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REFORMING COAL AND ELECTRICITY SUBSIDIES

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FOREWORD

This Working Paper is one of a series of eighteen studies carried out under an Annex I Expert Group project on "Policies and Measures for Possible Common Action". The studies were written by the OECD, together with the International Energy Agency, for the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The goal of the project was to assess a range of cost-effective greenhouse gas mitigation policies and measures for countries and Parties listed in Annex I to the UNFCCC. The working papers served as analytical input to negotiations under the UNFCCC. The working papers may also be useful to national policy makers. The measures analysed do not necessarily represent policy preferences of Annex I Parties.

The project benefited greatly from substantial input from delegates. Three successive chairmen of the Annex I Expert Group provided outstanding leadership for the project: Doug Russell (Canada); Ross Glasgow (Canada); and Ian Pickard (United Kingdom). The work was supervised by Jan Corfee Morlot (OECD). Fiona Mullins (OECD) drafted the initial framework which was used to structure the eighteen working papers.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Czechoslovakia (now Czech Republic and Slovakia), Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations," if appropriate.

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EXECUTIVE SUMMARY

Context

Subsidy reform is one of the major political themes of the 1980s and 1990s. Several OECD countries, from all OECD regions, have taken drastic steps to reassess and reduce subsidies to agriculture, energy, industry and transport. Economic reform has involved an even more comprehensive change in the level and type of subsidies present in central and eastern Europe and the countries of the Commonwealth of Independent States (CIS). Nevertheless, large subsidies remain in place both in OECD and non-OECD countries. Many of these subsidies encourage environmentally damaging activities.

Preliminary indications from studies by the World Bank, the OECD and others, are that, world-wide, subsidies to energy production and consumption amount to hundreds of billions of US dollars, and that removal of these subsidies would result in substantial reductions in CO_2 emissions, as well as stimulating economic growth. The greatest economic benefits are predicted to accrue to the countries with the largest subsidies — notably, among Annex I countries, those that are among the CIS. The OECD has undertaken a multi-year research project on “Environmental Implications of Energy and Transport Subsidies”, to look at the issue in more detail. The project aims to evaluate the potential for reducing environmental damage, while also achieving economic objectives, through removing subsidies and other types of support to transport activities and energy use. The project, which developed a set of country case studies, is now near completion; preliminary relevant results are reported here.

Description of Measures and Policy Objectives

The main focus of this paper is on reforming subsidies associated with coal and electricity. Such reform might contribute to meeting the policy objective of reducing greenhouse gas emissions. It might also address a range of other economic and environmental policy objectives.

The paper emphasises the interactive effect of subsidies and other supports associated with coal and electricity, including policies that were not designed as supports to coal or electricity production. It therefore considers subsidy reform in the context of the reform of a broader set of policies.

Approach and Methodology

This report to the Annex I Expert Group on the Framework Convention on Climate Change (UNFCCC) draws heavily on the existing case studies from the OECD project mentioned above to evaluate the potential for common action under the UNFCCC to reduce greenhouse gas emissions by removing subsidies.

Any assessment of the economic, social and environmental effects of removing subsidies would be incomplete without considering how governments might adjust taxation and expenditure to reallocate any funds formerly associated with those subsidies. This issue has not been thoroughly addressed in the OECD case studies or other existing analysis, and is only superficially considered in this paper, but it is an important area for further research.

Existing literature offers a wide range of definitions of the term “subsidy”, depending to a large extent on the reason that subsidies are being examined. While the simplest definition is: “a direct government payment to support the production, sale or purchase of a good or service”, this leaves out many types of government intervention that have economic and environmental effects analogous to those of such payments. Broader measures of support, such as the “producer subsidy equivalent” (PSE), include government policies that support the prices producers receive for goods, reduce the costs of their inputs, or that require consumers to purchase their products. In many cases there may be disagreement within a country or among countries as to what constitutes a subsidy to energy production or consumption.

Rather than focus on a single definition of “subsidy”, the OECD case studies examine a variety of types of support to energy production and consumption, and use a variety of economic models and assumptions to evaluate the possible effects of removing those supports. An initial study on coal subsidies looked at the effects of removing supports falling under the PSE definition in a number of countries. Subsequent studies on the electricity sector in a number of countries examined a broader range of policies that influence electricity demand, electricity supply industry (ESI) fuel and technology choice, investment decisions, and other factors that might have an environmental effect. A case study on the energy sector in the United States focused on federal supports, including grants, tax exemptions and low-interest loans. Finally, a case study on the energy sector in Russia compared the prices of fuels and electricity in 1994 with their estimated opportunity costs, to calculate the implied supports to consumers in the residential and industrial sectors. This range of approaches arose partly by necessity, from constraints on data and resources, and partly by design, in order to explore the value of using different approaches and models.

