power sector could increase variable production costs by five per cent and increase aluminium prices by three per cent, based on 66 per cent of the cost increase being passed through to customers. The increase in product prices in turn reduces the quantity demand by six per cent. Overall, earnings before interest, taxes, depreciation and amortisation (EBITDA) were estimated to fall by 31 per cent.

If the allowance price is ten €/t CO_2 eq, Reinaud estimated that the impact of increased electricity costs to aluminium smelters would increase their production costs by 3.8 per cent. Reinaud then assessed two scenarios: one in which the smelters opt to maintain market share (at the expense of profitability) and another in which smelters decide to maintain profitability (at the expense of market share). In the former case, smelters do not pass any of the increase production costs onto customers. The resulting reduction in operational margin is 29 per cent. If smelters pass the additional production costs onto customers, aluminium prices are predicted to increase by 3.4 per cent. Demand for aluminium in the short term is estimated to decrease 2.9 per cent.

26 Oxera (2004), 'CO_2 Emissions Trading: How will it Affect UK Industry? The Carbon Trust', July 2004.

27 J Reinaud, (2004), 'Industrial Competitiveness Under the EU ETS', IEA Information Paper, IEA, Paris.

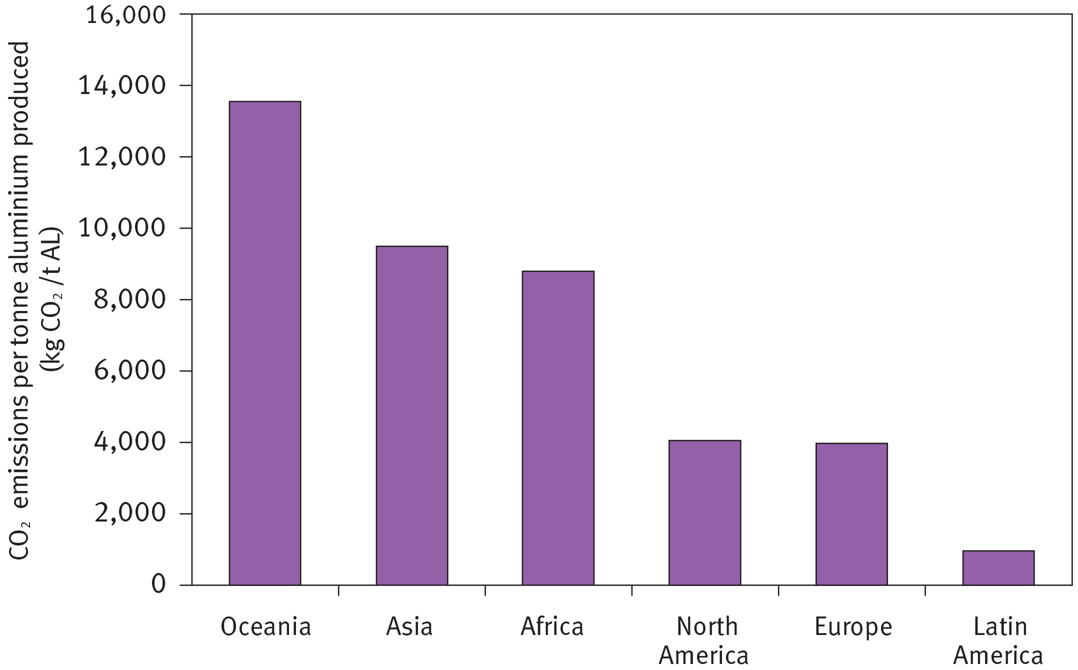
28 Both Oxera and Reinauld looked at the same sectors: cement, newsprint, cold-rolled steel and aluminium.

Electricity costs

Electricity costs have typically constituted 20–30 per cent of production costs[29] and therefore have an important influence on profitability. It is reported that, based on current electricity costs, this has now increased to 30–40 per cent for most smelters[30]. According to the UK Aluminium Federation, over 60 per cent of the western world's primary aluminium is produced from electricity generated by hydro-electric power. However, the EAA reports that there are only two plants in the EU which have their own on-site generation, the rest have long-term dedicated contracts with power suppliers for electricity.

Despite having the lowest electricity use per tonne of primary aluminium production, Oceania production is the most greenhouse-intensive, followed by Asia, Africa, North America, Europe and Latin America. If the EU ETS were to lead to the relocation of the smelting industry to other parts of the world, global GHG emissions would be likely to increase.

Figure 7 | CO_2 emissions per tonne of aluminium produced in world regions[29]



29 Turton, H. (2002) 'The Aluminium Smelting Industry: Structure, Market Power, Subsidies and Greenhouse Gas'.

30 Erik Nordheim, European Aluminium Association, Personal Communication, March 2006.

Exposure to international competition

When considering the impact of inclusion in the EU ETS, it is important to discuss the degree of openness to international competition for the aluminium sector in comparison with other sectors already in the EU ETS, such as iron and steel. The exposure of the European aluminium sector to international competition can be described by the:

- Import Penetration Ratio (IPR), which is the proportion of home consumption that is made up of imports.
- Export Ratio (ER), which represents the proportion of home production that is exported.

The IPR is an inward-looking measure of competitiveness as it represents the presence of global producers on the European market, while the ER is an outward-looking measure as it represents the presence of European producers on the global market. Table 9 gives values for these two indicators for 2003 and 2004.

Table 9 | International exposure of the European aluminium market

Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2003	1,961,434.68	2,540,953.90	21,899.80	0.57	0.01
2004	1,922,018.31	2,599,265.40	39,667.70	0.58	0.02

Figures are for production and trades of unwrought, non-alloy aluminium for EU25 countries. This is considered the best reflection of the primary aluminium market given the data available. Trade figures exclude intra-EU25 trades. Source: EUROSTAT

The IPR in both years is very high for the aluminium market, with almost six out of every ten tonnes consumed in Europe imported from outside the European market. In contrast, the ER for both years indicates that virtually all of European production is consumed within the EU25.

Box 2: OECD openness ratio for aluminium
Relationship with openness to international competition of iron and steel sector

- The OECD openness ratio, which essentially combines the IPR and ER, shows that aluminium is very open to international competition when compared with sectors already in the EU ETS such as iron and steel.
- With an openness ratio of 45%, the aluminium sector is significantly more exposed than the iron and steel sector which has a ratio of 25%.

There is a predominance of Asia/Pacific producers in the global aluminium market and this is explained by increases in demand from countries within the region, particularly China and India, and the relatively cheap labour and energy costs compared to European producers. Many global firms are moving investment towards the Asia/Pacific region as a result of the more favourable operating conditions[31].

Reviewing market statistics indicates that European aluminium producers are highly exposed to international competition, and from regions where production costs are generally lower. Also, even though the price of aluminium is currently relatively high and is expected to remain so in the short term, increased production in the medium term is predicted to remove the current situation of excess demand. As a result, it is likely that prices will return to the long-term trend, other things being equal.

31 Datamonitor (2005c)

5 Chemicals sector

5.1 Summary for sector

Based on the initial findings of the LETS Update working groups, CO_2 emissions from the fertiliser, ammonia and petrochemicals sectors were recommended for inclusion, along with N_2O emissions from the nitric acid and adipic acid sectors. The macroeconomic impacts of including (all of) the chemicals sector in the EU ETS were evaluated using the GEM-E3 macroeconomic model. This was complemented by using a bottom-up approach to examine economic impacts on the N_2O emitting sectors.

The GEM-E3 model was used to compare macroeconomic indicators for the chemicals sector under two scenarios:

- Current EU ETS – there is no expansion of the EU ETS, ie the EU ETS applies only to sectors currently (in Phase I) in the EU ETS and only to CO_2 emissions from those sectors. A reduction is required in emissions from the EU ETS sectors. No constraints are placed on emissions from the chemicals sector.
- Current EU ETS + chemicals – the EU ETS is expanded to include the chemicals sector.

The modelling represents a 'worst case' appraisal of the impacts of moving into the EU ETS in the sense that if the sector remains outside the EU ETS, emissions are unlikely to be allowed to be totally unconstrained, as they would be the target of other policies and measures.

The results from the modelling (described below) can only be taken as indicative of the impact of including the chemicals sector in the EU ETS:

- The results are for the chemicals sector as a whole rather than the sub-sectors identified as potentially suitable for inclusion by this study (petro-chemicals, fertilisers, ammonia and nitric and adipic acid production). It was not possible to subdivide 'the chemicals sector' within the GEM-E3 model. The sub-sectors identified are significant emitters of CO_2, and are estimated to account for almost 60 per cent of combustion and process-related CO_2 emissions from the sector[32].
- In the current EU ETS + chemicals scenario, the model assumes that all non CO_2 GHG from the chemicals sector are included in the EU ETS, rather than just N_2O as considered in the study. Again, this is a limitation of the way the model can be set up.
- Some combustion plant within the chemicals sector are already included within the EU ETS; it was not possible to reflect this in the 'current EU ETS' scenario.

The GEM-E3 model results suggest that on inclusion in the EU ETS, demand for chemical sector products will fall slightly, leading to a reduction in production, and a moderate fall in value added of 0.7 and 1.7 per cent for low and high post-Kyoto target scenarios respectively. Exports fall more significantly by six per cent under a high post-Kyoto target. These results suggest that while there may be some adverse impacts on the chemicals sector upon inclusion in the EU ETS, they are not so significant as to rule out inclusion. It would, however, be useful to carry out a further examination of economic impacts on the sector before a final decision is made on inclusion using either modelling techniques capable of more detailed subsectoral modelling, or a bottom-up approach.

32 (April 2006) 'LETS Update: Scoping Phase', Environment Agency for England and Wales.

When moving from the scenario of 'current EU ETS sector' trading to 'current EU ETS plus chemicals' trading, CO_2 emissions from the chemicals sector fall by five per cent and N_2O emissions by nine per cent for under a low EU post-Kyoto target. Under a high post-Kyoto target emission, reductions are approximately doubled. In real terms CO_2 emissions are significantly higher than N_2O emissions and the cost of abating these emissions will dominate the economic impacts on the sector.

Inclusion of N_2O emissions from nitric and adipic acid production was also examined using a bottom-up approach which considered the two production sectors individually. While adipic acid manufacturers have already installed abatement equipment, its operation could potentially be improved to reduce emissions further, and the assessment shows that the sector could benefit from participation in the EU ETS. Their marginal abatement costs are very low (yet positive), so that at an illustrative equilibrium allowance price of ten €/t CO_2 eq, producers accrue a significant amount of revenue from selling surplus allowances to offset any abatement costs. International exposure (both for adipic acid production and production of the intermediate product nylon 6-6) is relatively low. The amount of allowance revenue generated will depend on the allocation of allowances, and producers would be expected to abate emissions up to the maximum technical potential.

The bottom-up assessment suggests that the nitric acid sector would not reap financial benefits from participation in the EU ETS, but that impacts are not significant. Revenue from selling surplus allowances is not sufficient to offset total abatement costs; it only reduces the cost of meeting the sector's target. Despite the presence of significant total fixed abatement costs, inclusion in the EU ETS is not forecast to have a significant impact in the long run. As with adipic acid, international exposure of the sector for both the initial product (nitric acid) and main final product (nitrogenous fertiliser) is relatively low.

On the basis of this bottom-up modelling, we would recommend that N_2O from nitric and adipic acid are considered for inclusion in the EU ETS as the economic impacts are not significant for either sector. In both cases, care would need to be taken in the allocation of allowances, due to the low marginal costs of abatement and significant reductions from 'business as usual' emissions which are available.

5.2 Results from macroeconomic modelling

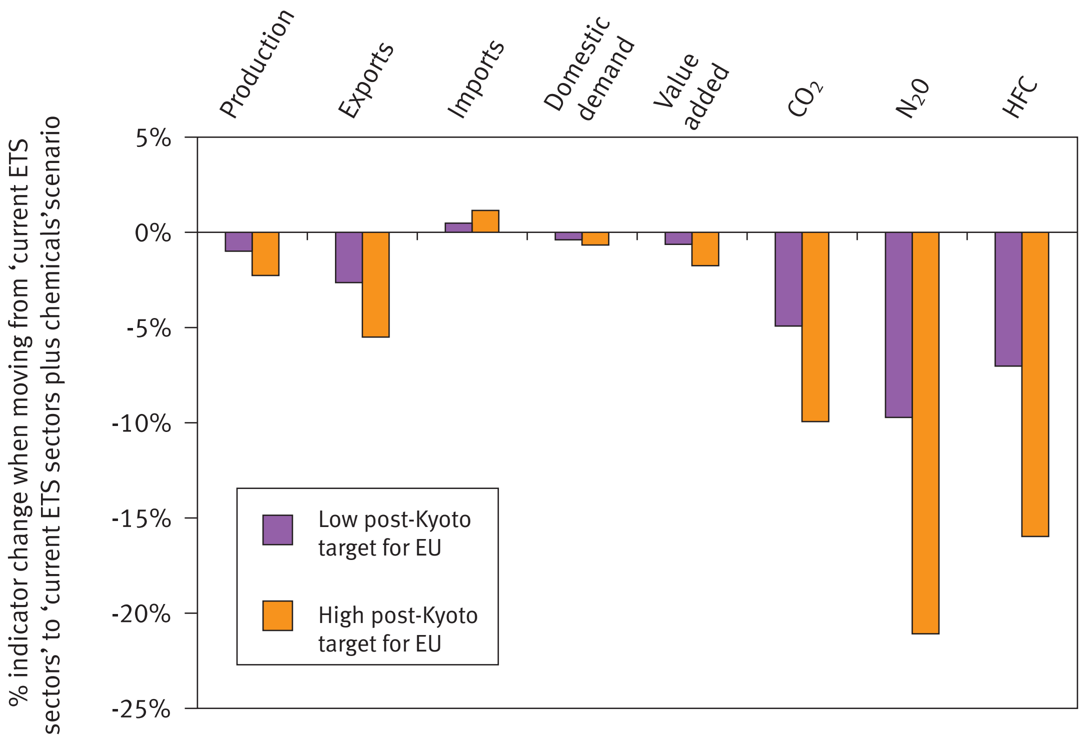
Economic indicators

Figure 8 shows the change in economic indicators when the chemicals sector is included in the EU ETS. Value added for the sector falls by 0.7 per cent in 2020 under a low post-Kyoto target, and by 1.7 per cent under a high post-Kyoto target. The sector production levels shrink by a slightly greater percentage.

Emissions

When moving from the scenario of 'current EU ETS sector' trading to 'current EU ETS plus chemicals' trading, the chemicals sector sees a decrease in CO_2 emissions of five per cent and a decrease of nine per cent for N_2O under a low EU post-Kyoto target. Under a high post-Kyoto target, emission reductions are approximately doubled. CO_2 emissions from the sector are about three times as large as CO_2 emissions so the most significant reductions in terms of tonnes of CO_2 eq are from reductions in CO_2 emissions. It was not possible to exclude HFC emissions from the chemicals sector when setting up the 'inclusion in the EU ETS' scenario in the model and these also fall significantly. As HFC reductions can be achieved at relatively low cost, this has the effect of softening the adverse impacts on the sector from inclusion in the EU ETS.

Figure 8 | Change in indicators for chemicals sector when CO_2, PFCs and HFCs are included in the EU ETS. Percentage change shown for the move from a 'current EU ETS sectors' to a 'current EU ETS sectors plus chemicals' trading scenario.



Data source: GEM-E3

5.3 Results from bottom-up modelling

Results from the impact tests for adipic acid

The adipic acid sector stands to benefit from participation in the EU ETS. Given an equilibrium allowance price of ten €/t CO_2 eq and the very low (yet positive) marginal abatement costs, adipic acid producers accrue a significant amount of revenue from selling surplus allowances to offset any abatement costs. The amount of allowance revenue generated will depend on the allocation of allowances, and producers would be expected to abate emissions up to the maximum technical potential.

Since the abatement cost curve comprises solely variable costs, only short-run impacts are considered in the model. In the short run, the negative net variable costs (incorporating revenue from allowance sales) essentially provide producers with the opportunity to reduce price, with the result that output increases. Gross profit margins increase by about eight per cent.

According to the economic impacts significance test conducted for the Sustainability Appraisal, participation in the EU ETS has 'no significant (adverse) impact' in the short term for the adipic acid sector.

Results from the impact tests for nitric acid

In contrast to the adipic acid sector, the nitric acid sector does not reap financial benefits from participation in the EU ETS. At the same time, the impacts are not significant.

While the marginal abatement costs (as characterised in the cost curve presented in Annex B) offers emission reductions at unit costs below the equilibrium allowance price of ten € per/t CO_2 eq, the allocation is fairly stringent relative to the maximum abatement potential of the sector. Thus, revenue from selling surplus allowances is not sufficient to offset total abatement costs; it only reduces the cost of meeting the sector's target.

Nevertheless total variable abatement costs (incorporating revenue from allowance sales) are still negative. This offers producers the opportunity to increase output in the short term, with gross profit margin increasing by just over one per cent.

Despite the presence of significant total fixed abatement costs the EU ETS has no significant impact in the long term.

International exposure for adipic acid and nitric acid

The exposure of the European adipic and nitric acid sectors to international competition can be described by the:

- IPR, which is the proportion of home consumption that is made up of imports
- ER, which represents the proportion of home production that is exported.

Tables 10 to 13 provide summary statistics of international exposure for the adipic acid and nitric acid sectors, respectively. Statistics are provided for both the raw material (adipic and nitric acid) and for the intermediate or final product (nylon 6-6 and nitrogenous fertilisers[33]).

In both sectors, an insignificant proportion of home demand for the raw material is met by imports from outside the European market. Furthermore, by far the majority of all European production is consumed within the EU25, although a greater fraction of adipic acid production, in contrast to nitric acid production, is exported. Disaggregated statistics on polyamide (nylon) 6-6 production from adipic acid were not available, but more aggregated statistics on polyamide production suggest that import penetration and export ratios are also low. For nitric acid, the import ratio for nitrogenous fertilisers (the main use of nitric acid) is higher than for nitric acid, but is still relatively low. Overall, the exposure of both sectors to international competition in both domestic and international markets is minimal.

Table 10 | International exposure of European adipic acid producers (tonnes of acid)*

Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2003	84,477	3,752	9,611	0.048	0.114
2004	85,236	2,501	10,504	0.032	0.123

*Excludes intra-EU25 trades
Source: EUROSTAT

33 Disaggregated data on polyamide (nylon) 6-6 was not available from Eurostat, so data for a group of polyamides is shown. Nitrogenous fertilisers are the most predominant use of nitric acid, accounting for about 90 per cent of use.