Role of Subsidy Reform in Meeting Greenhouse Gas Mitigation, Economic and other Policy Objectives

Countries may have many reasons to reform subsidies. Uppermost among these reasons are several economic justifications: 1) it may be that the original policy objective of a subsidy is no longer a priority or that the cost of the subsidy is no longer justified or affordable; 2) the subsidy may cause unwanted distortions in consumption, production or investment decisions; 3) it may be that the subsidy is badly designed, supporting a policy objective through indirect and/or inefficient means; or 4) the subsidy may cause distortions in patterns of trade, leading to objections from trading partners (both other countries and other competing industries). While these economic concerns have tended to lead the agenda for subsidy reform, environmental benefits have also often formed part of the rationale.

The OECD case studies show that it is not possible to generalise about the environmental and economic effects of removing subsidies, but they do identify particular types and combinations of policies whose removal or reform would probably reduce greenhouse gas emissions. For example:

- removing coal producer grants and price supports (including market entry barriers and preferential conditions in ESI regulation and financing): this option appears from the OECD case studies to offer a large potential for greenhouse gas mitigation, of the order of hundreds of millions of tonnes of CO_2 per year by 2010 if implemented throughout the Annex I region. Methane emissions are also likely to be reduced.

- removing sales tax exemptions for electricity (and other energy forms): this option appears to offer a small potential for greenhouse gas mitigation, less than one million tonnes of CO_2 per year by 2010 in the case studies where the issue was examined.

- eliminating ESI obligations and subsidies to supply remote areas: this option appears from the case studies to offer a small potential for greenhouse gas mitigation, perhaps in the region of a few million tonnes of CO_2 per year by 2010 in the Annex I region.

- removing electricity subsidies for energy-intensive industries: again, this option appears to offer a small mitigation potential, perhaps in the region of a few million tonnes of CO_2 per year by 2010.

Greenhouse gas mitigation as a result of reforming these policies is likely to be larger beyond 2010: removing market distortions leads to changes in investment choices by electricity suppliers and consumers, with increasing effects on the generating mix, energy efficiency and greenhouse gas emissions.

Some of these measures might have advantages from common action — for example, agreement to phase out the provision of subsidies to energy-intensive industry might help to address concerns about competitiveness, making subsidy removal more politically feasible. Removing protection for domestic coal producers and national ESIs in Europe, in particular, would increase the potential for a continent-wide electricity market. This would provide additional flexibility to exploit the most cost-effective, low-greenhouse gas-emitting, power sources, and would enhance the greenhouse gas mitigation from removing subsidies. The extent of the potential for this type of reform will be investigated in more depth in further development of the current study, and in the study on Market Barriers/Market Access. Other reforms — such as eliminating subsidies for supplying remote areas, might be in the national interest but would probably not yield substantial additional benefits if adopted as common actions. All of these measures would tend to reduce trade distortions, offering economic benefits and, in the long term, increasing the competitiveness of domestic industry.

The results of the analyses depend on: the methodology used; the range and type of any other policy reforms that are included — in particular, where there is a network of policies and institutions that tend to reinforce the effects of the subsidies; the way any reforms are assumed to be implemented; and the way any additional government revenue or reduced government spending is recycled in the economy. Countries will need to carry out their own detailed analysis to determine possible outcomes of different approaches to subsidy removal.

There are many circumstances where removing electricity sector subsidies may have very little effect on greenhouse gas emissions. This may apply, for example, to some types of consumer support. Removing other subsidies may increase greenhouse gas emissions. This applies where subsidies to ESI investment are supporting the use of nuclear power, hydroelectric power, off-grid renewables, or energy efficiency investments. There may be cases where removing a subsidy to an energy-intensive industry in one country would lead to a shift in production to other countries with lower costs or environmental standards, resulting in a net increase in global greenhouse gas emissions.