Table 11 | International exposure of European polyamide producers (tonnes of polymer)*

Polyamides -6, -11, -12, -6,6, -6,9, -6,10 or -6,12 in Primary Forms					
Year	**Production (tonnes)**	**Imports (tonnes)**	**Exports (tonnes)**	**IPR**	**ER**
2003	2,004,766	107,168	141,128	0.054	0.07
2004	2,052,486	111,883	191,245	0.057	0.09

*Excludes intra-EU25 trades
Source: EUROSTAT

Table 12 | International exposure of European nitric acid producers (tonnes of nitrogen)*

Nitric acid: measures of international exposure					
Year	**Production (tonnes)**	**Imports (tonnes)**	**Exports (tonnes)**	**IPR**	**ER**
2003	4,471,065	20,141	29,852	0.005	0.007
2004	6,578,243	6,329	38,445	0.001	0.006

*Excludes intra-EU25 trades
Source: EUROSTAT

Table 13 | International exposure of European nitrogenous fertiliser producers (tonnes of nitrogen)*

Fertilizers containing nitrogen, phosphorus and potassium (>10% nitrogen)					
Year	**Production (tonnes)**	**Imports (tonnes)**	**Exports (tonnes)**	**IPR**	**ER**
2003	10,699,428	1,623,723	1,338,682	0.148	0.13
2004	9,993,095	1,759,174	880,146	0.162	0.09

*Excludes intra-EU25 trades
Source: EUROSTAT

6 Coal-mine methane

6.1 Summary for sector

Methane emissions from active coal mines accounted for 0.7 per cent of EU25 total GHG emissions in 2003. In Europe four countries, the United Kingdom (UK), the Czech Republic, Germany and Poland, dominate coal production and collectively account for about 94 per cent of total production.

The results of both the GEM-E3 modelling and the bottom-up assessment indicate that the coal sector would benefit from inclusion of coal-mine methane in the EU ETS. The sector has low (or even negative) abatement costs, due to the value of electricity generated from recovered methane, and significant reductions in emissions are available. Within the GEM-E3 modelling this results in the coal sector undertaking significant abatement and becoming a net seller of permits. This highlights the need to take care in setting the allocation for this sector to ensure that it does not experience windfall gains and flood the market. The GEM-E3 model forecasts increases in production (and value added) as the financial benefits of inclusion are used by the sector to reduce the price of coal, which results in increased demand. This could help to ameliorate the significant shrinkage in coal production which is expected in the future.

A similar picture emerges from the bottom-up assessment. Sector expansion is predicted because the negative variable costs of abatement essentially provide producers with the opportunity to reduce price, with the result that output increases. The bottom-up assessment also suggests that the coal sector in Poland and the Czech Republic could benefit more than the UK and German industry due to lower abatement costs. This could put the UK and German coal industry under greater competitive pressure from Polish and Czech imported coal. In the analysis undertaken, there are no adverse impacts on domestic production from inclusion in the EU ETS, because of the possibility of reducing prices. However, as with the aluminium sector, if inclusion were to lead to any increase in production costs, then this could not be passed on as the price of coal is set internationally.

Although the modelling points to the benefits of including coal-mine methane in the EU ETS, there are significant barriers. Safety concerns have been raised by all the major producers in Europe as combustion plant approval is in the hands of the mining authorities. In addition, Germany's 'feed-in tariff' legislation is not compatible with plant included in the EU ETS.

Overall, the Sustainability Appraisal leads to the recommendation that coal-mine methane should be included in the EU ETS with the caveat that safety concerns are addressed. Based on the modelling results, the low abatement costs within the sector mean that the economic impacts of inclusion could be positive, so the position of EU coal on the international market should not be jeopardised.

Further work which could be useful before inclusion in the EU ETS is a review of feasible abatement opportunities and updating of the marginal costs abatement curves for the sector. This would help to provide a sound basis for setting allocations for the sector. A watching brief on the coal industry restructuring process is also needed as the EU sector will shrink significantly in the next ten years.

6.2 Results from macroeconomic modelling

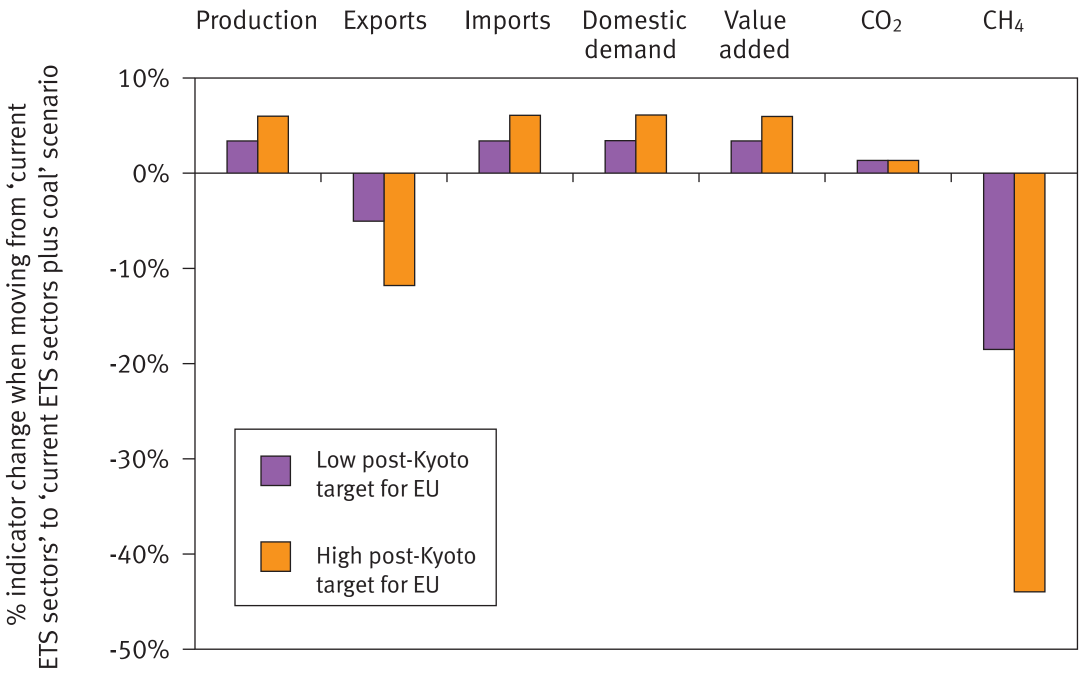
Economic Indicators

The results from GEM-E3 modelling show that the coal sector benefits from coal-mine methane inclusion in the EU ETS. Inclusion in the EU ETS increases value added for the sector by 3.6 per cent in 2020 under a low post-Kyoto target and 6.5 per cent under a high post-Kyoto target (see Figure 9). Production grows by a similar amount and this is because the low abatement costs and substantial reductions which are available, allow the sector to become a net seller of permits. Within the model, the revenue from this is used by the sector to reduce the price of coal and demand for coal therefore increases. Exports of coal from the European coal industry decrease by between roughly five per cent and ten per cent under the low and high scenarios. This does not affect overall production levels, as exports are only a small fraction of production (currently about one per cent).

Emissions reductions

Inclusion in the EU ETS reduces methane emissions by 18 per cent and 45 per cent in 2020 for the low and high emissions target scenarios, respectively (see Figure 9). This is in comparison to the current EU ETS scenario where emissions are constrained to the baseline reference level. The large reduction in emissions indicates that the sector takes more action than is required to meet the reduction in its cap and is a net seller of permits. In reality a 45 per cent reduction in methane emissions would be challenging for the sector to achieve and suggests that the marginal abatement cost curve in the GEM-E3 model may not take account of recent action to abate methane emissions in the UK. The model may thus be overestimating the remaining abatement potential. The small increase in CO_2 emissions of two per cent in 2020 is linked to the energy use demands from mining in line with an increase in coal production when the EU ETS is expanded to cover coal-mine methane.

Figure 9 | Change in indicators when coal-mine methane is included in the EU ETS.
Percentage change shown for the move from a 'current EU ETS sectors' to a 'current EU ETS sectors plus coal' trading scenario.



Source: GEM-E3

6.3 Results from bottom-up modelling

The bottom-up assessment examined the impact on the coal sector of inclusion in the EU ETS assuming:

- an illustrative carbon price of ten €/t CO_2
- marginal abatement costs for coal-mine methane based on cost curves published by the Energy Modelling Forum (EMF) for the EU15 and Eastern Europe[34]
- a required reduction between 2010 and 2020 of 8 per cent; this is the overall reduction in the EU ETS cap assumed in the GEM-E3 modelling under a low post-Kyoto target.

The main abatement options are the utilisation of coal-mine methane in gas turbines and Combined Heat and Power (CHP) plant to generate electricity, which can be used onsite, offsetting power costs, with any excess sold to the grid. Marginal abatement costs are therefore sensitive to the price assumed for electricity. For the EU15, marginal abatement costs for the baseline electricity price assumed by the EMF were used. The EMF baseline prices for Eastern Europe was considered to be too low, and given the trend towards a common electricity price across the EU, it was assumed that by 2013, the electricity price in Eastern Europe would have reached the EU15 level. In both cases this produces marginal abatement costs curves which show substantial reductions are available at a negative cost, ie there is a net benefit to the mine operator through the value of the electricity produced.

Results from the impact tests for coal-mine methane

Under the assumptions described above, the coal sector in both the EU15 and the EU10 stand to benefit from inclusion in the EU ETS. This is mainly a result of the significant reductions which are available at a negative cost. The required reduction is thus easily met and the sector can also reduce emissions further allowing additional revenue from the sale of permits.

Abatement costs in the EU10 are lower than in EU15, partly because the cost of labour to install and maintain equipment is assumed to be lower and partly because different abatement technologies are appropriate for Eastern and Western Europe. This means that more reductions are available at a negative cost than in the EU15 and so the EU10 coal sector benefits more from inclusion in the EU ETS.

In the short term, the negative variable costs essentially provide producers with the opportunity to reduce price, with the result that output increases. Gross profit margin also increases in the short term. In the long term, the coal sector is predicted to expand, even in the case with 'minimum' impact.

International exposure of the coal sector

Coal production in the EU25 accounts for about four to five per cent of global coal production. Coal producers have to deal with the purchasing power of the large electricity generators who are driving for lower coal prices in the liberalised electricity market. Pressure also comes from the international market, where trade is dominated by four major producers, who can exert a strong influence on coal production for export, and thus price. Subsidies allow EU producers to stay competitive on price with coal from outside the EU, but subsidies are to be phased out, as the major coal industries in the EU restructure.

Table 14 provides summary statistics of international exposure for the EU15 coal sector; it was not possible to generate statistics for the EU25 because intra-EU trade could only be excluded for the EU15. Clearly, a significant proportion of demand in the EU15 is met by imports, much of it from Poland and the Czech Republic – close to 18 per cent in 2002. The previous financial impact tests showed that the EU10 coal sector would benefit more than the EU15 coal sector from participation

34 EMF Cost Curves. International Non CO_2 Greenhouse Gas Marginal Abatement. Draft Report. Appendices: International Methane and Nitrous Oxide Emissions and Mitigation Data, April 2005, www.epa.gov/outreach/appendices.html

in the EU ETS. This is likely to put EU15 coal producers under greater competitive pressure from EU10 producers – ie imports from Poland and the Czech Republic may well increase.

Regarding exports (extra-EU15), by far the majority of all EU15 production is consumed within the EU15. However, both Poland and the Czech Republic export over 20 per cent of domestic production, most of which goes to other Member States.

Table 14 | International exposure of the EU15 coal sector

Combined steam and coking coal: measures of international exposure*					
Year	**Production (tonnes)**	**Imports (tonnes)**	**Exports (tonnes)**	**IPR**	**ER**
2002	33,477,163	53,952,269	366,497	0.620	0.011

*Excludes trades with EU10
Source: EUROSTAT

European coal industry restructuring

The structure of the coal industry in each of the four main producer countries is very different (Box 3). In the UK the coal sector is already privatised and has been declining for several years. It is relatively exposed to international competition as the power sector is also privatised. In Germany, significant shrinkage is forecast and an aid package is to be granted to assist in this process. In the Czech Republic, a restructuring exercise to privatise the industry has failed, and Government support has been extended. In Poland a restructuring programme, aimed at privatising the industry, has been initiated.

Box 3: Structure of the coal industry in producer countries

- **United Kingdom:** UK COAL employs approximately 9,300 people, of which just over 70% work in deep mining. Total UK production has been gradually declining for years. The UK has exported very little coal (less than one million tonnes per annum) in the last five years. UK coal imports were higher in years when the gas price is high as electricity generators switched between the two fuels. Since privatisation of the power sector, the UK coal sector has become increasingly exposed to international competition, since consumers are free to purchase coal from the most economic source.

- **Germany:** German coal production is forecast to scale down to 16 million tonnes by 2012 in order to retain a long-term core mining industry that is financially viable. As a result of the downscaling, the industry's workforce is forecast to fall from 42,000 to 20,000 employees. To aid with the transitional costs an aid package will be introduced for the coal industry; about €17 billion to be granted between 2006 and 2012.

  Despite the official downscaling of the coal industry in Germany, there is currently a school of thought that the country may be better placed to revive the industry. The head of the German coal mining company RAG, Werner Müller, and head of the German coal mining company, BDI, Jürgen Thumann, published a brochure entitled 'The Global Commodities Crisis is Burning the Mittelstand'. This argues that German reserves of one billion tonnes of coking coal should be utilised to make the country as independent as possible in the world market, arguing that the rise in raw material prices could cost up to 40,000 jobs if no action is taken.

- **Czech Republic:** Since the fall of Communism, demand for coal as a primary energy source has fallen, though coal is forecast to meet ~25% of the country's energy mix until 2030. During the 1990s the number of people employed in the coal industry fell by about 60%. During the Communist era, a key feature of the coal industry was that production outstripped demand. Moreover, production exceeded its own revenue. Without restructuring, the industry would collapse. In 1992 the 'Energy Policy of the Czech Republic' defined the foundations for restructuring. Under this policy, the Government decided which less competitive mines should be sold, which should be consolidated, and which should be supported. All coal mines were then allocated between 16 coal enterprises and private investment was sought. This has not proved that successful and the Government has revised its plans for the state funding of coal mines, extending support times.
- **Poland:** The Polish economy underwent a radical overhaul during the 1990s making it one of the strongest in Eastern Europe. Recently, however, it has been hit by high unemployment and GDP growth has slowed. The Polish coal industry has been subject to a cycle of losses. As a result, the Government instigated a restructuring programme. The programme allowed for the closure of unprofitable mines, financial and employment restructuring, privatisation and the improvement of management and environmental standards. Coal is expected to continue to play a major role in the country's energy mix. It is hope that privatisation will aid industry productivity, as well as attract much-needed capital for modernisation.

6.4 Other issues

6.4.1 Safety

Safety is a key concern when dealing with fugitive methane emissions from active coal mines, and was highlighted by all the stakeholders consulted through Working Group B of the LETS Update study (Box 4). The key point made is that the national authority with responsibility for safety in mines can overrule or refuse methane combustion plant installation. This reduces the level of control mining companies have over dealing with methane and the flexibility and speed with which they can meet EU ETS targets.

The appraisal of feedback on safety issues leads to the strong caveat that coal-mine methane could only be included in the EU ETS if key safety issues were addressed. We recommend that further consultation with mining authorities and mine companies' health and safety divisions is carried out after the study. Although safety constraints can slow down the installation of combustion plant in the UK, the UK ETS inclusion of coal-mine methane and the significant improvement in methane abatement under the UK ETS demonstrates that mining companies can work within safety constraints and still make savings under an ETS.

6.4.2 Interaction with other policies

Germany's RAG mining company have raised concerns that the inclusion of coal-mine methane in the EU ETS would clash with German legislation. The federal government of Germany gives financial support to the use of coal-mine methane by granting remuneration, or 'feed-in tariff' for electricity produced using methane from active and abandoned coal mines. The favourable price for electricity is regulated by the Renewable Energy Sources Act and about 40 CHP plants have been installed in six active coal mines so far under the Act.

The conflict of regulation stems from the provision in the Act that no facility is allowed to participate in the EU ETS if it is supported under this scheme. At present due to strongly increased electricity prices, 'feed-in tariffs' are only slightly above wholesale prices, though in the past they have been significantly higher. If feed-in tariffs ceased, the impact would be smaller at today's high electricity prices, though it is difficult to predict the price movements to 2013.

Germany's situation is unique regarding the conflict of 'feed-in tariff' legislation with EU ETS inclusion and would need close attention if coal-mine methane was included in the trading scheme.

Box 4: Stakeholder feedback on safety issues

- **Germany:** Germany's major mining company, RAG[35], commented that the German mining authorities have an influence over safety decisions at their mines. In some circumstances the authorities can order the mining company to take action that leads to the unplanned venting of methane to the atmosphere. Methane combustion plant is approved by the mining authority and thus the decision on methane combustion plant installations to some extent lies outside the control of the mining companies.
- **UK:** UK Coal[36] produces the majority of Britain's coal and they would be in favour of inclusion in the EU ETS if safety constraints could be overcome and if any grandfathering baseline took account of early action. We have added these issues to the route map. Safety legislation restricts methane combustion below concentration levels of 27%. Below 27% flares and engines must be turned off. Flaring approvals can take up to eight months to obtain.
- **Poland:** Poland's Coal Mining Institute commented that safety regulations are not a major barrier in Poland to methane combustion installations such as CHP plant using methane pumped from seam, though, as with other Member States, there are some safety concerns regarding the combustion of ventilation shaft methane.

35 RAG and the German Coal Association Position Paper, January 2006.

36 UK COAL, Chris McGlen response to the LETS Update Working Group B Report, December 2006.

7 Limitations of the modelling

7.1 Limitations of the model

At the time that the LETS Update project programme was set up, the key elements of the Sustainability Appraisal had not been defined, so the choice was made to use a general model, GEM-E3, which could examine both economic effects, social effects (ie employment), and environmental impacts (energy use and emissions), and which had been used previously to carry out a Sustainability Appraisal. As the project progressed, it became clearer that more sectoral analysis of the potential economic impacts, particularly on competitiveness, would be appropriate, but it was not possible to accommodate a change of model and modelling approach within the project timescale and resources.