Depending on the way supports are reformed, governments may be able to meet their original policy objectives more efficiently than before. Alternative measures, perhaps including different subsidies uncoupled from fossil fuel production and consumption, could achieve the same objectives with lower economic and environmental costs. For example, supports to coal producers and energy intensive industry are often aimed at maintaining employment in the regions where these industries are located. These subsidies could be converted to local incentives for employment. Residential consumer subsidies are often aimed at ensuring access to electricity for low-income households. These subsidies could be converted to direct grants or subsidies for home insulation and energy-efficient appliances, or income support payments. Rural electrification subsidies are often provided to national monopoly electricity suppliers and can result in grid extensions, where stand-alone supplies would have been more cost-effective. These subsidies could be converted to aids for local initiatives to establish renewable supplies and co-generation, encourage energy-efficiency investments or simply to provide income support for rural and remote residents.

Potential for Common Action

Replication of successful measures

Many of the benefits from policy reforms can be derived from unilateral action. Before taking action, it can be expected that most governments would wish to carry out their own in-depth analysis to evaluate the extent of their national supports for coal and electricity, and the possible effects of policy reform on greenhouse gas emissions and other policy objectives. The political feasibility of subsidy reform may depend strongly on the approach taken to reforms and the explanation provided to, and extent of discussion with, those who have benefited from the subsidies.

Agreement to take action toward an aim or target

Differences in national circumstances make it unlikely that countries could agree common, quantitative aims for policy reforms. However, they might be able to consider qualitative aims or benchmarks. Examples might be the aim of reducing budgetary subsidies for electricity consumption, or supports to coal production according to the "PSE" definition. The more general the aim, the more likely it is that a common action might be feasible. Meanwhile, such aims may be espoused as a result of international negotiations to open fuel and electricity markets up to trade.

Co-ordination to implement the same or similar measures

The feasibility of some reforms, such as reducing the subsidisation of electricity for energy-intensive industry, might be improved through international co-ordination to avoid adverse effects on trade. Indeed, trade concerns have been a major reason for not reducing such subsidies in the past.

Specific Policies and Measures Implemented Together

The differences among countries are such that there are few identical policy reforms that countries would be likely to implement in a harmonised way. However, some reforms may be possible — for example, opening up markets mutually to allow competitive tendering.

Approaches to Common Action, their Rationales, Possible Participants and Vehicles for Action

This report identifies some examples of possible approaches to common action:

Replication of successful measures

The first approach is an agreement among countries engaged in subsidy reform, or interested in undertaking such processes, (i) to collect, share and monitor information on subsidy removal in their energy sectors. Information might include: descriptions of certain key government interventions in the sector including grants, loans, detailed information on fuel and electricity pricing and taxation, indicators of ESI economic and environmental performance. (ii) to carry out and share analysis of energy policies that tend to increase greenhouse gas emissions, and of the costs of these policies.

The reporting process could form part of national communications to the UNFCCC COP.

Based on the results from the case studies, the following pieces of information appear important in attempting to understand whether a country's coal and electricity-related policies are likely to increase greenhouse gas emissions:

- the level of direct financial support to coal and electricity production;
- direct financial supports to electricity consumers;
- trade policies for fuels or equipment used in electricity generation or for electricity;
- price regulations and price supports, including controls on procurement of fuels and equipment;
- investment conditions for the ESI.

It might be possible to build on existing databases and experience in the IEA, the OECD and the Energy Charter.

This common action would obviously have no direct effect on subsidies, greenhouse gas or the economy. However, by exchanging information and experience, it would enhance countries' ability to assess their own situation objectively. Once countries enter into a commitment to report on their subsidies and to analyse the effects of their removal, there is an increased chance that they will, indeed, remove subsidies where analysis indicates that the results would be beneficial.

Agreement to take action towards a target

The second approach is similar to the first, but includes an agreement among countries engaged in subsidy reform to adopt targets for subsidy reduction according to some agreed metric, or to carry out subsidy reform in a manner that supports the objective of greenhouse gas mitigation. The countries would probably be a subset of Annex I countries — indeed, several agreements might be established involving groups of countries with different national circumstances. This could be an initiative through the UNFCCC, but it might also need to involve other organisations and fora with an interest in this area, including the IEA, Energy Charter, World Trade Organisation and others.

The main advantage of this approach is that it allows countries to make their own decisions about the subsidy reform paths most appropriate for them, and encourages them to carry out in-depth analyses of the options available. The main disadvantages of choosing a target approach rather than picking particular subsidies for removal as a common action are: that the effort countries are making is hard to measure — some countries may need a more specific commitment to galvanise action; and the reduction in trade distortions may be smaller than where countries co-operate on a measure-by-measure basis.

Co-ordination to implement the same or similar measures

The third approach identified here is an agreement among countries to remove certain specific types of subsidy. This might be an extension of Approach (b) to include, for example, a focus on removing coal subsidies or subsidies for electricity consumption by energy-intensive industries. Alternatively, it might include an agreement to move from complex means of producer and consumer support towards more specifically targeted direct subsidies.

The three options are not in any way exclusive. Indeed, some countries might prefer the implementation of options (b) or (c) to follow prior implementation of option (a).

PART 1. INTRODUCTION

Policy Objective

Common action to reform electricity-related subsidies could contribute to a variety of policy objectives, including: reducing greenhouse gas emissions and other environmental impacts of electricity and fuel use; increasing the flexibility of the electricity sectors; increasing economic efficiency improving the targeting of employment and other social/economic policies; improving the conditions for and benefits of international trade; reducing government spending and increasing revenues.

Full Description of Measures

This study examines case study evidence on the effects of removing or reforming the following types of subsidy:

- Budgetary subsidies, such as: government grants towards the operation, investment or research and development costs of the electricity supply industry or those of its suppliers of fuel, services and equipment; tax exemptions and differential taxation of fuels and electricity; below-market-price government financing, government collateral for loans for energy supply projects, tax exemptions for bonds issued by utilities, government controls on rates-of-return from energy investments. The study identifies both subsidies whose removal is likely to increase greenhouse gas emissions — i.e. those which tend to increase production and consumption of fossil fuels, or which tend to increase the carbon intensity of the fuel mix — and subsidies that tend to reduce greenhouse gas emissions.

- Measures, or packages of measures, that result in energy producers receiving prices that are higher, or paying input prices that are lower, than would apply without the measures. (Note: indirect price supports will be addressed in the market reform study, but will also be discussed here, partly because removal of budgetary subsidies may be more effective when linked to removal of other supports for domestic producers, but also because many of the existing studies treat direct and indirect supports together.) Again, the study focuses on price supports for energy forms, such as deep-mined coal, and also on measures that reduce the cost of capital.

- Measures, or packages of measures, that result in cross-subsidies among electricity consumers. These may include price and other market regulations, such as laws requiring utilities to supply electricity to high-cost consumers at prices below the long-run marginal cost of supply.

The study does not attempt to be comprehensive, and does not address all types of subsidy or support to the electricity sector; the exclusion of any measure from this paper does not imply that it is unimportant.

Various types of common action are examined:

I. An agreement among countries engaged in subsidy reform, or interested in undertaking such reform, (i) to collect, share and monitor information on subsidies in their electricity sectors. Information might include: descriptions of all government interventions in the sector including grants, loans, taxes, regulations, planning constraints etc.; detailed information on fuel, electricity pricing and taxation; and detailed economic and environmental indicators for the electricity sector; (ii) to carry out and share analysis of the effects of their electricity policies on greenhouse gas emissions, and of the costs of these policies. The agreement could be reached in 1997, with a reporting and review format agreed during 1998 and implemented by 2000.

II. As measure (a), but including an agreement among countries engaged in subsidy reform to adopt targets for subsidy reduction according to some agreed metric such as the producer subsidy equivalent (PSE).

III. An agreement among countries to reform certain specific types of policies, such as those that support coal use in the electricity supply industry (ESI), or those that support electricity consumption by energy-intensive industries.

Approach and Methodology

The study is based on a set of country case studies, using a range of energy market, energy systems, and macroeconomic models to evaluate the effects of removing various types of government interventions that can be classed as “subsidies”. The study also draws on other relevant literature, and compares this with the case study evidence.

The case studies are part of an on-going project under the OECD Pollution Prevention and Control Group, which began in 1992. Following a scoping study to develop the methodology for the project, case studies were carried out analysing the environmental and economic effects that would result from:

1. phasing out price supports and budgetary subsidies to current coal production in several countries;

2. removing or reforming a wide range of policies that affect the electricity sectors of Australia, Italy, the United Kingdom and Norway;

3. removing a wide range of federal subsidies to energy production and use in the United States;

4. removing direct subsidies and price controls in energy markets in Russia;

5. reducing the social, environmental and budgetary costs, and introducing user fees to reflect remaining costs, of road transport in France, Japan and the United States.