The modelling work carried out therefore has some limitations and does not provide full answers to the questions posed on potential economic impacts for the aluminium and fertiliser, ammonia and petrochemicals sectors in the Working Group A and B reports. The modelling work is more robust for the coal sector, particularly as is it complemented by a more bottom-up assessment. Similarly there is more confidence in the results for the nitric and adipic acid-producing sectors, which were also assessed using a bottom-up approach.

The main limitations of the GEM-E3 model as used to assess the inclusion of the aluminium and chemicals sector are set out below.

7.2 Aluminium

The greatest level of disaggregation available in the model is the non-ferrous metals sector. Within this sector, aluminium production accounts for almost a fifth of non-ferrous metals production (by mass), about a third of direct (process and combustion) CO_2 emissions and about 50 per cent of end use energy demand (including electricity use). It is significantly more energy intensive than other parts of the non-ferrous sector. The use of the non-ferrous sector to represent the aluminium sector in the analysis is thus a very coarse approximation and is a serious limitation of the modelling work carried out.

The results for the non-ferrous sector indicate that PFC emissions could be halved under a high post-Kyoto target if the sector is included in the EU ETS. The only PFC emitter in the non-ferrous metals sector is the aluminium industry and this reduction seems high given the proposed adoption of best available technologies to reduce these emissions within the sector. It appears that this proposed development is not taken into account in the reference baseline for the model, and thus the real, additional reduction potential for PFCs in the aluminium sector may be overestimated by the model.

7.3 Chemicals

It is not possible to subdivide the chemicals sector within the GEM-E3 model, and the results presented in this appraisal are therefore for the chemicals sector as a whole rather than the sub-sectors identified as potentially suitable for inclusion in the EU ETS by the study (petrochemicals, fertilisers, ammonia and nitric and adipic acid production). The sub-sectors identified are significant emitters of CO_2, and are estimated to account for almost 60 per cent of combustion and process-related CO_2 emissions from the sector. They also account for a similar proportion of end use energy demand, but only about a quarter of value added, as this tends to be highest for small volume fine chemicals and pharmaceutical products.

When the chemicals sector is included within the EU ETS in GEM-E3, all non CO_2 GHG emissions are included, not just N_2O. This is a limitation of the way the model was configured for the study. As there are significant HFC reduction opportunities (at relatively low cost) within the chemicals sector in the model, these are taken up once the sector is within the EU ETS. This gives additional flexibility for the sector and probably lessens the impact of inclusion in the EU ETS.

Finally, some combustion plant (over 20MW) within the chemicals sector are already included within the EU ETS; it was not possible to reflect this in the 'current EU ETS' scenario.

7.4 Coal

In setting up the scenarios, an overall cap for the EU ETS was defined in terms of the reductions required for the EU ETS sectors between 2010 and 2020, but allocations/caps for the individual sectors were not defined, but were set to the overall average reduction required for the EU ETS. For the coal sector, where emissions are forecast to fall significantly anyway due to declining production, this means that its cap in the EU ETS is not very stringent. Adverse impacts are therefore minimised. In reality, NAPs should take account of such trends in production and set allocations such as to minimise any potential windfall profits.

7.5 Recommendations for further work

It is recommended that the impacts on the aluminium sector are examined further before a final decision is made on its inclusion in the EU ETS. It seems unlikely that other general energy or energy-environment models would have the required level of detail, so a sectoral model should be used. Given the international nature of the aluminium sector, it should ideally be a global model, and at the very least should be capable of examining trade interactions. The sensitivity of the results in any such study to assumptions about post-Kyoto targets in other countries which are major producers of aluminium, for example Canada, should also be examined.

8 Design and harmonisation issues

8.1 Introduction

Working Group C of the LETS Update project, carried out further work on a number of areas for improving the design and harmonisation of the EU ETS[37], as selected in the Scoping Phase. The following areas were selected from a wider list generated in the Scoping Phase for more in-depth assessment:

- The role of domestic offset projects in the future EU ETS
- The interaction between the EU ETS and other EU policies and measures
- Improving the transparency of developing and assessing NAPs with respect to the:
  - determination of growth rates used to set allocations
  - contribution of ETS sectors and non-ETS sectors to reaching the Kyoto/Burden Sharing targets.

A detailed analysis of each of these topics and the conclusions on how to take them forward is presented in the final report from Working Group C. This section presents the Sustainability Appraisal of the conclusions and recommendations for each of the above areas, including a qualitative analysis of the environmental, economic and social impacts. As the conclusions relate to an existing policy, considering the very broad range of impacts is not relevant here. Only the relevant issues are highlighted and discussed.

For each of the areas assessed, the Sustainability Appraisal concludes with an overall assessment balancing the potential impacts on the environment, society and the economy.

8.2 Domestic offsets

A wide range of domestic offset schemes at various stages of development were reviewed to draw out lessons for a potential system for the EU. These include the:

- New Zealand Projects to Reduce Emissions (PRE) scheme
- New South Wales Greenhouse Gas Abatement Scheme (GGAS)
- Canadian Domestic Offset Programme
- North American Regional Greenhouse Gas Initiative (RGGI)
- French study on domestic offset projects commissioned by the French government
- German study on potential 'National Projects' (domestic offsets) scheme.

The discussion covers the approach to additionality, links with existing policies and measures, project size, monitoring and reporting requirements, trade-ability of credits, credit type and fungibility of credits with other schemes, any coverage within the EU (all or only certain Member States) and geographical coverage of a project (ie whether credits from the project can only be used towards the host country's targets). In designing a scheme decisions would have to be made about the role of government, the eligibility of projects and the determination of additionality.

Allowing the linking of domestic offset projects to the EU ETS and allowing full fungibility of credits between the two systems would be an option to enable the EU ETS to effect emissions in some of

37 (April 2006), 'LETS Update: Working Groups C' Environment Agency for England and Wales.

the more dispersed emissions sectors such as transport and the residential sector. No specific model is recommended, instead directions are given on how to design such a scheme with reference to the elements listed above. Two clear points of guidance are stipulated, however, that:

- rules and procedures for verifying domestic offset credits are such that emissions sold into the EU ETS system are additional and certain
- the additional availability of potentially low-cost compliance options for EU ETS participants is balanced with the need to maintain an incentive for in-house emission reductions by EU ETS participants.

Previous studies of transaction costs relating to the domestic offset schemes were summarised and related to the EU case. The Sustainability Appraisal looks at the environmental, economic and social impacts of the overall concept of a domestic offset scheme, and indicates where these impacts vary depending on the design of the offset scheme.

Environmental impacts

From an environmental point of view, the use of a domestic offset programme will have a limited direct effect, as emission reductions achieved in non-EU ETS sectors will result in credits sold into EU ETS sectors. As a consequence, emissions in the ETS sectors will increase compared to emissions in the absence of a domestic offset scheme. Only if discounting is applied, ie not all emission reductions of a project are converted into credits, will domestic offset projects result in extra emission reductions. There can be an indirect effect, however, when the carbon price incentive becomes available to other sectors and organisations, creating an increased awareness of and interest in emission reductions measures. This could lead to increased implementation of such measures, beyond the realm of a domestic offset programme.

A potential environmental disadvantage is that the linking of such an offset scheme with the EU ETS would further enable[38] the EU ETS sectors to reach their reduction targets without in-house reductions. This disadvantage resulted in Working Group C's conclusions that the design of such an EU scheme should help with maintaining a carbon price signal for the EU ETS.

Economic impacts

The introduction of a domestic offset scheme has an important economic advantage. Capturing emissions from sectors that are made up of a large number of dispersed emissions sources, such as the transport and domestic sectors, within the scope of flexible trading mechanisms is very difficult. A domestic offset scheme could provide these sectors with access to the EU ETS and provide participants with extra flexibility in achieving their emissions targets. As a result, the EU ETS will access a wider range of low-cost abatement options, enabling the EU ETS cap to be met at a lower cost than would otherwise be the case.

The cost of a domestic offset scheme has to be understood in light of the functioning of the broader market for carbon credits. If a domestic offset project does not offer value for money – ie if the cost to the project developer through transaction and abatement costs is greater than the market price for credits – the project will not take place.

Therefore, it is important to consider the following economic costs:

- The transaction costs for the project developer, for example monitoring, reporting and verification and the actual abatement costs
- The cost to government of setting up and maintaining the scheme.

[38] The Linking Directive already allows EU ETS installations to reach their targets with CDM/JI credits.

In terms of transaction costs, a scheme should only be set up where it can be determined that the scope of eligible projects will realistically offer the potential to deliver emissions at a cost that will attract project developers.

The overall costs, including those to government, should be seen in comparison to the cost of setting up any other policy or measure to stimulate emissions reductions in non-EU ETS sectors within the scope of the domestic offset scheme. Any such set-up costs are likely to be reduced overall where a scheme is designed at the EU-level rather than by individual Member States.

The in-depth investigation into domestic offsets included a wide assessment of information on transaction costs. Of the systems summarised, the Canadian system investigated transaction costs in the greatest depth. As most of the other systems studied are under development, little additional information is currently available on transaction cost. CDM projects are in a more advanced stage of realisation and, therefore, some cost elements are also available from that mechanism.

Indicative figures from both the Canadian study and CDM estimates show that total transaction costs to project developers can be as high as €135,000, or even slightly more. This must be seen in the context of credit values of up to several million Euros and total project investment cost of up to several hundreds of millions of Euros. The Canadian study estimates lower transaction costs in general than were apparent through experience with CDM, and here the differences might be due to differences in system design, although the Canadian study does include a stringent scenario. The differences in cost might also relate to the sectors in which projects were carried out – it is important to consider sector overlap with potential domestic offset schemes in Europe when trying to apply costs.

Looking at the detailed breakdown of costs in the Canadian study, it is clear that in some sectors, and with the correct system design, transaction costs to the project developer can be kept under €2–€3/tonne. The Canadian study highlighted the following as ‘sectors’ that would be eligible to be part of a domestic offset scheme: action on renewables, action on energy efficiency, landfill gas, agriculture, forestry and ‘other sectors’. The right system design could create a system where domestic offset projects are viable for project developers.

The administrative costs vary little with system design and make up a smaller part of overall system costs than the project developer’s portion. In looking at the Canadian study, the projects which carried the highest total system transaction costs were those in the agriculture and forestry sector. It should be noted that these projects are likely to be the most contentious from the perspective of a European system. Therefore, overall, the combination of developer and administrative costs should enable a cost-effective scheme to be created.

If the same restrictions are applied to a European domestic offset project system as in the CDM structure (in terms of stringent additionality etc), domestic offset projects will have to show considerable opportunities for emissions reductions in order to be cost-effective. However, lessons learnt from the CDM structures could reduce costs for any schemes that are now created, for example how to set up funds for projects, methodologies etc.

It is clear from the work done thus far that costs can be reduced through elements of system design. As illustrated by the Canadian study, and investigated in the French domestic offset paper, costs can be reduced per tonne of abatement in sectors with diffuse emissions sources, where pooling (ie forming consortia of smaller operators to achieve reductions as a group) takes place. This could be an important consideration in the proposed European domestic offset scheme, as the intention is to access sectors that lie outside the EU ETS which tend to have diffuse emissions.

Social impacts

The proposal to include domestic offsets in general will not have a wide range of social impacts. Depending on the range of projects made eligible for inclusion in the scheme, some could have additional benefits from a social perspective such as:

- job creation in certain sectors (for example for agricultural or forestry projects), specialist project development, and/or monitoring and reporting
- reductions in fuel poverty where emissions reductions target the residential sector
- improvements in mobility through integrated approaches to transport.

The degree and nature of these social impacts are greatly dependent on the design of the domestic offset scheme. The assessment has also been based assuming a potential programme would meet the criteria for a domestic offset programme as formulated by Working Group C:

- Rules and procedures for verifying domestic offset credits are such that emissions sold into the EU ETS system are additional and certain.
- The additional availability of potentially low-cost compliance options for ETS participants is balanced with the need to maintain an incentive for in-house emission reductions by ETS participants.

Conclusions

Looking at these three elements together, it is clear that, if properly designed, the inclusion of a domestic offset scheme will yield increased flexibility in achieving the EU ETS cap and will stimulate emissions reductions in difficult sectors. The careful design of the approach should ensure that transaction costs are kept low, and the nature of the market will select cost-effective projects.

8.3 The interaction between the EU ETS and other policies and measures

The analysis of the interaction between the EU ETS and other EU-level policies and measures (P&Ms) highlighted the complexity of such interactions.

The P&Ms that currently have the highest degree of interaction with the EU ETS are the:

- Integrated Pollution Prevention and Control (IPPC) Directive
- Renewable Electricity (RES-E) Directive
- Combined Heat and Power (CHP) Directive
- Energy Performance of Buildings Directive (EPBD).

Two P&Ms that have a high potential to interact with the EU ETS in the future are the:

- waste treatment Directives
- potential carbon capture and storage legislation.

An interaction checklist was developed with areas of interaction between the EU ETS and other EU P&Ms for policy-makers to consider when developing new policies. This checklist was based on the six P&Ms above, which were studied in detail. The findings can be seen in the report from Working Group C. It is the use of such a checklist approach that is assessed in this Sustainability Appraisal.

Environmental impacts
The use of the checklist should increase the synergies between the EU ETS and other policies that also reduce GHG emissions. As a result, in qualitative terms, an increase in the co-ordination of the approach to policy formulation could result in greater emissions reductions overall.

Furthermore, some of the policies covered in the checklist have other environmental goals, although they also effect reductions in GHG emissions. It is possible that the increased synergy will bestow benefit on these other environmental goals as well. This is dependent on the outcome of the policy-makers use of the checklist in relation to individual policies and therefore cannot be quantified, but should be considered as a possible gain.

On the other hand, there may be trade-offs identified between different policy areas, for example low sulphur fuel versus emissions reductions. However, more careful consideration of policy formation can only help reduce the environmental trade-off necessary and is unlikely to cause damage to the environment when compared to the case without such careful consideration.

Economic impacts
The checklist is intended for use at Member State and EU-level. This will require additional time from the relevant civil servants, at some cost to governments. However, it is expected that if used appropriately, the checklist should not prove a great additional cost to governments as it seeks to guide the policy-maker in their approach, rather than to increase the work of policy formation. In addition, upfront consideration of possible overlap between different P&Ms is likely to reduce cost compared to retroactively addressing adverse effects of P&Ms already implemented.

A more integrated approach to the range of policies designed to stimulate GHG emissions reductions should reduce transaction costs to those in the private sector who are investing in abatement. These reduced costs would come from clearer guidance about the roles of different policies and measures and maximal use of synergies such as common definitions, common monitoring and reporting guidelines etc.

Social impacts
It is not foreseen that this proposal will have any significant social impacts.

Conclusions
The benefits of the use of a checklist to further improve the co-ordination of greenhouse gas policy formulation appear to outweigh any costs.

8.4 Improving the transparency of the EU ETS

This part of the study looked at the potential to improve the transparency of the NAP preparation and assessment process. Two areas were investigated in detail:
- The determination of growth rates used to set allocations
- The contribution of EU ETS sectors and non-ETS sectors to reaching the Kyoto/Burden Sharing targets.

Transparency on growth rates
This section studied the Phase I NAPs, as well as a range of other source material, to highlight, and where possible compare, the range of growth rates used to set allocations.

The overall recommendation from this work was that a template be used to make sure that the information needed to make a sensible comparison between growth-rate assumptions is provided by countries. This template should highlight the information that is the basis of both the NAPs as well as for other projections and historical data sources.

Member States would first need to provide clear definitions on the different growth parameters including:

- sector aggregation level and sector definition
- type of growth rate and units used
- type of emissions included
- gross versus net growth rates
- inclusion of New Entrants Reserve (NER) or not
- source of growth rates.

The template could then be used by Member States to provide all of the above data themselves. The sample template in the final report of Working Group C includes a breakdown between process and energy emissions, incumbents and new entrants, 'business as usual' (BaU) growth and growth under the cap. It also requires the provision of a range of growth factors from other sources to be used for comparison purposes.

Overall, the use of a common reporting format, including the above definitions and template, would increase the transparency of the NAP process.

Transparency on the contribution of sectors to meeting the Kyoto targets

A methodology has been proposed to demonstrate the relative burden that has been put on the EU ETS and non-ETS sectors over a long timeframe. This methodology was investigated in terms of the barriers to its implementation and the benefits from the perspective of different Member State governments. The intention was to improve the ability to compare effort between sectors over time within a country and even between countries. The increased transparency would help the Commission in its assessment of whether the EU ETS caps represented fair assumptions in relation to the pressure on EU ETS sectors, and a Member State's overall ability to meet their Kyoto committment, given their sectoral caps.

The methodology was investigated in detail in relation to its potential application in Austria, Italy, the Netherlands and the UK. Discussions with the modelling teams in these Member States highlighted several concerns about the feasibility of using the methodology in question.

The final report of Working Group C identifies potential solutions to the barriers to applying the methodology. These include the development of a single EU model that models all Member States in the same way. Alternative suggestions were made relating to the detail of the methodology itself. Overall, the Working Group concluded that further work was needed to assess the interest in, and feasibility of, applying the proposed methodology.

For the purposes of the Sustainability Appraisal, the introduction of a methodology to increase the transparency of the split between EU ETS and non-ETS sectors is assessed, as well as the option of an EU model.

Conclusions

The overall recommendations in these areas seek to improve transparency. Therefore the Sustainability Appraisal focuses on the impacts relating to the overall goal of improved transparency, using the hypothetical case where NAPs are perfectly transparent, as well as the individual recommendations themselves.

Environmental impacts

In a hypothetical case where the transparency of the NAPs is perfect, it is likely that the environmental integrity and effectiveness of the scheme would be improved.

This conclusion is based on the logic that the European Commission reviews and approves the NAPs. The caps are the key determinants of environmental effectiveness of the EU ETS. With increased overall transparency of NAPs the Commission will be able to understand better the appropriateness of the caps in relation to the system's objective. In particular, the recommendation designed to improve the reporting of growth rates would increase transparency around the setting of sectoral caps compared to other indicators, such as historic growth etc. This information will help the Commission judge whether sufficient effort is being made by the EU ETS sectors and enable better prevention of windfall profits. The reviewers could use this knowledge to justify requests for increased stringency. Tight caps would be a key determinant of environmental effectiveness of the scheme, improving the environmental impact in terms of reductions in GHG emissions.