The results of case studies under 1 to 4 above are summarised in Appendix A. Table 1 summarises the subsidies covered and the methodology used in each case study.

Table 1. Case Studies in the OECD Project on the Environmental Implications of Energy and Transport Subsidies

Studies	Country	Principle Author	Type of Subsidies Covered	Methodology for Assessment
Coal	France, Germany, Japan, Spain, Turkey, United Kingdom	DRI, Paris office	Operating subsidies and price supports	Country energy market economic models, world coal market economic model
Electricity	Australia, Italy, Norway, United Kingdom	Barry Naughten, ABARE GianCarlo Tosato, ENEA Eli Jensen, NOE Laurie Michaelis, OECD	Capital and operating subsidies, price controls (including cross subsidies), research and development	Bottom-up electricity generation or energy system analysis; assessment of existing market reform
Whole Energy Sector	United States, Russia	M. Shelby, US EPA E. Gurvitch, A. Golub	Budgetary subsidies and price controls	General equilibrium and combined engineering/economic models in US input-output model in Russia

As the table indicates, the studies use a wide range of methodologies. This is partly intentional, as one aim of the project is to evaluate different methodologies for subsidy appraisal. It was also necessary, because comparable data are not available for each country, and within the budget available for the project, it has not been possible to develop and configure the same type of model for each case study. The project has depended heavily on adapting existing models, research and analysis.

The mix of methodologies may be seen by some people as a weakness: it rules out direct comparisons of the results for different countries and different sectors. However, the intention is not to rank countries according to the "goodness" or "badness" of their subsidies, but to identify promising opportunities for subsidy reform. The use of several methodologies, looking at the issue from several angles, provides additional insight which cannot be obtained from using a single approach.

Context

Many of the most visible technological developments of the 20th Century are associated with, or dependent on, the widespread availability of electricity. It has made huge contributions to our quality of life and to economic development. For access to electricity, we depend on the existence of a widespread, high density transmission and distribution network. The high cost of duplicating distribution networks has led to the monopoly supply of electricity in most countries. Governments ensure that electricity is widely, if not universally, available, through public sector ownership and direction of utilities, or by regulating their activities if they are privately owned.

Governments support electricity provision and use, as well as the use of particular sources of energy and equipment for electricity generation and supply, through a host of measures. These include budgetary measures such as direct grants, infrastructure provision, provision of low-cost capital, tax exemptions and allowances, import tariffs and export credits, and controls on the market such as price regulation, profit regulation, monopoly protection or prohibition, compulsion to supply and compulsion to purchase from particular suppliers, import and export quotas. While many of these measures do not fit the common conception of a "subsidy", all of them can have the same effects as a subsidy for affected producers and/or consumers.

Reasons for Policy Reform

In most Annex I countries, access to electricity is now near-universal, while technical development and market growth has made it more economical for electricity markets to operate on a competitive basis. In this context, many governments, with the encouragement of institutions such as the OECD, European Commission, the World Bank and others, are endeavouring to reduce the role they play in these sectors and to reduce or eliminate subsidies. This subsidy reform agenda is motivated partly by concerns such as "balancing the budget" and improving "economic efficiency" — making sure that people and firms pay the economic costs of their actions.

Other reasons for supports, such as concern about national energy security and protection of domestic industries, have given way somewhat, as energy prices remain low, new reserves are developed, and trade barriers fall. Growing concern about the environmental impacts of electricity generation and transport activities has led to another concern about the way governments are involved in these sectors — that is, that government policies might encourage activities that cause environmental damage. Supports to environmentally damaging activities seem particularly inappropriate in the context of increasing government expenditure and regulation to reduce environmental damage. Thus, there is a need to find different ways of achieving a trade-off among a variety of economic, political, social and environmental objectives, and a process of readjustment has been begun in many countries. From the environmental perspective, there is a particular interest in this process of readjustment, as it may offer no-regrets opportunities to reduce greenhouse gas emissions and other environmental impacts of electricity production and use.

While most studies find that removing subsidies and recycling the revenues through reduced taxes on earnings or capital, would have a beneficial effect for the economy, findings regarding the environmental effects are mixed. Removing some subsidies would have a large environmental benefit, while removing others would require the introduction of additional measures to avoid increasing environmental damage.

Defining Subsidies

The OECD project started with a "Scoping Study" (PHB, 1993), which raised an issue that has resurfaced repeatedly throughout the project, as well as in other fora that have attempted to come to grips with subsidies: what is a subsidy? In practice, the answer depends on the reason for asking the question and many answers were offered in the course of the project:

1. The definition of "subsidy" might be narrowly defined to mean only: "government grants to the producers or consumers of a good or service, directly related to the production or consumption of that good or service". In this case, the concept of "subsidy" is tightly focused as a particular type of government action.

2. Several studies (e.g. Larsen and Shah, 1992; Burniaux *et al*., 1992; Golub *et al*., 1996) use a definition based on the prices of goods and services. The existence and size of a subsidy is indicated by the divergence between actual prices and "reference" prices which would obtain in an undistorted market. The greatest difficulty in this case is in deciding what is meant by an "undistorted" market. Using this definition, it is very hard to distinguish between deviations from "undistorted" prices that arise from government policies, and deviations that arise from other local circumstances.

3. An alternative measure of support is the OECD's producer subsidy equivalent (PSE), which is described in the box. The PSE is essentially a broader indicator of support encompassing the two definitions above, along with: "tax expenditures", where, under particular circumstances, governments impose taxes below the normal rate or offer tax rebates; supports to particular types of investment, through the tax system or through government loans at interest rates below the market rate.

Producer subsidy equivalents: a good measure of trade distortion, but not of environmental damage

The Producer Subsidy Equivalent (PSE) concept aims to cover all state aids, direct and indirect, that have an effect on the current costs of, and prices paid to, domestic producers. In general, it consists of direct government payments to support current production, indirect supports to current production, plus any price support, measured by the excess of the price received by domestic producers over the price paid for imports.

At first sight, the way the PSE measures raised prices as subsidies can be surprising. Normally, subsidies are thought of as measures that reduce prices. This is true in the case of consumer subsidies, and in fact the existence of a price support contributes to a negative consumer subsidy equivalent (CSE).

Because the PSE measures conditions that protect or support domestic producers and consumers, it is a useful indicator of market distortions that tend to disrupt trade. In order to identify which distortions tend to lead to environmental damage, however, one must evaluate the effects of the different measures included in the PSE. Both payments from governments to producers and price supports encourage increased domestic production along with any attendant environmental damage. On the other hand, price supports tend to reduce domestic consumption, along with its attendant environmental effects. In the latter case, however, the actual net effect will depend whether or not consumers are both free to, and have an interest in, switching to cleaner fuels. Often, in order to maintain high producer prices, governments impose restraints on consumers — e.g., local purchase obligations — that negate the effects that higher prices would otherwise have on fuel choice (see Steenblik and Coroyannakis, 1995; Newbery, 1995).

The effects of removing PSE type supports can only be evaluated effectively with a detailed understanding of local circumstances and the alternative technologies and energy sources available.

The case studies explored different definitions. This was partly by design, to explore the extent to which these different definitions were useful. However, it was also necessary as the project evolved. An initial study on coal subsidies (DRI, 1994) looked at the effects of removing supports falling under the producer subsidy equivalent (PSE) definition in a number of countries. This study indicated the importance of understanding the wider context in which coal is produced. Coal production may be supported not only by PSE-type supports provided directly to the coal industry, but also by government policies affecting the ESI and competing fuel suppliers. Subsequent studies on the electricity sector in a number of countries (Jansen, 1996; Michaelis, 1996a; Naughten *et al*., 1996; Tosato *et al*., 1996) examined a broader range of policies that influence electricity demand, ESI fuel and technology choice, investment decisions, and other factors. Definitions of subsidies in other studies were, to a large extent, determined by the type and quality of information available. The case study on the energy sector in the United States (Shelby *et al*., 1994) used the first definition above, taking existing estimates of the size of federal supports, including grants, tax exemptions and low-interest loans. Finally, the case study on the energy sector in Russia (Golub *et al*., 1996) used the second, price-based definition above, comparing the prices of fuels and electricity in 1994 with their estimated opportunity costs, to calculate the implied supports to consumers in the residential and industrial sectors.

The OECD has developed considerable experience in finding and measuring supports, most notably through the work of the OECD Agriculture Directorate, which produces annual estimates of the level of supports for agricultural products in OECD countries. The metrics employed for these supports, the PSE and CSE (consumer subsidy equivalent), are useful for identifying trade distortions. The International Energy Agency (IEA) annually estimates the PSE associated with coal in several Member countries[1] (e.g. IEA, 1995a, 1994a). However, these have not achieved the level of international acceptance enjoyed by agricultural PSEs as indicators of support. This may be because there has been less economic and political need to find ways of measuring distortions in energy trade than in the case of agricultural trade.