Looking specifically at the recommendations in this report, the information in the template in relation to growth rates is likely to have a great effect on the transparency in relation to environmental integrity of the scheme itself, ie appropriateness of the caps.

Information about the split of burden over time between EU ETS and non-ETS sectors is likely to improve the environmental integrity of a Member State's approach to meeting its Kyoto targets. Where it is used in relation to the EU ETS, changes might result in greater stringency in the cap. Increased clarity of information is also likely to have an effect on emissions reductions through decisions on P&Ms in other sectors. Also, qualitatively, in many countries the EU ETS sectors (heavy industry) have been responsible for many of the early moves to make emissions reductions, so it could be expected that the analysis would encourage policy improvements in other sectors.

Therefore, the growth rates information is likely to have a greater environmental benefit than the information on policy pressures in the context of the EU ETS. However, the latter recommendation will affect approaches for meeting national goals overall. This area represents a larger amount of emissions and therefore greater environmental benefit is at stake.

Economic impacts

Looking at the overall case, increased transparency is simply the increased availability of relevant information. This should cost little in theory. However, each individual recommendation has to be looked at more closely, as the true cost of analysing and displaying complex data in a comparable way can be great.

The introduction of growth-rate information is also likely to create a more level playing field between sectors operating in different European countries. The exposure of sectors where windfall emission rights have been given in one Member State will enable the Commission to make decisions that reduce competition distortions. This should lead to economic advantages.

The current analysis shows that a wide range of growth rates has been used across the same sectors in different countries. These growth rates are so different in their nature (for example emissions versus production) that they are often not even comparable. It is not possible, therefore, at this stage to give an indication of the scale of these competitiveness issues, but it is highly likely both that they exist and that more transparent reporting should help facilitate improvements in this area.

There will be costs in Member State time in order to fill in these templates. This time cost is however likely to be minimal as in most cases the information requested will be part of the Member State's assumptions and rationale. Furthermore, presentation of growth rate information will reduce the time necessary for the Commission to review the NAPs as it will be more straightforward to understand the logic behind the caps. Therefore the net cost across policy makers is likely to be small. In fact, it could be argued that because Member States have better access to knowledge about their own country the extra cost to a Member State is less than the reduction in Commission time, thus making common reporting formats for growth rates favourable economically.

The recommendation in relation to calculating the pressure between EU ETS and non-ETS sectors to meet Kyoto targets implies greater costs. The use of the original methodology, as investigated in different Member States, highlighted a number of barriers. It is clear that it would require a great deal of time on the part of Member States, possibly months or more of modellers' time, to implement the methodology. Furthermore, the variability in models between countries might mean that even after this work has been carried out, the results still might not be completely comparable.

One alternative suggestion was to create an EU-wide model. It is likely that this approach would cost in the realm of €1 million.

Social impacts

An increase in transparency will have the social benefit of improving the freedom of information available to the public. Although this information should already be accessible, by request through the Freedom of Information Act[39], increased access to information can be considered an improvement.

Beyond the provision of information, no social impacts directly associated with these recommendations have been identified.

Conclusions

This Sustainability Appraisal indicates that, certainly in the case of the growth rates reporting template, the benefits outweigh any disadvantages or costs in terms of overall sustainability. This conclusion is supported by the recently published Commission Guidance document on drafting Phase II NAPs[40]. This document contained reporting templates on growth rates that go part way towards meeting the standard recommended in the final report of Working Group C. Further progress towards the ideal standard would increase transparency further.

However, the Sustainability Appraisal indicates that the work on policy pressures may be more costly. Working Group C's conclusion is that further work is undertaken to explore different options. This will enable changes to the proposed methodology to provide the information needed from an environmental perspective, at lower cost.

39 Information already provided at Member State level, see for example, UK Freedom of Information Act 2000 available from: www.opsi.gov.uk/ACTS/acts2000/20000036.htm

40 Communication from the Commission, (2005), 'Further guidance on allocation plans for the 2008 to 2012 trading period of the EU Emission Trading Scheme' COM (2005) 703, 22 December 2005.

It must be noted that the problems with the use of the proposed methodology for assessing sectoral policy pressure are largely due to deficiencies in the current reporting under the Monitoring Mechanism. These deficiencies lead to a large degree of incomparability of approaches between Member States. As a result, substantial difficulties exist in assessing the effectiveness of policies and measures, the progress of different Member States towards their Kyoto/Burden Sharing targets and the contribution of different sectors to reaching those targets. This can potentially have large impacts on both the environmental effectiveness of European climate change policy and the competitiveness position of different industries.

The above issues might be best addressed, from a methodological point of view, by the development of an EU-wide model, using a common approach for all Member States, which allows for a modelling of the effectiveness of policies and measures. A preliminary, rough estimate of the development cost for such a model would be about €1 million. It must be noted, however, that it is not clear whether Member States would be willing to use such a model (or its results) over their own models, especially developed to fit their national context and needs.

It should be noted that the Commission Guidance on Phase II, published in December 2005, also includes greater reporting about policies and measures in other sectors. However this does not account for claims made in some NAPs about historical and overall policy pressures to reduce emissions in certain sectors. The approach taken in the Guidance documents supports the conclusion of this Sustainability Appraisal, that an approach to understanding this split is important, but should not be undertaken at too high a cost. Note that a low-cost approach that does not provide the correct and truly comparable information is not the right approach and many pitfalls exist in this arena.

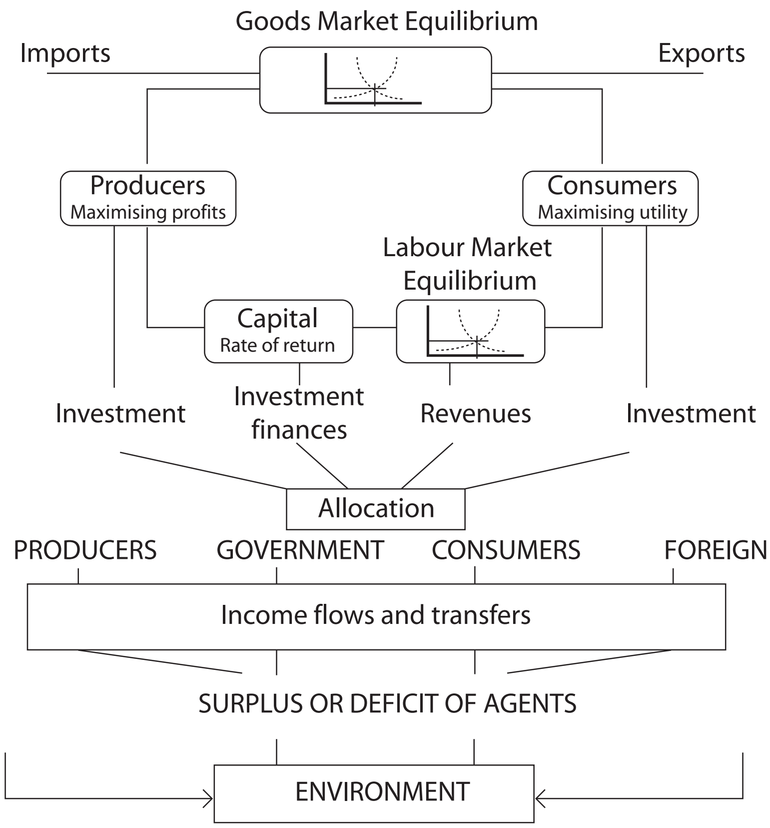
Annex A

Description of GEM-E3 model and detailed results of GEM-E3 modelling

General features of the GEM-E3 Model

1. Its scope is general in two ways: it includes all simultaneously interrelated markets and represents the system at the appropriate level with respect to geography, the sub-system (energy, environment, economy) and the dynamic mechanisms of agent's behaviour.
2. It formulates separately the supply or demand behaviour of the economic agents which are considered to optimise individually their objective while market-derived prices guarantee global equilibrium.
3. It considers explicitly the market clearing mechanism and the related price formation in the energy, environment and economy markets: prices are computed by the model as a result of supply and demand interactions in the markets and different market clearing mechanisms, in addition to perfect competition, are allowed.
4. The model is simultaneously multinational (for the EU or the World) and specific for each country/region; appropriate markets clear European/Worldwide, while country/region-specific policies and distributional analysis are supported.
5. Although global, the model exhibits a sufficient degree of disaggregation concerning sectors, structural features of energy/environment and policy-oriented instruments (for example taxation). The model formulates production technologies in an endogenous manner allowing for price-driven derivation of all intermediate consumption and the services from capital and labour. In the electricity sector, the choice of production factors can be based on the explicit modelling of technologies. For the demand-side the model formulates consumer behaviour and distinguishes between durable (equipment) and consumable goods and services.
6. The model is dynamic, recursive over time, and driven by accumulation of capital and equipment. Technology progress is explicitly represented in the production function, either exogenous or endogenous, depending on Research and Development (R&D) expenditure by the private and public sectors and taking into account spillover effects.
7. The model formulates pollution permits for atmospheric pollutants and flexibility instruments allowing for a variety of options, including: allocation (grandfathering, auctioneering, etc), user-defined bubbles for traders, various systems of exemptions, various systems for revenue recycling, etc.

Figure 10 | Diagramatic representation of the GEM-E3 Model



Modelling the scenarios in GEM-E3

The analysis with the GEM-E3 model starts by constructing a reference projection of economic growth for the 18 regions with which the world is represented in the model. The reference projection named baseline scenario, serves as a basis of comparison for the policy scenarios. For the development of the baseline scenario, assumptions were made on total factor productivity and anticipated growth rate of sectors.

The market for pollution permits is simulated in the GEM-E3 model as follows: Given the total supply of permits, the price of permits is derived by equilibrating the demand for emission rights and the fixed supply. This can be done on a national or a multinational level. After an initial allocation of the permits a polluter may purchase or sell permits depending on his production plans and his abatement and substitution possibilities. While a purchase will increase the costs of production, a sale of permits will reduce the output prices (perfect competition assumption).

In the present study, it is assumed that the rights are distributed according to a grandfathering principle, corresponding to the level the agents were emitting in the base year. An economic agent then has to compare the costs of reducing emissions below his endowment, to the benefit from selling his permits to the market.

The analysis starts by imposing an emission reduction constraint at the level of the club. In particular the following clubs were formulated for each scenario:

Scenario 1

- Club Non-EU Annex B: A common target is applied to all non-EU Annex B countries. Full trade among all sectors and countries is assumed.
- Club EU: A target on EU is applied. Full trade among EU sectors is assumed.
- CDM is accessible to all Annex B regions. The CDM hosting regions are: Brazil, China, East Asia, India, Latin America Mexico and Venezuela.

Scenario 2

- The difference from Scenario 1 is that the EU Club is split into:
  – sectors that participate to the EU ETS
  – the rest of economy (non-ETS sectors + households).

Scenario 3

- Non-ferrous metal industry participates in the EU ETS.

Scenario 4

- Chemical industry participates in the EU ETS.

Scenario 5

- Coal Industry participates in the EU ETS.

Scenario 6

- Chemical and aluminium industries participate in the EU ETS.

The allowances for candidate sectors (aluminium, chemicals and coal) are set to their baseline emissions when they do not participate in the EU ETS (ie in scenarios 2 to 6).

To meet the global emission reduction constraint it is assumed that a perfect (no transaction costs) pollution permit market is established for energy and non-energy-related emissions. This emission constraint, imposed in the model, acts additionally to the baseline scenario assumptions triggering structural changes and substitutions.

For climate change, imposing a global emission reduction constraint enables the internalisation of the costs of emission reduction. In the model, the shadow value of such a constraint introduces additional costs to the firms and households, and associates those costs to final and intermediate consumption of goods that emit CO_2. Moreover in the case of non-energy-related gasses where emissions are linked to the level of production of the appropriate sectors, the shadow costs are additional to the unit cost of production of these branches. Therefore, the agents face a change in the cost of using the commodities and production factors.

As regards to the revenues/losses realised through the sales/purchases of pollution permits, these are recycled in the economy by distributing them to capital income. Rents of permits allocated to capital income are further distributed to the owners of the firm (households) in the form of dividends. This affects disposable income of households and hence demand.

Capital is assumed to be fully mobile across sectors but not between countries. At a regional level, this results in a uniform rate of return on capital for the whole economy.

Finally it should be noted that general equilibrium models such as GEM-E3, for a given abatement scenario, tend to produce lower market clearing prices than partial equilibrium (energy) even when total elasticities and elasticities of substitution between fuels together with marginal abatement cost relationships (for non-energy GHGs) are equivalent. The main reason for this tendency is the additional flexibility that characterises general equilibrium models: abatement is achieved not only through reduction of energy use and inter-fuel substitution but also through reduction of overall activity as well as the substitution between energy intensive activities with less energy intensive ones. These reductions occur as part of the standard behaviour of economic agents (households and firms) as they adjust their decisions (consumption patterns and input configurations) while maximising (welfare or profits) in the face of altered prices (of goods and services and factors of production including intermediate purchases).

Annex B

'Bottom-up' modelling

Competitiveness impacts

General impacts

The EU ETS will result in both winners and losers. The former will have one of, or a combination of, the following characteristics: low emissions (relative to their allocation), low marginal abatement costs, the ability to pass compliance costs onto customers, and low exposure to the power sector (ie use relatively little electricity). In contrast, losers will be characterised by some or all of the following: significant amounts of electricity use in their operations, relatively high emissions and marginal abatement costs, and constraints to their ability to pass compliance costs onto customers. The two extreme cases are shown in Table 15. Most affected firms (installations) will fall somewhere in between these examples.

Table 15 | Broad determinants of winners and losers in the EU ETS[41]

Installation	Emissions relative to BaU	Marginal abatement cost relative to allowance price	Implied trading activity	Ability to increase price	Exposure to power sector
Winner	Lower	Lower	Seller	High	Low
Loser	Higher	Higher	Buyer	Low	High

The overall economic impact on firms – ie the total cost of being included in the EU ETS – will comprise:

- direct costs – ie the cost of abating emissions plus (or minus) the value of transactions in the allowance market, depending on whether the firm is a buyer (or a seller)
- indirect costs – ie the impact of the EU ETS on the price of factor inputs (mainly electricity).

Aluminium

This section only considers the indirect costs of the EU ETS on the aluminium sector.

The primary aluminium sector is very much concerned with variable costs, since they account for about two-thirds of total production costs.

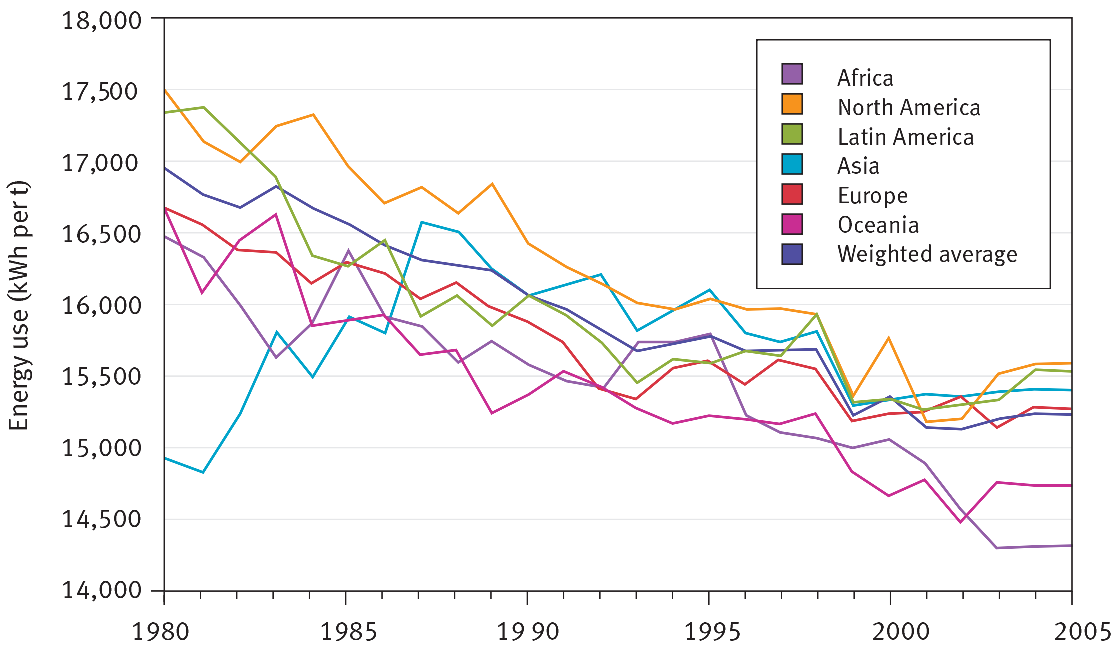
One reason for this is the relatively high cost of raw materials, with bauxite (and alumina) typically produced thousands of kilometres from European smelters. Production of primary aluminium starts with the mining of bauxite, found in Australia, South America, India, the Caribbean and Africa. Bauxite is next refined to produce alumina, which is in turn smelted to produce aluminium. To produce one tonne of primary aluminium takes approximately two tonnes of alumina, which in turn takes four tonnes of bauxite.

41 P Ekins, (2005), 'Emissions Trading: Impacts on Electricity Consumers', a summary report submitted to OFGEM, Policy Studies Institute.

A second reason is the large amount of (uninterrupted) electricity consumed by smelters. The reduction of aluminium from alumina is very power-intensive. As a result, a significant part of world primary aluminium production is located near cheap energy sources (for example hydro-electric power in Canada or the oil and gas fields in the Middle East). Indeed, smelters would be expected to obtain cheaper power than other industrial customers, since they demand a continuous high-voltage base load and often enter into take-or-pay contracts. Even still, electricity costs typically constitute 20–30 per cent of production costs[42]. Electricity prices therefore have an important influence on profitability. Interestingly, according to the UK Aluminium Federation, over 60 per cent of the western world's primary aluminium is produced from electricity generated by hydro-electric power. However, the EAA reports that there are only two plants in the EU which have their own on-site generation, the rest have long-term dedicated contracts with power suppliers for electricity.

Globally, most smelters use a similar amount of electrical energy per unit of aluminium metal produced (see Figure 11). Modern smelters use as little as 14 kWh of electricity to produce a Kilogram (Kg) of aluminium from alumina. Energy consumption has been reducing over time as a result of improved cell design and the use of microprocessors and computer-controlled pot lines. In 2005, it took approximately 15.3 kWh of electricity, on average, to produce one Kg of aluminium in Europe; lower than North America, Latin America and Asia, but higher than Africa and Oceania. With respect to trends in electricity use, aluminium production has continually improved its efficiency. (The UK Aluminium Federation claims that further reductions will be possible with the development of inert anodes.)