As predicted by the OECD project scoping study (PHB, 1994) and demonstrated in the various case studies, looking for policies that have a negative impact on the environment implies a rather different focus from that of budgetary subsidies or producer supports: it also involves looking for policies that support the <u>use</u> of goods and services that tend to be polluting, or that influence the <u>manner</u> of production and use. While barriers to trade and competition can support polluting activities such as coal mining, they can also work in the opposite direction. These barriers can also support the development of indigenous renewable energy sources, as well as the development of nuclear power with low full-fuel cycle greenhouse gas emissions compared with fossil fuels (EC, 1996), but other environmental impacts and risks.

This paper takes a pragmatic approach. It addresses government policies that influence the ESI, its fuel and equipment suppliers, or its customers, in ways that might lead to greater greenhouse gas emissions than might be expected if those policies did not exist. The use of the word “subsidy” is largely avoided, although many of the policies addressed could be called “subsidies”. The paper also focuses on “policy reforms” rather than “subsidy removal”, recognising that the matter under discussion is part of the normal process of readjusting the balance of policies to address multiple objectives.

It must be recognised that any process of policy reform is liable to be opposed by some groups in society, who expect that reforming existing policies will have detrimental effects for themselves or others. In view of this, the paper places particular emphasis on the need to address the concerns of these groups and to identify approaches to reform that offer social and economic benefits, as well as mitigating greenhouse gas emissions. The existing OECD case studies offer few answers in this area, and considerable additional work is needed by national governments in assessing their own paths for any policy reforms.

[1] Belgium, Canada, France, Germany, Japan, Spain, Turkey, and the United Kingdom

PART 2. CASE STUDY FINDINGS ON EFFECTS OF POLICY REFORMS

For the OECD case studies, supports to the electricity sector were classified as follows:

1. Government spending programmes, including grants to offset operating losses, and research and development funding;

2. Indirect government aid, in the form of market protection, price support, and statutory protection for monopolies and vertical integration in the ESI;

3. Capital subsidies, including the provision of government equity, soft loans, and limited liability (mainly for the nuclear industry);

4. Tax policies, including preferential tax treatment for the ESI and its suppliers;

5. Trade policies, whether to encourage or discourage imports and exports;

6. More general energy policies, relating to resource and infrastructure development, trade and competition;

7. Consumer subsidies, such as preferential tax treatment for electricity sales, cross-subsidies to rural and remote consumers, or reduced tariffs for energy intensive industries;

8. Failure to internalise environmental costs.

The depth of treatment of the different types of support varied widely among the case studies. Appendix A summarises case study findings on the economic and greenhouse gas effects of energy policy reform, showing how widely the results can vary depending on the assumptions made, the period considered, the range of policies considered, and the manner in which they are reformed.

Table 2 gives a few of the quantitative results of these case studies, along with those from some other major studies on energy subsidy removal. It should be emphasised that, due to the complexity of the analyses carried out and the differences in methodologies for the various studies, the figures are not directly comparable, but give an indication of the range of findings of different authors looking at subsidy removal in different countries, under different assumed circumstances and over different time scales.

The case studies point to certain types of subsidy, the reform of which might play a particularly important role as part of a greenhouse gas mitigation strategy. While the case studies evaluate the effects of removal of a wide range of electricity industry supports, most of the greenhouse gas emission mitigation is the result of reductions in the share of coal in energy inputs for power generation, or reductions in the amount of power consumed. We therefore focus in this study on subsidy reforms focused on these two types of change: reforms to subsidies that support coal use in power generation, and reforms to consumer subsidies.