Figure 11 | Electrical power used per metric ton of primary aluminium produced



Source: IEA Statistical database.

Despite having the lowest electricity use per tonne of primary aluminium production, Oceania production is the most greenhouse-intensive, followed by Asia, Africa, North America, Europe and Latin America. If the EU ETS were to lead to the relocation of the smelting industry to other parts of the world, global GHG emissions would likely increase[43].

42 H Turton, (2002), 'The Aluminium Smelting Industry: Structure, Market Power, Subsidies and Greenhouse Gas Emissions', Discussion Paper No. 44, The Australian Institute.

43 A chart detailing global emission levels is provided in Section 4.

Review of studies on indirect costs of the EU ETS

Two studies have looked at the indirect costs of the EU ETS on the primary aluminium sector[44 45]. The results are summarised below.

Oxera made the following key assumptions (for aluminium smelters): price elasticity of demand = -0.8; average variable production cost = £786/tonne (€1,140/tonne); electricity consumption = 15,351 kWh/tonne; and non-EU suppliers have 35 per cent of the EU market.
The price of aluminium used in the modelling was £1,000/tonne (€1,450/tonne).

For the period 2008–2012 an allowance price of ten €/t CO_2 eq was assumed. After 2012 the price rises to 25 €/t CO_2 eq.

The wholesale price of electricity used in the analysis, prior to the introduction of the EU ETS was just over £23/MWh (€33/MWh). OXERA estimated that an allowance price of ten €/t CO_2 eq would increase the variable production costs of UK generators by 23 per cent, which would increases wholesale prices by 15 per cent, based on 90 per cent of the cost increase being pass-through to customers.

The predicted 15 per cent increase in wholesale electricity prices was estimated to increase variable production costs by five per cent and increase aluminium prices by three per cent, based on 66 per cent of the cost increase being pass-through to customers. The increase in product prices in turn reduces the quantity demand by six per cent. Overall, EBITDA were estimated to fall by 31 per cent.

Oxera assumed that all smelters purchase electricity, despite around 20 per cent of EU smelters generating their own power. This would tend to overstate the financial impact. At the same time, the modelling approach adopted ignores the potential loss of exports that may result from the introduction of the EU ETS. This would tend to underestimate the financial impact.

Reinaud made the following assumptions: price elasticity of demand = -0.86; average variable production cost = $1,000/tonne (€885/tonne); and electricity consumption = 15,200 kWh/tonne. The price of aluminium used in the modelling was $1,600/tonne (€1,290/tonne).

If the allowance price is ten €/t CO_2 eq. Reinaud estimated that wholesale electricity prices would increase by 11 per cent. If 100 per cent of the price increase was passed onto aluminium smelters, their production costs would increase by 3.8 per cent (+2.4 per cent with 75 per cent pass through by electricity suppliers). Reinaud then assessed two scenarios: one in which the smelters opt to maintain market share (at the expense of profitability) and another in which smelters decide to maintain profitability (at the expense of market share). In the former case, smelters do not pass any of the increased production costs onto customers. The resulting reduction in operational margin is 29 per cent (-7 per cent with 75 per cent pass through by electricity suppliers).

If smelters pass the additional production costs onto customers, aluminium prices are predicted to increase by 3.4 per cent (+2.4 per cent with 75 per cent pass-through by electricity suppliers). Demand for aluminium in the short run is estimated to decrease by 2.9 per cent (2.0 per cent decrease with 75 per cent pass-through by electricity suppliers). This is a short run impact. In the long run, faced with reduced profitability, smelters could opt to shut down or relocate outside the EU, and then sell aluminium back into the EU market[46]. An illustration of the financial problem high power costs cause aluminium producers is provided in Box 5.

44 Oxera, (2004), 'CO_2 Emissions Trading: How Will It Affect UK Industry', report prepared for the Carbon Trust, Oxera Consulting, Oxford.

45 J Reinaud, (2004), 'Industrial Competitiveness under the EU ETS', IEA Information Paper, IEA, Paris.

46 Many other factors will influence relocation decisions, including the availability of skilled labour, transportation infrastructure, the tax and regulatory regime, etc.

In theory, freight costs could offer some protection to the aluminium sector from foreign competition in domestic markets. Reinaud investigated this issue by comparing non-carbon constrained aluminium plus freight costs with EU-produced aluminium plus the indirect costs of the EU ETS (assuming 100 per cent pass through by electricity suppliers – ie the extreme case). She found that the price of aluminium with the indirect costs of the EU ETS could well exceed the costs of imported aluminium with freight costs (which, over the period studied, were considerably higher than the medium-term average). In other words, even relatively high freight costs offer limited protection against imported aluminium. This will limit the ability of smelters to pass increased production costs onto customers, which means that operating margins are likely to reduce. This is consistent with Oxera's finding that EBITDA could fall by 31 per cent.

Box 5: Illustration of power price increases on competitiveness

- Rising power prices put European aluminium producers at a cost disadvantage in the global aluminium market.
- The current power contracts for Hydro's German primary aluminium plants expire at the end of 2005. Current power prices in Germany are significantly higher than in 2002, when these plants were acquired. Moreover, based on the ongoing negotiations for renewal of the power contracts, Hydro expects even higher prices. As a result, the expected future cash flows from the German primary aluminium plants are not sufficient to support the present book value of these assets. The final write-down amount will be included in the fourth quarter 2004 results, and is expected to represent a charge to operating income of approximately Norwegian Krone (NOK) 2.4 billion.
- The assumptions used for the calculations are based on four-year forecasts for the aluminium price and the $-€ exchange rate. The power price assumptions reflect the current market level and outlook for the longer term. (The $-€ exchange rate compounds the problem of rising power prices.)
- Hydro is continuing to monitor the future competitive position of its German primary aluminium plants.

Source: 'Hydro Aluminium Write-Down of Book Value of German Primary Aluminium Plants', (14 December 2004), New Materials News.

Key points

Aluminium smelters are very power-intensive, with power costs comprising up to a third of total production costs. They are therefore highly exposed to the indirect costs of the EU ETS via electricity supply.

Despite seeming quite similar, both studies are not that comparable. The Oxera study had a UK focus with allowances allocated to match BaU projections. In contrast, Reinaud's analysis was EU-wide and required sectors to reduce emissions by two and ten per cent. Reinaud also restricted the ability of sectors to pass through increases in production costs so as to maintain constant operating margins. Oxera estimated pass through as a simple function of global competition in both domestic and international markets.

Nonetheless, in both studies, of all the sectors modelled[47], the aluminium sector was clearly the most likely to experience the greatest financial impact; even when the impact was limited to indirect costs (the other sectors modelled participate in the EU ETS and were thus exposed to both direct and indirect costs). It is therefore likely that the financial impact of participating in the EU ETS would only worsen, when direct costs must also be borne (unless smelters receive a generous allocation relative to BaU emissions and have marginal abatement costs lower than ten €/t CO_2 eq).

In general, the degree of non-EU competition faced by participants in their respective markets was one of the key determinants of the financial impact of the EU ETS. Not only are competitors outside the EU free from the marginal cost increases associated with complying with a carbon emission limit, but also their presence limits the extent to which firms in the scheme can pass on the cost increases to customers. This is particularly true in the case of the highly open aluminium sector (see below), despite being characterised in the reports reviewed as an oligopoly. The aluminium sector's ability to influence price is severely restricted.

Another key determinant is the own-price elasticity of demand. The more responsive demand is to price changes, the greater the financial impact of the EU ETS. However, other things being equal, the estimated price elasticities for primary aluminium suggest that aluminium smelters could, in theory, pass costs on to customers without significantly affecting demand and total revenue (see Box 5). As noted above, the threat of international competition severely limits pass through by smelters. Increased production costs are thus likely to be absorbed, lowering operating margins. If, as a result, fixed costs (including an adequate return on investment) are no longer covered, smelters could shut down or relocate.

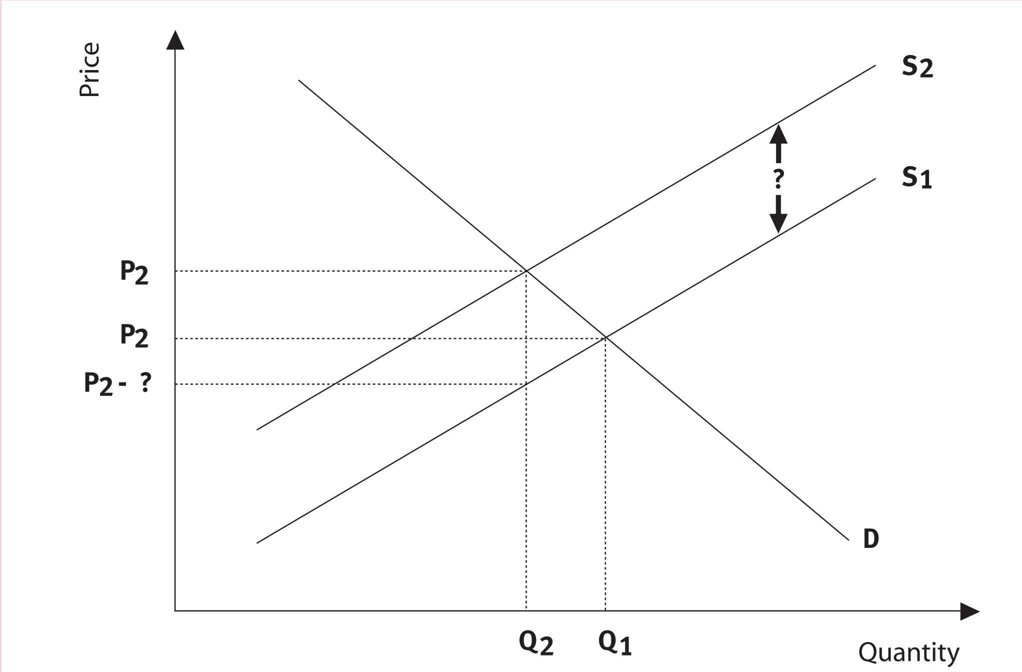
Box 6: Determinants of cost pass through

The figure below illustrates the theoretical effect of a uniform change in variable production costs on the equilibrium price level. An increase of D per unit of production leads to change in supply from S1 to S2, leading to a corresponding change in equilibrium price from P1 to P2. However, the price change, P2-P1, is less than D, indicating that the costs of the change do not accrue solely to the customer. The producer absorbs a portion of the change. Therefore, the ability of firms to pass increases in production costs onto customers is determined by the nature of supply and demand in the market. More specifically, the steeper the demand curve and the steeper the supply curve, the larger the cost pass through.

In the short run, firms' supply responses to changes in equilibrium price are determined by, amongst other factors, spare production capacity, inventory size and the supply of production inputs. However, in the long run firms are able to select any output level given that they are able to plan more fundamental changes to production processes and operating levels. As a result, the nature of demand is the major determinant of cost pass through in the long run.

The nature of global aluminium demand is characterised by the elasticity of demand. This gives the percentage change in demand that follows a 1% increase in price. An elasticity of less than one (described as 'inelastic') means that the change in demand is less than the change in price; characterised by a relatively steep demand curve. In this case, demand is reasonably robust to price increases from cost pass through. Alternatively, an elasticity of greater than one ('elastic') indicates that demand is very sensitive to price changes; characterised by a relatively horizontal demand curve.

47 Both OXERA and Reinaud modelled the same sectors: cement, newsprint, cold-rolled steel and aluminium.



As a basic rule: if the absolute value of the own-price elasticity of demand < 1 (price inelastic), a change in price will cause a less than proportional change in the quantity demanded, and total revenue will change in the same direction as the change in price. Thus, if prices are increased by passing the compliance costs of the EU ETS onto customers, then total revenue will also increase. In contrast, if the absolute value of the own-price elasticity of demand > 1 (price elastic), a change in price will cause a greater than proportional change in the quantity demanded, and total revenue will change in the opposite direction as the change in price.

Key factors which determine the elasticity of demand are:

- the availability of substitutes: If there are close substitutes for a good then price becomes more elastic given that a rise in market price provides an incentive to switch to substitutes
- the degree of necessity to customers: The more customers are reliant on a good, the less sensitive demand is to price changes.

The aluminium market

The market for aluminium is global, where demand for primary aluminium, which excludes recycled materials, has been driven by strong demand from developing countries in recent years. More than 33 million tonnes of primary aluminium is used globally per year. The global market value increased by 31.9 per cent over 2003–2004. However, producers have been unable to match increases in demand with corresponding increases in production volumes, which grew by 9.6 per cent in the same period, and thus much of the change in market value reflects an increase in prices[48].

48 Datamonitor, 2005a.

The exposure of the European aluminium sector to international competition can be described by:

- the IPR, which is the proportion of home consumption that is made up of imports
- the ER, which represents the proportion of home production that is exported.

The IPR is essentially an inward-looking measure of competitiveness as it represents the presence of global producers on the European market, while the ER is an outward-looking measure as it represents the presence of European producers on the global market. Table 16 gives values for these two indicators for the two most recent years for which data is available.

Table 16 | International exposure of European aluminium market

Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2003	1,961,434.68	2,540,953.90	21,899.80	0.57	0.01
2004	1,922,018.31	2,599,265.40	39,667.70	0.58	0.02

Figures are for production and trades of unwrought, non-alloy aluminium for EU25 countries. This is considered the best reflection of the primary aluminium market given the data available. Trade figures exclude intra-EU25 trades.
Source: EUROSTAT

The IPR in both years is very high, with almost six out of every ten tonnes consumed in Europe imported from outside the European market. In contrast, the ER for both years indicates that virtually all of European production is consumed within the EU25.

The OECD openness ratio, which essentially combines the IPR and ER, shows that aluminium is very open to international competition when compared with sectors already in the EU ETS such as iron and steel. With an openness ratio of 45 per cent, the aluminium sector is significantly more exposed than the iron and steel sector which has a ratio of 25 per cent.

Given the high import dependence of the European market, an analysis of world primary aluminium production can provide further insight on the competitiveness of European producers. Figure 12 shows the market share by value of production separated into global regions. It can be seen that while Europe is a major producer, its biggest competitor is the Asia Pacific region. The Asia Pacific region outperformed the European market over the period 2000–2004, during which the compound annual growth rate of Asia/Pacific firms was 17.4 per cent compared to 5.8 per cent for Europe[49].

The manufacturing and converting industries in Europe use about 3.4 million tonnes of rolled products, 2.4 million tonnes of extruded products, 0.5 million tonnes of other semi-fabricated products and 0.7 million tonnes of aluminium foil per year. In addition, approximately 1.9 million tonnes of casting alloys are used mainly from the secondary aluminium industry.

The Asia/Pacific region is further expected to increase by 21.7 per cent over 2004–2009[50], compared to 14.8 per cent for Europe[51]. AME Mineral Economics predict world demand for primary aluminium to grow by nearly five per cent per year, from 2004 to 2010. World aluminium capacity projections are well matched to forecast demand, as an extensive list of greenfield and brownfield projects are planned. Even if only those projects already firmly committed go ahead, the current

49 Datamonitor, 2005a: 8.

50 Datamonitor, 2005c.

51 Datamonitor, 2005b.

supply-demand alumina imbalance is forecast to disappear in 2007 (see Table 17). With smelters no longer limited by alumina supply, global smelter utilisation rates will rise and smelters will be able to keep up with primary demand, with real-term aluminium prices drifting below the long-term trend line. Currently, London Metal Exchange (LME) prices have set a series of multi-year highs; the LME three-month aluminium price is $2,000 per tonne (€1,600 per tonne), which is considerably higher than that used in the Oxera and Reinaud analyses. It is worth noting that, since 1990, the annual average aluminium price has only exceeded $1,600 per tonne (€1,290 per tonne) three times.

Figure 12 | Market share by value of production

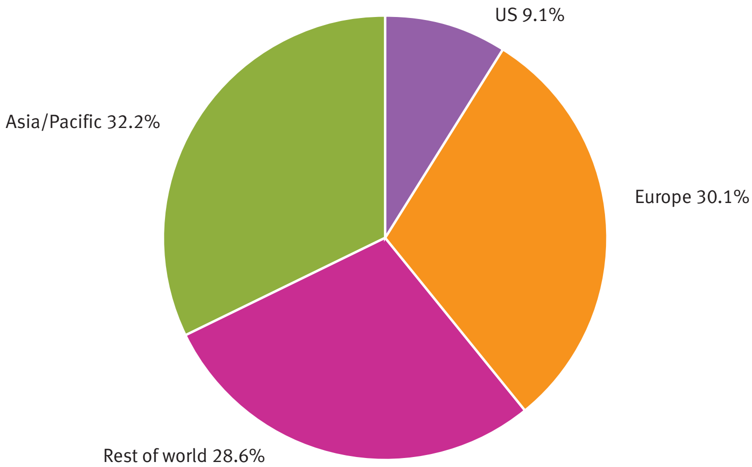
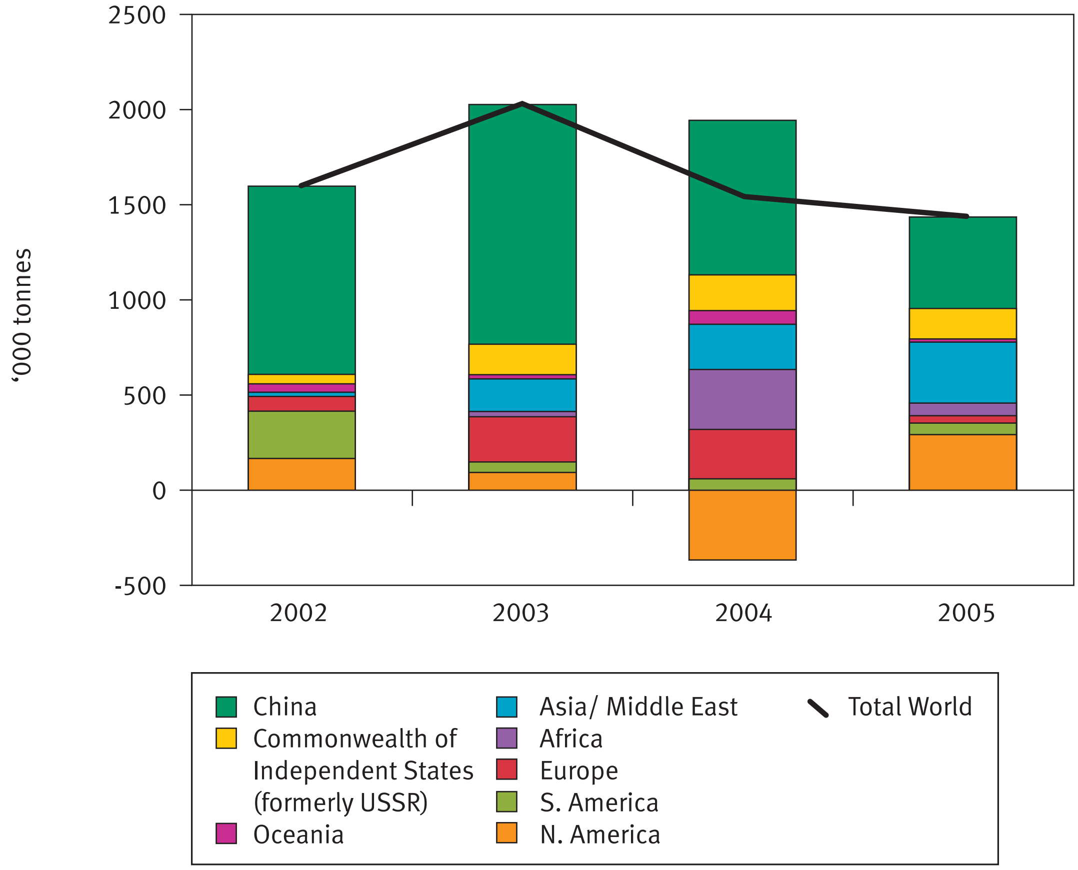


Table 17 | Primary aluminium supply-demand balance

Western World	2002	2003	2004	2005	2006
Demand	**19,640**	**20,780**	**22,070**	**22,723**	**23,354**
% Change year-on-year	3.2	5.8	6.2	3.0	2.8
Production	17,540	18,130	18,678	19,471	20,255
Net Eastern bloc exports	2,600	3,050	2,980	3,009	2,870
Total supply	**20,140**	**21,180**	**21,658**	**22,480**	**23,125**
% Change year-on-year	3.0	5.2	2.3	3.8	2.9
Balance	**500**	**400**	**-412**	**-243**	**-229**
Market stocks	**3,475**	**3,463**	**3,051**	**2,809**	**2,579**
Weeks of consumption	9.2	8.7	7.2	6.4	5.7
Global balance	**2002**	**2003**	**2004**	**2005**	**2006**
World consumption	**25,380**	**27,752**	**29,951**	**31,395**	**33,122**
% Change year-on-year	6.0	9.3	7.9	4.8	5.5
World production (1)	**26,009**	**28,028**	**29,606**	**31,012**	**32,893**
% Change year-on-year	6.6	7.8	5.6	4.7	6.1
Balance	**629**	**276**	**-345**	**-383**	**-229**
Prices	**2002**	**2003**	**2004**	**2005**	**2006**
LME cash price (c/lb)	**61.2**	**64.8**	**77.1**	**80.0**	**77.0**
LME cash price ($/t)	1,349	1,428	1,700	1,764	1,698

Source: Macquarie Research, October 2005.

Figure 13 | Source of supply growth in primary aluminium production – Aluminium production growth by region



Source: Macquarie Research, October 2005.

The predominance of the Asia/Pacific producers is explained by increases in demand from countries within the region, particularly China and India, and the relatively cheap labour and energy costs compared to European producers. Many global firms are moving investment towards the Asia/Pacific region as a result of the more favourable operating conditions[52].

The above market statistics clearly indicate that European aluminium producers are highly exposed to international competition from regions where production costs are generally lower. Also, even though the price of aluminium is currently relatively high and is expected to remain so in the short term, increased production in the medium term is predicted to remove the current situation of excess demand. As a result, it is likely that prices will return to the long-term trend, other things being equal.

52 Datamonitor, 2005c.

Other sectors

In this section, a financial impact model – typically applied in Regulatory Impact Assessment – is used to assess the effects of the EU ETS on the following three sectors:

- Coal (CH_4 emissions)
- Adipic acid (N_2O emissions)
- Nitric acid (N_2O emissions).

In contrast to the aluminium sector, the analysis considers only the direct costs of the EU ETS.

Description of methodology

The methodology used to assess the financial impact on the coal, nitric acid and adipic acid sectors of participating in the EU ETS is based on the approach used by the US EPA for Regulatory Impact Assessment[53 54]. Only the 'tests' for significant impacts are explained below, along with the basic formulas underpinning each test. The mathematical derivation of these formulas from an economic model of perfect competition is not presented.

A clear advantage of the methodology is that it does not require detailed information about the nature of demand and production functions, information which is rarely available to researchers. Instead, data requirements are limited to:

- average variable costs
- fixed costs
- product price
- variable abatement costs
- fixed abatement costs
- elasticity of demand.

The methodology is based on the following assumptions:

- All plants in the industry employ the same technology
- The market is initially in long-run equilibrium
- The variable abatement cost is constant across output
- Market demand is unchanging.

In addition, being based on a model of perfect competition, it is assumed that firms in the EU are price takers, and given price, they choose a level of output that maximises profit.

Ideally, the methodology should be used at the level of the firm. However, this level of analysis is not possible within the scope of this project. Resources only permit us to undertake the analysis at the EU sector level – for example, the EU nitric acid sector is treated as a single firm. The results will therefore mask significant variation in losses and gains within each sector. For coal-mine methane, the sector is divided between the EU15 and the recently acceded countries (denoted the EU10).

Tables 18 and 19 present the assumed input values for each sector. There is a lot of uncertainty surrounding these values – in particular, the average variable and fixed production costs prior to EU ETS participation. Consequently, the sensitivity of the results is subjected to plus or minus 20 per cent variation in the assumed input values.

53 D Dole, (2001), 'Measuring the Impact of Regulation on Firms, Working Paper 01–03', National Centre for Environmental Economics, US Environmental Protection Agency, Washington, DC.

54 P Ekins, (2005), 'Emissions Trading: Impacts on Electricity Consumers', a summary report submitted to OFGEM, Policy Studies Institute.

Table 18 | Chemicals: sector cost, price and elasticity assumptions

Adipic acid	
Input variables	
Per unit variable cost	€1,150.00
Per unit fixed cost	€400.00
Production (tonnes)	€86,400
Price	€1,600.00
Variable compliance cost	€10,342,000
Fixed compliance cost	€0
Elasticity of demand	€0.60

Notes: Per unit variable and fixed costs based on three-year average of two European firms in the sector. Price from UK Institute of Chemical Engineers (guide price for academic studies). Fixed and variable compliance costs from abatement cost curves in Annex B. Elasticity of demand is for synthetic nitrogen fertiliser[55 56].

Nitric acid	
Input variables	
Per unit variable cost	€105.00
Per unit fixed cost	€4.00
Production (tonnes)	€15,020,000
Price	€125.00
Variable compliance cost	€24,100,000
Fixed compliance cost	€63,260,000
Elasticity of demand	€0.35

Notes: Per unit variable and fixed costs based on three-year average of two European firms in the sector. Price from Chemical Week (May 2005). Fixed and variable compliance costs from abatement cost curves in Annex B. Elasticity of demand is for nylon 6-6 from US EPA textile models used for Regulatory Impact Assessment.

Table 19 | Coal: sector cost, price and elasticity assumptions

EU coal	
Input variables	
Per unit variable cost	€33.00
Per unit fixed cost	€7.20
Production (tonnes)	€82,858,000
Price	€55.00
Variable compliance cost	€248,370,000
Fixed compliance cost	€193,000,000
Elasticity of demand	€0.09

Notes: Per unit variable and fixed costs based on three-year average of two European firms in the sector. Price is a weighted average of coal prices paid by end users (weighted by Electricity Supply Industry (ESI) and industrial users) in Germany and the UK, from International Energy Agency (IEA) Coal Statistics, (2005). Fixed and variable compliance costs from abatement cost curves in Annex B. Elasticity of demand is for EU member of G7 from Jones (1996).

EU10 coal	
Input variables	
Per unit variable cost	€19.80
Per unit fixed cost	€7.20
Production (tonnes)	€115,157,000
Price	€32.00
Variable compliance cost	€1,600,700,000
Fixed compliance cost	€536,290,000
Elasticity of demand	€0.09

Notes: Per unit variable and fixed costs based on three-year average of two European firms in the sector. Price is a weighted average of coal prices paid by end users (weighted by ESI and industrial users) in Poland and the Czech Republic, from IEA Coal Statistics (2005). Fixed and variable compliance costs from abatement cost curves in Annex B. Elasticity of demand is EU member of G7 from Jones (1996). Based on OECD comparative price indices, the variable costs of coal production are assumed to be 60% of those in the EU15.

55 Oxera, (2004), 'CO2 Emissions Trading: How Will It Affect UK Industry', report prepared for the Carbon Trust, Oxera Consulting, Oxford.

56 J Reinaud, (2004), 'Industrial Competitiveness under the EU ETS', IEA Information Paper, IEA, Paris.

Short-term impacts

The short-term impact of the EU ETS on a sector is measured by the total net cost of participation relative to the sector's equilibrium level of gross profit, which we shall now refer to as the 'cost-to-profit ratio'. An EU ETS participation cost-to-profit ratio indicates the scheme's long term, as well as short-term impact, since profitability is a key factor in the rate of survival of firms.

The total net cost of participation comprises three elements:

- Fixed abatement costs
- Variable abatement costs
- The value of allowance transactions.

For each sector, these three elements are summarised in the form of abatement cost curves. It is assumed that the equilibrium price of allowances in 2013 is ten €/t CO_2 eq.

Short-run analysis of the costs of participation in the EU ETS is established on the basis of two tests.

Test one

The first test calculates the 'cost-to-profit' ratio based on an assumption of no-cost pass through. With this test, if costs are very small they are likely to have a negligible impact on firms, and thus it is not necessary to consider cost pass through. If the impacts of regulation are judged to be insignificant following this test there is really no need to proceed with the other tests. However, since we are also interested in positive impacts from the EU ETS, we implemented all proceeding tests, even if there were no significant adverse impacts following this test.

The Revenue Ratio (RR), excluding the potential for cost pass through, is calculated as:

$$(1) \quad RR = \frac{(\text{Fixed Abatement Cost + Variable Abatement Cost})}{\text{Revenue}}$$

Dividing through by the sector's gross margin, leads to the revenue ratio, which represents the net cost of compliance as a proportion of sector revenue. If this ratio is less than 0.01, then we conclude that the EU ETS does not have a significant financial impact. The value, 0.01, is the benchmark used by the US EPA*[57].

Gross Margin (GM) is calculated as:

$$(2) \quad GM = \frac{(\text{Revenue} - \text{Variable Cost})}{\text{Revenue}}$$

Note that variable cost in the above formula refers to variable costs before participation in the EU ETS. In order to calculate the cost-to-profit ratio, divide (1) by (2).

Test two

The second test calculates the maximum and minimum impact on sectors following adjustments to the EU ETS, capturing a wide range of potential equilibrium price and production outcomes. An upper bound on the cost-to-profit ratio is created by taking into account the potential for cost pass through.

The upper bound of the RR, including the potential for cost pass through, is calculated as follows:

$$(3) \quad RRMAX = \frac{[\text{Fixed Abatement Cost + Variable Abatement Cost} * \max\{1,\text{-Elasticity}*\text{GM}\}]}{\text{Revenue}}$$

[57] US EPA, (1999), 'Revised Interim Guidance for Rule Writers', US Environmental Protection Agency, Washington, DC.

where the max {} operator selects the greater of the two components separated by the comma. Dividing (3) by (2) yields the cost-to-profit ratio.

A lower bound on the cost-to-profit ratio takes into account the production cost response from the decrease in demand following the price increase. A significance test for these estimates is achieved by converting the lower bound cost-to-profit ratio to a revenue ratio in the same manner as the first test.

The lower bound of the RR, including the potential for cost pass through, is calculated as follows:

(4) RRMIN = RRMAX – (1+ _DSR)*(- _DSR)*GM

where _D is the potential impact on demand calculated as:

(5) _DSR = (Variable Abatement Cost/Revenue)*Elasticity

The term in the brackets () is the per cent change in market price.

If the ratio, RRMIN, is greater than 0.03, then we conclude that participation in the EU ETS has a significant impact. Again, the value, 0.03, is the benchmark used by the US EPA.

Long-term impacts

In the perfectly competitive model, long-equilibrium is achieved where market price equals average costs. Profit maximisation requires that firms produce at the lowest average cost. Given that the minimum efficient scale (the level of production that has the lowest average cost) of the sector is in part determined by fixed costs, fixed abatement costs can affect the long-term profitability of the sector. Furthermore, in the long run, the sector's gross profit must be sufficient to cover the fixed costs of production if the firm is to continue operating. Therefore, we assess the long-term impact by predicting the percentage change in the size of the sector (number of firms). This is achieved by making alternative assumptions about the shape of the average cost function.

The minimum percentage change in the size of the sector (number of firm closures) is calculated as:

(6) FCMIN = - Elasticity*RR

where RR is as in equation (1).

If the minimum percentage change in the sector size, FCMIN, is greater than 0.03, then we conclude that EU ETS has a significant long-term impact.

The maximum percentage change in the size of the sector (number of firm closures) is calculated as:

(7) FCMAX = (1- FCMIN)/ [(1+ _DLR)] - 1

where _DLR is the change in demand in the long-run, calculated as:

(8) $\_DLR = \frac{\text{Fixed Abatement Cost}}{\text{Revenue * GM}}$

If the maximum percentage change in the sector size, FCMAX, is less than 0.01, then we conclude that EU ETS has no significant long-term impact. In both tests, the critical values represent the benchmarks used by the US EPA.

The results of the financial impact assessment are provided below. It is important not to read too much into the absolute values generated by the model; but rather, focus on (a) whether the significance tests identify significant (adverse) impacts and (b) the direction of effects (ie positive or negative).

Coal-mine methane

European sector

Global hard coal production in 2004 is estimated at 4,630 Mt, of which the EU25 contributes about four to five per cent. Production of coal in the EU25 is dominated by four countries, which collectively account for close to 94 per cent of total production: the UK, the Czech Republic, Germany and Poland.

United Kingdom: The UK coal industry employs approximately 9,300 people, of which just over 70 per cent work in deep mining. Most coal-mining projects are found in England, with only 1,200 workers in Scotland and 800 in Wales.

In 2004, 12.5 million tonnes was produced from deep mines, with a further 12 million tonnes produced from opencast mining. Deep mining output suffered a year-on-year fall of 20 per cent due to mine closures. Open cast mining was two per cent lower in 2004 than in 2003. Total UK production has been gradually declining for years.

The UK has exported very little coal (less than one million tonnes per annum) in the last five years. Imports in 2004 were 36.2 million tonnes; higher than 2003 despite higher international prices. Increased imports are due to mine closures, as well as the need for customers (principally generators) to meet environmental standards (for example SO_2 emissions). Coal that is traded with sulphur content typical of UK norms (1.7 per cent) tends to be traded at a discount to most imported coal (0.6 to 0.9 per cent). The UK imports coal from various sources globally, including Australia, Colombia, Poland, South Africa and the US. In 2004 the UK electricity sector accounted for nearly three-quarters of UK coal use.

The amount of coal the country imports is dependent on the gas price, as electricity generators switch between the two fuels. For example, in 2001 the UK imported 35.3 million tonnes at a time when gas prices were relatively high, but in 2002, when the gas price dropped, the UK imported 28.6 million tonnes.

Since privatisation of the power sector, the UK coal sector has become increasingly exposed to international competition, since consumers are free to purchase coal from the most economic source.

Czech Republic: During the Communist era, a key feature of the coal industry was that production outstripped demand. Moreover, production exceeded its own revenue. Without restructuring the industry would collapse. In 1992 the ‘Energy Policy of Czech Republic’ defined the foundations for restructuring. Under this policy, all coal mines were categorised as: (1) consistently loss-making; (2) borderline cases that could struggle in the future; and (3) competitive mines. Based on this classification, the Government decided which mines should be sold, which should be consolidated, and which should be supported. All coal mines were then allocated between 16 coal enterprises. Once the new structure was in place, the Government sought private investment for the newly established enterprises. This has not proved that successful and the Government has revised its plans for the state-funding of coal mines, extending support times.

Since the fall of Communism, demand for coal as a primary energy source has fallen. Between 1989 and 1999, hard coal saleable production fell by 57 per cent, brown coal by 48 per cent and lignite by 33 per cent. Some predictions suggest that by 2020 production and consumption may drop by a further 32 per cent. As demand has declined, so has the coal industry workforce. During the 1990s the number of people employed in the coal industry fell by about 60 per cent.

Coal in the Czech Republic is today used in metallurgy and power generation. Coal has a role to play in the Government's Energy Policy, which aims at using domestic energy sources, while also encouraging private investment. Coal is forecast to meet approximately 25 per cent of the country's energy mix until 2030.

Poland: The Polish economy underwent a radical overhaul during the 1990s making it one of the strongest in Eastern Europe. Recently, however, it has been hit by high unemployment and GDP growth has slowed.

The Polish coal industry has been subject to a cycle of losses. As a result, the Government instigated a restructuring programme. The programme allowed for the closure of unprofitable mines, financial and employment restructuring, privatisation and the improvement of management and environmental standards. Coal is expected to continue to play a major role in the country's energy mix. It is hoped that privatisation will aid industry productivity, as well as attract much-needed capital for modernisation.

Germany: Because coal in Germany is largely underground and typically very inaccessible, it can be costly to mine. It has therefore tended to receive Government support. In 1997 an agreement was signed with the industry that regulates Government policy on subsidies. A revised plan has been developed, which will see German coal production scaled down to 16 million tonnes by 2012. This is designed to retain a long-term core mining industry that is financially viable. As a result of the downscaling, the industry's workforce is forecast to fall from 42,000 to 20,000 employees. To aid with the transitional costs an aid package will be introduced for the coal industry; about €17 billion to be granted between 2006 and 2012.

Despite the official downscaling of the coal industry in Germany, there is currently a school of thought that the country may be better placed to revive the industry. The head of RAG, Werner Müller, and head of the BDI, Jürgen Thumann, published a brochure entitled 'The Global Commodities Crisis is Burning the Mittelstand'. This argues that German reserves of one billion tonnes of coking coal should be utilised to make the country as independent as possible in the world market, arguing that the rise in raw material prices could cost up to 40,000 jobs if no action is taken. Some of the plans suggested include expanding the capacity of the Prosper mine by 100 per cent with an investment of approximately €300 million, in addition to commissioning a new €800 million mine in the Ruhr.

Table 20 | Production, imports and exports for Europe's big four coal producers (includes intra-EU trade)

	Year	Production (Mtce)	Imports (Mtce)	Exports (Mtce)	IPR	ER
UK	1990	76.6	14.7	2.6	0.166	0.034
	2000	26.5	22.2	1.1	0.466	0.042
	2002	25.4	25.8	0.9	0.513	0.035
	2003	24.0	29.3	0.8	0.558	0.033
	2004	21.2	33.0	0.8	0.618	0.038
Germany	1990	174.0	16.4	11.7	0.092	0.067
	2000	86.6	31.7	0.8	0.270	0.009
	2002	84.0	36.4	0.9	0.305	0.011
	2003	82.7	36.7	0.8	0.309	0.010
	2004	83.8	39.4	0.8	0.322	0.010
Czech Republic	1990	49.6	2.2	10.4	0.053	0.210
	2000	35.7	1.5	8.3	0.052	0.232
	2002	34.6	1.6	7.1	0.055	0.205
	2003	34.8	1.8	7.0	0.061	0.201
	2004	33.6	2.2	7.0	0.076	0.208
Poland	1990	134.9	0.6	27.6	0.006	0.205
	2000	101.9	1.5	24.8	0.019	0.243
	2002	101.7	2.5	24.8	0.031	0.244
	2003	101.2	2.3	21.3	0.028	0.210
	2004	99.1	2.3	20.9	0.029	0.211

Source: EA Coal Statistics (2005).

In general, the liberalisation of electricity markets – the single largest customer for coal in the EU – has focused generators' attention on variable costs. Generators now search for the cheapest source of coal, either domestically or overseas. Subsidies allow EU producers to maintain competition on price with coal from outside the EU, but subsides are being phased out, as the major coal industries in the EU restructure.

Not only do coal producers have to deal with the purchasing power of the large electricity generators, but on the international market, trade is dominated by four producers (Anglo Coal, BHP Billiton, Rio Tinto and Xstrata), who can exert a strong influence on coal production for export, and thus price.

Europe currently receives close to 43 per cent of world steam coal imports, reflecting its growing dependency on imported coal. Demand for coal in Europe has been rising, but production has been falling, and as a result increasingly more coal is imported. This is illustrated in Table 20 (and discussed more below).

Financial impact

The results of the impact tests for EU15 and EU10 (Eastern European) coal producers are shown in Table 21 and 22.

Table 21 | Results of financial impact tests for EU15 coal sector

Test	Value	Comments
Short run analysis		
Change in market price	-5.45%	
Short run change in output	0.49%	
Change in gross margin	5.76%	
Maximum potential impact Revenue ratio Cost to profit ratio	 -1.22% -3.04%	
Minimum potential impact Revenue ratio Cost to profit ratio	 -1.02% -2.54%	 No significant impact
Long run analysis		
Long run change in output	10.59%	
Firm closures Maximum Minimum	 -9.48% -0.11%	 No significant impact No significant impact

Table 22 | Results of financial impact tests for EU10 coal sector

Test	Value	Comments
Short run analysis		
Change in market price	-43.44%	
Short run change in output	3.91%	
Change in gross margin	76.80%	
Maximum potential impact Revenue ratio Cost to profit ratio	 -28.88% -75.76%	
Minimum potential impact Revenue ratio Cost to profit ratio	 -27.34% -71.70%	 No significant impact
Long run analysis		
Long run change in output	38.17%	
Firm closures Maximum Minimum	 -25.75% -2.60%	 No significant impact No significant impact

Key points

The coal sectors in both the EU10 and EU15 stand to benefit from participation in the EU ETS, mainly as a consequence of two factors, given an equilibrium allowance price of ten €/t CO_2 eq:

- The rather lax allocation (requiring a reduction of baseline emissions of eight per cent), when the maximum technical potential offers considerably larger reductions.
- The negative total net abatement costs over most of the abatement cost curve.

A greater portion of the cost curve for the EU10 coal sector offers negative abatement costs. Thus when faced with the same reduction target (allowance) this sector benefits more than the EU15 coal sector. This is reflected in the statistics in the above tables, which are more advantageous for the EU10, as opposed to the EU15, coal sector.

In the short term, the negative variable costs essentially provide producers with the opportunity to reduce price, with the result that output increases. Gross profit margin also increases in the short run.

In the long term, both sectors are predicted to expand, even in the case with ‘minimum’ impact.

Note that the comment ‘not significant’ is the result of the test with reference to a critical value (see above), and this test is orientated towards negative impacts. It does not therefore rule out significant positive impacts.

Figure 14 | EU15 coal-mine methane abatement cost curve

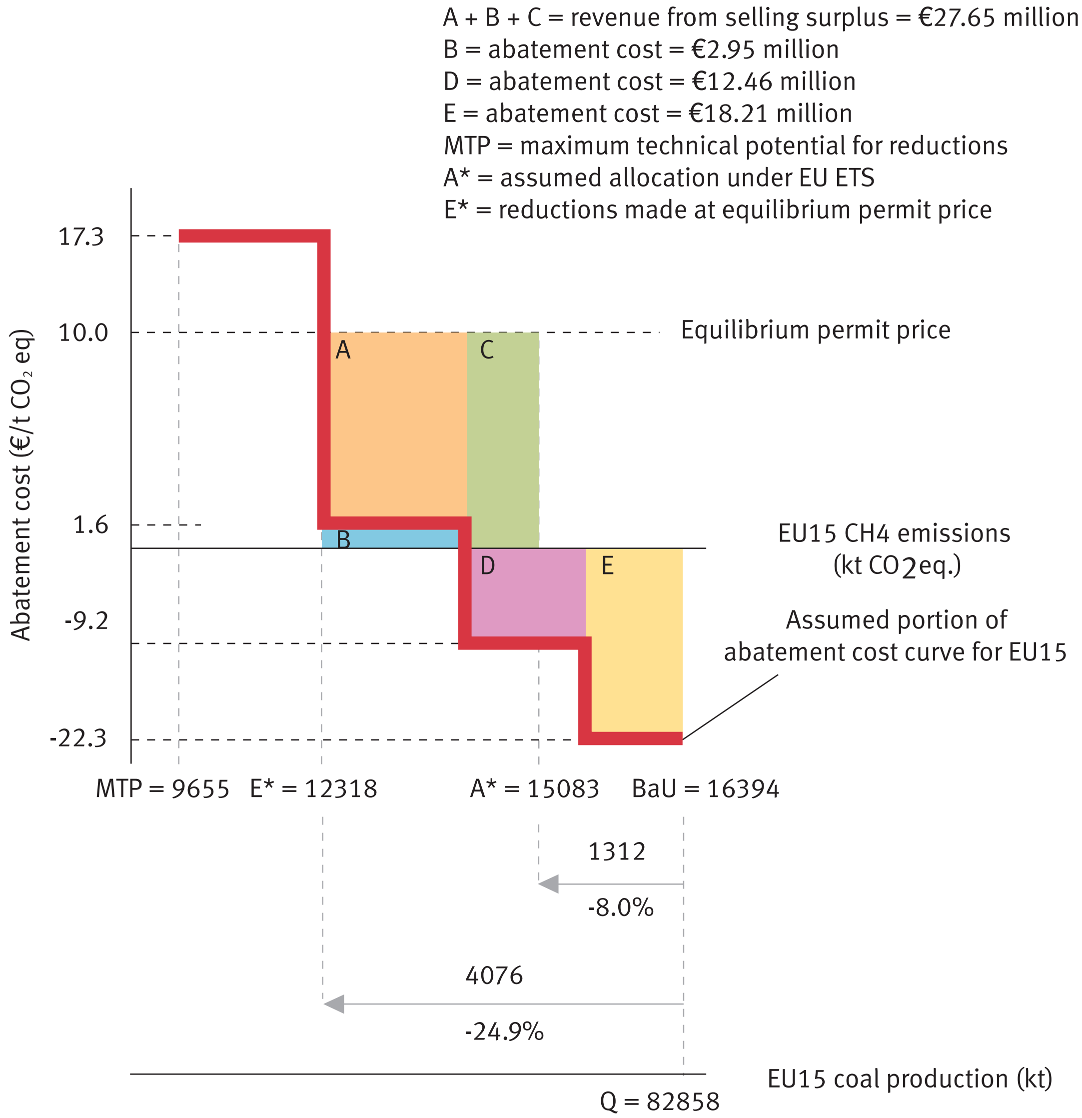
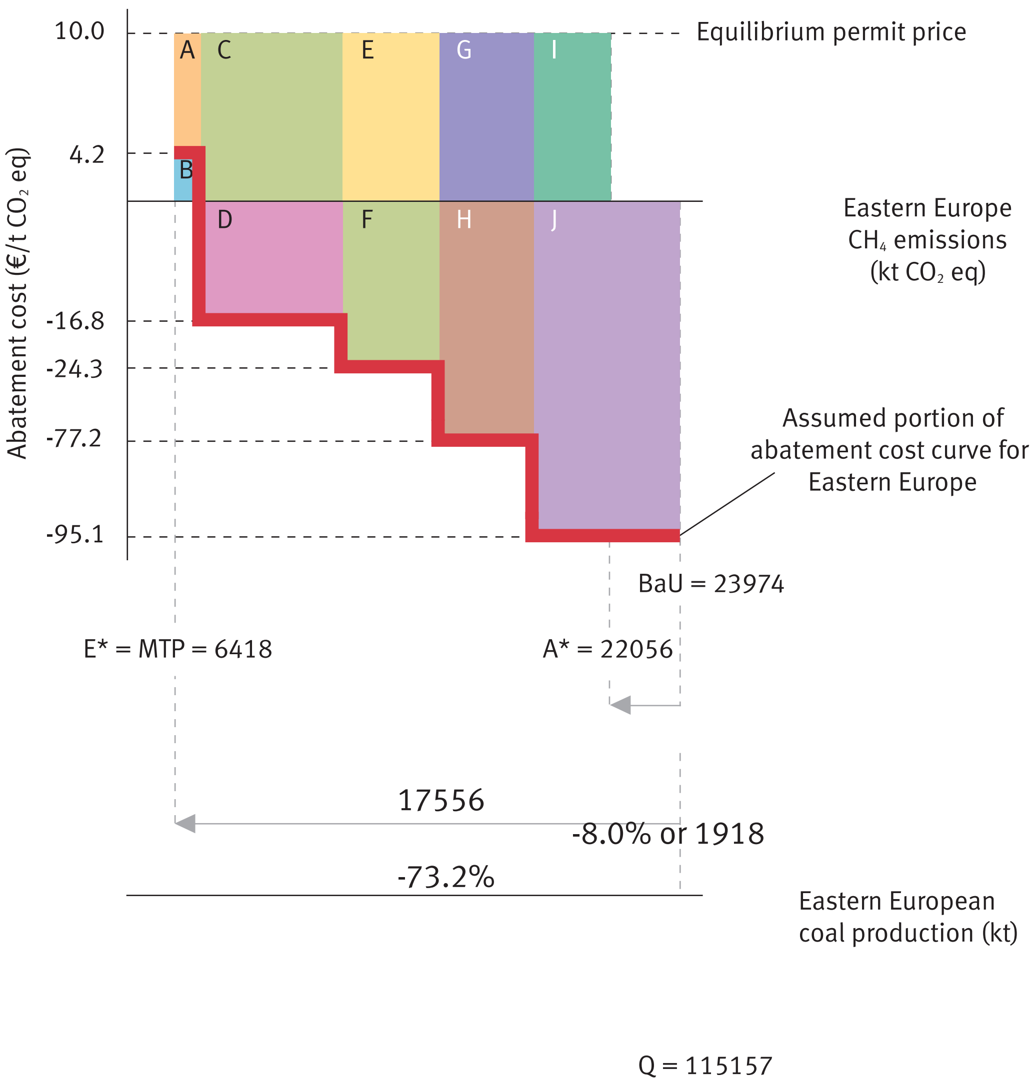


Figure 15 | Eastern Europe coal-mine methane abatement cost curve

A + B + C + E + G + I = revenue from selling surplus = €156.38 million
B = abatement cost = €1.53 million
D = abatement cost = €110.79 million
F = abatement cost = €58.16 million
H = abatement cost = €164.14 million
J = abatement cost = €576.46 million
MTP = maximum technical potential for reductions
A* = assumed allocation under EU ETS
E* = reductions made at equilibrium permit price



Adipic acid

Adipic acid is a white crystalline solid used primarily as a component in the production of 6-6 nylon, which is a linear polyamide made by condensing adipic acid with hexamethylene diamine. Nylon 6-6 accounts for approximately 70 per cent of demand for adipic acid. The market for nylon 6-6 is predominantly in fibres. Nylon 6-6 fibre is used in apparel, especially ladies' hosiery, sleepwear, and underwear, carpets, and home furnishings. Other nylon 6-6 fibre uses include tyre cord, fishing line, brush bristles, and in tough fabrics for parachutes, backpacks, luggage, and business cases. Engineering resins, chiefly for auto parts moulding applications, provide the next largest outlet. The major non-nylon uses of adipic acid are in plasticisers, unsaturated polyesters, and polyester polyols (for polyurethane resins).

Global capacity for adipic acid was approximately 2.8 Mt in 2003. Demand for adipic acid in 2003 was estimated at 2.21 Mt[58]. A situation of excess supply thus exists in the global market, with many adipic acid facilities operating at about 85 per cent of full capacity. Industrial demand for adipic acid is however expected to increase by approximately two per cent per year through 2008.

Financial impact

The results of the impact test for adipic acid producers are shown in Table 23.

Table 23 | Results of financial impact tests for adipic acid sector

Test	Value	Comments
Short run analysis		
Change in market price	-7.48%	
Short run change in output	4.49%	
Change in gross margin	8.09%	
Maximum potential impact Revenue ratio Cost to profit ratio	 -7.48% -26.60%	
Minimum potential impact Revenue ratio Cost to profit ratio	 -6.16% -21.91%	 No significant impact
Long run analysis		
Long run change in output	0.00%	
Firm closures Maximum Minimum	 4.49% -4.49%	

58 Chemical Week, April 23 2003.

Key points

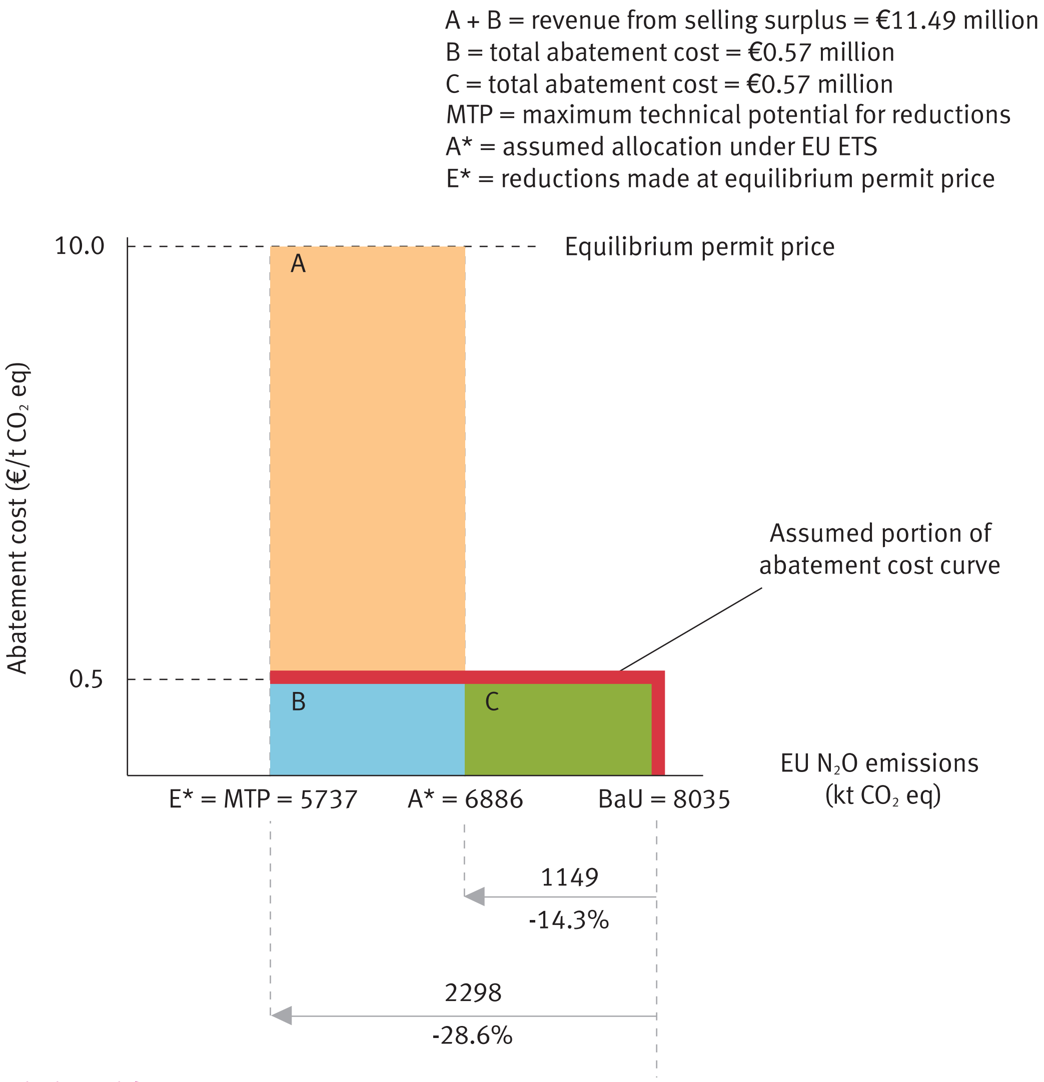
As with the coal sector, the adipic acid sector stands to benefit from participation in the EU ETS. Given an equilibrium allowance price of ten €/t CO_2 eq and the very low (yet positive) marginal abatement costs, adipic acid producers accrue a significant amount of revenue from selling surplus allowances to offset any abatement costs. The amount of allowance revenue generated will depend on the allocation of allowances, and producers would be expected to abate emissions up to the maximum technical potential.

Since the abatement cost curve (Figure 16) comprises solely variable costs, only short-run impacts are considered in the model. In the short run, the negative net variable costs (incorporating revenue from allowance sales) essentially provide producers with the opportunity to reduce price. In the model used above it is assumed that producers take up this opportunity, with the result that output increases (as demand increases in response to a lower price). Gross profit margins increase by about eight per cent. Operators could instead opt to maintain prices, and take the reduction in operating costs as an increase in profitability.

According to the significance test – participation in the EU ETS has 'no significant (adverse) impact' in the short run.

In the 'real world', experience within the chemical industry suggests that while price reductions can give a short-term advantage against competitors, they have little or no effect on the market as a whole. This is because the market is controlled by demand for the end product, and price cuts in raw materials and intermediates are so diluted by the time the end product (for example nylon carpets) reaches the market that there is little or no effect on demand. The increase in margins suggested by the model might therefore not materialise. However, there would still be no adverse impact on the sector.

Figure 16 | Adipic acid abatement cost curve



Nitric acid

Nitric acid is an inorganic compound, typically used to make synthetic commercial fertiliser. Fertiliser use represents about 65 per cent of the world nitric acid market. It is also used in the production of adipic acid, explosives, and metal etching and in the processing of ferrous metals[59].

Global nitric acid production is about 50 million tons. Nitric acid production levels closely follow trends in fertiliser consumption because of nitric acid's role as a major component in fertiliser production. Trends in fertiliser production vary widely across different regions of the world. For example, in Western Europe, because of concerns over nutrient loading of water bodies, the use of nitrogen-based fertiliser has been declining. However, in regions such as Asia, South America, and the Middle East, nitrogen-based fertiliser production capacity is increasing.

Ammonia, a vital input to fertiliser, has seen significant price increases due to inter-industry competition for natural gas. Fertiliser prices also increased, and reached record highs in 2004[60]. Despite increasing fuel costs, nitric acid production is expected to increase over time, pulled by demand in emerging economies in Asia.

59 US EPA, 2005.

60 British Sulphur Consultants, 2005.

The actual number of nitric acid production plants globally is unknown, since nitric acid production often takes place within larger facilities that manufacture products that use nitric acid, such as fertiliser. The IPCC suggests the number of facilities to be between 250 and 600. The European fertiliser industry operates close to 75 nitric acid plants, with a total annual production capacity of about 20 million tonnes.

Abatement options for the nitric and adipic acid sectors are relatively limited. Nitric acid production plants have technologies that indirectly destroy N_2O, but enhanced flaring and improved operation and maintenance (O&M) of production equipment could reduce emissions further.

Financial impact

The results of the impact test for adipic acid producers are shown in Table 24.

Table 24 | Results of financial impact tests for nitric acid sector

Test	Value	Comments
Short run analysis		
Change in market price	-1.28%	
Short run change in output	0.45%	
Change in gross margin	1.30%	
Maximum potential impact Revenue ratio Cost to profit ratio	 2.09% 13.04%	
Minimum potential impact Revenue ratio Cost to profit ratio	 2.16% 13.49%	 Significant impact No significant impact
Long run analysis		
Long run change in output	21.06%	
Firm closures Maximum Minimum	 -18.00% 0.73%	 No significant impact No significant impact

Key points

In contrast to the other sectors, the nitric acid sector does not reap financial benefits from participation in the EU ETS. At the same time, the impacts are not significant.

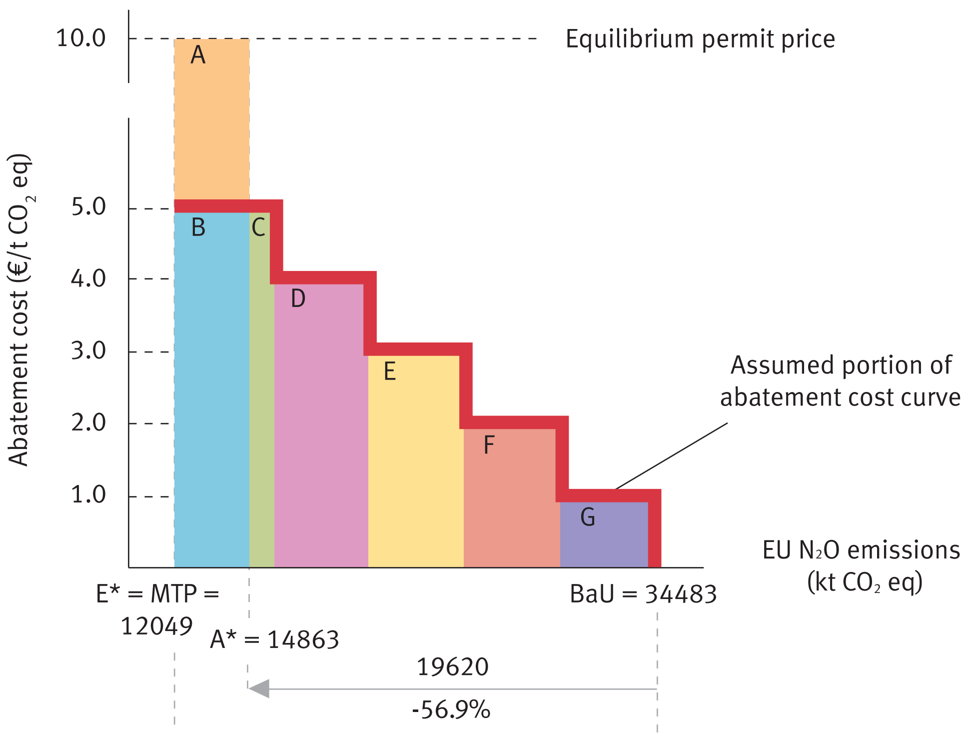
While the marginal abatement costs (as characterised in the cost curve presented at Figure 17) offer emission reductions at unit costs below the equilibrium allowance price of ten €/t CO_2 eq, the allocation is fairly stringent relative to the maximum abatement potential of the sector. Thus, revenue from selling surplus allowances is not sufficient to offset total abatement costs; it only reduces the cost of meeting the sector's target.

Nevertheless total variable abatement costs (incorporating revenue from allowance sales) are still negative. This offers producers the opportunity to increase output in the short run, with gross profit margin increasing by just over one per cent.

Despite the presence of significant total fixed abatement costs, the EU ETS has no significant impact in the long run.

Figure 17 | Nitric acid abatement cost curve

A + B = revenue from selling surplus = €28.14 million
B = abatement cost = €14.07 million
C = abatement cost = €8.36 million
D = abatement cost = €17.95 million
E = abatement cost = €13.46 million
F = abatement cost = €8.97 million
G = abatement cost = €4.49 million
MTP = maximum technical potential for reductions
A* = assumed allocation under EU ETS
E* = reductions made at equilibrium permit price



International exposure

As with aluminium, the exposure of the European coal, adipic and nitric acid sectors to international competition can be described by the:

- IPR, which is the proportion of home consumption that is made up of imports
- ER, which represents the proportion of home production that is exported.

Tables 25 and 26 provide summary statistics of international exposure for the adipic acid and nitric acid sectors, respectively. In both sectors, an insignificant proportion of home demand is met by imports from outside the European market. Furthermore, by far the majority of all European production is consumed within the EU25, although a greater fraction of adipic acid production, in contrast to nitric acid production, is exported. Overall, the exposure of both sectors to international competition in both domestic and international markets is minimal.

Table 25 | International exposure of European adipic acid producers (metric tonnes of acid)*

Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2003	84,477	3,752	9,611	0.048	0.114
2004	85,236	2,501	10,504	0.032	0.123

*Excludes intra-EU25 trades
Source: EUROSTAT

Table 26 | International exposure of European nitric acid producers (tonnes of nitrogen)*

Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2003	4,471,065	20,141	29,852	0.005	0.007
2004	6,578,243	6,329	38,445	0.001	0.006

*Excludes intra-EU25 trades
Source: EUROSTAT

Table 27 | International exposure of the EU15 coal sector*

Combined steam and coking coal: measures of international exposure					
Year	Production (tonnes)	Imports (tonnes)	Exports (tonnes)	IPR	ER
2002	33,477,163	53,952,269	366,497	0.620	0.011

*Excludes trades with EU10
Source: EUROSTAT

Table 28 | International exposure of the EU15 coal sector: Imports from Poland and the Czech Republic

Year	Poland (t)	Czech Republic (t)	Total (t)
1995	4,919,429	2,108,728	7,028,157
1996	4,569,044	2,270,863	6,839,907
1997	6,220,194	2,152,022	8,372,216
1998	5,638,376	1,924,333	7,562,709
1999	5,249,180	1,858,241	7,107,421
2000	6,513,500	1,556,823	8,070,323
2001	6,585,715	1,654,809	8,240,524
2002	7,699,842	1,718,571	9,685,413
2003	5,151,365	1,785,772	6,937,137
2004	5,027,116	1,088,497	6,115,613

Source: EUROSTAT

Table 27 provides summary statistics of international exposure for the EU15 coal sector; it was not possible to generate statistics for the EU25 because intra-EU trade could only be excluded for the EU15. Clearly, a significant proportion of home demand in the EU15 is met by imports. Moreover, a considerable portion of demand is met by imports from Poland and the Czech Republic – close to 18 per cent in 2002 (see Table 28). The previous financial impact analysis showed that the EU10 coal sector would benefit more than the EU15 coal sector from participation in the EU ETS. This is likely to put EU15 coal producers under greater competitive pressure from EU10 producers – ie imports from Poland and the Czech Republic may well increase.

Regarding exports (extra-EU15), by far the majority of all EU15 production is consumed within the EU15. However, both Poland and the Czech Republic export over 20 per cent of domestic production, most of which goes to other Member States.

Results of sensitivity tests

EU10 Coal sector

Table 29 | Sensitivity analysis: price

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-11.71%	-9.37%	-7.81%
Short run change in output	1.05%	0.84%	0.70%
Maximum potential impact			
Revenue ratio	-2.61%	-2.09%	-1.74%
Cost to profit ratio	9.03%	66.83%	-12.38%
Minimum potential impact			
Revenue ratio	-2.92%	-2.11%	-1.64%
Cost to profit ratio	10.10%	67.68%	-11.67%
Long run analysis			
Long run change in output	-31.48%	-232.93%	43.13%
Firm closures			
Maximum	46.28%	-175.37%	-30.03%
Minimum	-0.23%	-0.19%	-0.16%

Table 30 | Sensitivity analysis: fixed compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-43.44%	-43.44%	-43.44%
Short run change in output	3.91%	3.91%	3.91%
Maximum potential impact Revenue ratio Cost to profit ratio	 -31.80% -83.40%	 -28.88% -75.76%	 -25.97% -68.13%
Minimum potential impact Revenue ratio Cost to profit ratio	 -30.25% -79.34%	 -27.34% -71.70%	 -24.43% -64.07%
Long run analysis			
Long run change in output	30.54%	38.17%	45.81%
Firm closures Maximum Minimum	 -21.20% -2.86%	 -25.75% -2.60%	 -29.81% -2.34%

Table 31 | Sensitivity analysis: variable cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-43.44%	-43.44%	-43.44%
Short run change in output	3.91%	3.91%	3.91%
Maximum potential impact revenue ratio Cost to profit ratio	 -28.88% -57.20%	 -28.88% -75.76%	 -28.88% -112.17%
Minimum potential impact Revenue ratio Cost to profit ratio	 -26.83% -53.14%	 -27.34% -71.70%	 -27.84% -108.11%
Long run analysis			
Long run change in output	-28.82%	-38.17%	56.52%
Firm closures Maximum Minimum	 -20.35% -2.60%	 -25.75% -2.60%	 -34.45% -2.60%

Table 32 | Sensitivity analysis: variable compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-34.75%	-43.44%	-52.13%
Short run change in output	3.13%	3.91%	4.69%
Maximum potential impact			
Revenue ratio	-20.20%	-28.88%	-37.57%
Cost to profit ratio	-52.98%	-75.76%	-98.55%
Minimum potential impact			
Revenue ratio	-18.97%	-27.34%	-35.70%
Cost to profit ratio	-49.75%	-71.70%	-93.64%
Long run analysis			
Long run change in output	38.17%	38.17%	38.17%
Firm closures			
Maximum	-26.31%	-25.75%	-25.18%
Minimum	-1.82%	-2.60%	-3.38%

EU15 Coal sector

Table 33 | Sensitivity analysis: price

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-6.81%	-5.45%	-4.54%
Short run change in output	0.61%	0.49%	0.41%
Maximum potential impact			
Revenue ratio	-1.52%	-1.22%	-1.01%
Cost to profit ratio	-6.08%	-3.04%	-2.03%
Minimum potential impact			
Revenue ratio	-1.36%	-1.02%	-0.81%
Cost to profit ratio	-5.46%	-2.54%	-1.61%
Long run analysis			
Long run change in output	21.18%	10.59%	7.06%
Firm closures			
Maximum	-17.36%	-9.48%	-6.51%
Minimum	-0.14%	-0.11%	-0.09%

Table 34 | Sensitivity analysis: fixed compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-5.45%	-5.45%	-5.45%
Short run change in output	0.49%	0.49%	0.49%
Maximum potential impact			
Revenue ratio	-2.06%	-1.22%	-0.37%
Cost to profit ratio	-5.16%	-3.04%	-0.92%
Minimum potential impact			
Revenue ratio	-1.86%	-1.02%	-0.17%
Cost to profit ratio	-4.66%	-2.54%	-0.43%
Long run analysis			
Long run change in output	8.47%	10.59%	12.71%
Firm closures			
Maximum	-7.64%	-9.48%	-11.24%
Minimum	-0.19%	-0.11%	-0.03%

Table 35 | Sensitivity analysis: variable cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-5.45%	-5.45%	-5.45%
Short run change in output	0.49%	0.49%	0.49%
Maximum potential impact Revenue ratio Cost to profit ratio	 -1.22% -2.34%	 -1.22% -3.04%	 -1.22% -4.34%
Minimum potential impact Revenue ratio Cost to profit ratio	 -0.96% -1.84%	 -1.02% -2.54%	 -1.08% -3.85%
Long run analysis			
Long run change in output	8.14%	10.59%	15.13%
Firm closures Maximum Minimum	 -7.43% -0.11%	 -9.48% -0.11%	 -13.04% -0.11%

Table 36 | Sensitivity analysis: variable compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-34.36%	-5.45%	-6.54%
Short run change in output	0.39%	0.49%	0.59%
Maximum potential impact Revenue ratio Cost to profit ratio	 -0.12% -0.31%	 -1.22% -3.04%	 -2.31% -5.76%
Minimum potential impact Revenue ratio Cost to profit ratio	 0.03% 0.08%	 -1.02% -2.54%	 -2.07% -5.17%
Long run analysis			
Long run change in output	10.59%	10.59%	10.59%
Firm closures Maximum Minimum	 -9.56% -0.01%	 -9.48% -0.11%	 -9.39% -0.21%

EU25 Nitric acid sector

Table 37 | Sensitivity analysis: variable cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-1.28%	-1.28%	-1.28%
Short run change in output	0.45%	0.45%	0.45%
Maximum potential impact Revenue ratio Cost to profit ratio	 2.09% 6.36%	 2.09% 13.04%	 2.09% -260.72%
Minimum potential impact Revenue ratio Cost to profit ratio	 2.23% 6.81%	 2.16% 13.49%	 2.08% -260.27%
Long run analysis			
Long run change in output	10.27%	21.06%	-421.17%
Firm closures Maximum Minimum	 -9.98% -0.73%	 -18.00% -0.73%	 -130.91% -0.73%

Table 38 | Sensitivity analysis: variable compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-1.03%	-1.28%	-1.54%
Short run change in output	0.36%	0.45%	0.54%
Maximum potential impact Revenue ratio Cost to profit ratio	 2.34% 14.64%	 2.09% 13.04%	 1.83% 11.43%
Minimum potential impact Revenue ratio Cost to profit ratio	 2.40% 15.00%	 2.16% 13.49%	 1.92% 11.97%
Long run analysis			
Long run change in output	21.06%	21.06%	21.06%
Firm closures Maximum Minimum	 -18.07% 0.82%	 -18.00% 0.73%	 -17.92% 0.64%

Table 39 | Sensitivity analysis: price

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-0.23%	-0.19%	-0.16%
Short run change in output	0.02%	0.02%	0.01%
Maximum potential impact			
Revenue ratio	-0.05%	-0.04%	-0.03%
Cost to profit ratio	-0.05%	-0.04%	-0.04%
Minimum potential impact			
Revenue ratio	-0.03%	-0.03%	-0.02%
Cost to profit ratio	-0.03%	-0.03%	-0.02%
Long run analysis			
Long run change in output	0.19%	0.15%	0.12%
Firm closures			
Maximum	-0.18%	-0.14%	-0.12%
Minimum	0.00%	0.00%	0.00%

Table 40 | Sensitivity analysis: variable cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-7.48%	-7.48%	-7.48%
Short run change in output	4.49%	4.49%	4.49%
Maximum potential impact			
Revenue ratio	-7.48%	-7.48%	-7.48%
Cost to profit ratio	-17.60%	-26.60%	-54.41%
Minimum potential impact			
Revenue ratio	-5.49%	-6.16%	-6.84%
Cost to profit ratio	-12.91%	-21.91%	-49.72%
Long run analysis			
Long run change in output	0.00%	0.00%	0.00%
Firm closures			
Maximum	4.49%	4.49%	4.49%
Minimum	-4.49%	-4.49%	-4.49%

Table 41 | Sensitivity analysis: variable compliance cost

Test	-20%	Value	+20%
Short run analysis			
Change in market price	-5.98%	-7.48%	-8.98%
Short run change in output	3.59%	4.49%	5.39%
Maximum potential impact			
Revenue ratio	-5.98%	-7.48%	-8.98%
Cost to profit ratio	-21.28%	-26.60%	-31.92%
Minimum potential impact			
Revenue ratio	-4.94%	-6.16%	-7.38%
Cost to profit ratio	-17.56%	-21.91%	-26.24%
Long run analysis			
Long run change in output	0.00%	0.00%	0.00%
Firm closures			
Maximum	3.59%	4.49%	5.39%
Minimum	-3.59%	-4.49%	-5.39%

No test for fixed compliance cost since these are zero in the base case.

Further copies of this report are available from the Environment Agency's Climate Change Unit by emailing: peter.drury@environment-agency.gov.uk or by telephoning 01454 624093

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