Table 2. Summary Results from Case Studies on Energy Subsidy Removal

(note that subsidies are defined in various ways and are not comparable)

Study	Subsidy or Group of Subsidies Removed	Monetary Equivalent of Distortion (US$ million, various years, 1988-1995)	Decrease in Annual CO_2 Emissions Relative to Reference Scenarios Resulting from Reforms by 2010 million tonnes	Other Economic Effects of Removing Subsidies
Larsen 1993	Global price subsidies to consumers of fossil fuels (difference between domestic and world prices)[b]	215 000	1366 (a)	Enhanced economic growth
GREEN	Global price subsidies to consumers of fossil fuels (difference between domestic and world prices)[b]	235 000	1 800 in 2000 15 000 in 2050	Enhanced economic growth in most regions, largest in CIS. Improved terms-of-trade for non-OECD countries.
DRI	Coal PSEs in Europe and Japan	5 800	10 (DRI estimate) >50 (OECD estimate)	Job loss in coal industry, increased coal trade
Böhringer	Coal in Germany	6 700	NQ	Nearly 1 per cent GDP increase. Job loss in coal industry, increased coal trade.. Cost of using subsidies to maintain jobs is 94-145,000 DM per job per year. Reduces cost of meeting CO_2 target.
Australia	State procurement/planning	133	0.3	Reduces cost of meeting CO_2 target
	Barriers to gas and electricity trade	1400	0.8	Reduces cost of meeting CO_2 target
	Below-market cost financing	NQ	NQ	
Italy	Net budgetary subsidies to ESI *VAT below market rate* *Subsidies to capital* *Excise tax exemption for fossil fuels use by ESI*	4 000 300 1 500 700	12.5 0.6 3.3 5.9	Reduces cost of meeting CO_2 target/makes CO_2 tax more effective.
	Total net and cross-subsidies	10 000	19.2	
Norway	Barriers to trade	NQ	8 for Nordic region	
Russia	Direct subsidies and price control for coal	3600	120	1 per cent drop in employment
	Price control/debt forgiveness for electricity consumers	6000	(about half due to shift from coal to other fuels, half to reduced final energy demand)	(but note that model included no subsidy recycling mechanism)
UK	Grants and price supports for coal and nuclear producers	2500	0 to 40	
	Below-market required rate of return for ESI			
	VAT on electricity below general rate	1200	0.2	
US	DFI (1993) analysis of Federal subsidies	8 500[c]	10	
	DJA (1994) analysis of Federal subsidies	15 400[c]	64	GNP increased 0.2 per cent if revenue used to reduce capital taxes

a) model used is comparative static: emission reduction is calculated using mostly 1991 market data

b) this measure of "subsidies" is a crude one, and does not necessarily indicate the existence of any particular government policy

c) the two studies analyse different sets of energy supports and use slightly different estimates for some of them: these figures are not a reliable indication of total US federal energy subsidies. See Appendix A, Table **14** for details. Results are sensitive to assumptions regarding the future structure of the US ESI.

NQ = not quantified

Supports to Coal Production and Use

Coal supports form one of the most important classes of policies for reform, as greenhouse gas mitigation is incorporated into the set of policy objectives in the energy sector. These supports include budgetary subsidies to coal production and use, as well as a variety of policies that encourage or require the ESI and others to consume domestically produced coal, or discourage them from using other sources of energy. Investment subsidies in the ESI, implying real rates of return on capital below the market rate, can act as a support to coal use, as can differential environmental constraints applying to different fuels. For example, countries with emission standards for large combustion plants often apply weaker standards to coal than to other fuels, based on the "best available technology" (BAT) or "best available technology not entailing excessive cost" (BATNEEC) principles. While it is arguable which of these should be described as "subsidies", any policy reform process needs to take into consideration the full range of such measures, as removing only one type of support may have no effect on coal use.

Alternatives to coal

The effect of removing subsidies to domestic coal producers depends heavily on the type of subsidy removed and the availability and economics of alternative energy sources, including imported coal. While in the past, coal was the cheapest fuel for power generation in many regions, it is now in competition with natural gas, which can be used in "combined cycle gas turbine" plant (CCGT). CCGT has many advantages over coal-fired plant for the ESI: low capital cost per kW of generating capacity; very high thermal conversion efficiency; short construction time; and short start-up times. It also has environmental advantages over coal, including less land use, lower emission of regulated (conventional) pollutants, and most importantly for our study, about half the CO_2 emissions of coal-fired plant per unit of electricity generated (Eyre and Michaelis, 1992). Where large reserves of natural gas are available at moderate prices (below US$5/GJ), the continued use of coal (at prices above US$1/GJ) in new generating capacity is unlikely without some form of subsidy or market protection.

Where natural gas is not locally produced or where reserves are small, it may be less able to compete with coal and other energy sources in the long term, and governments may prefer to husband any existing reserves for priority uses. Natural gas transport over long distances is expensive. In the most extreme cases, countries without direct access to natural gas pipelines have to pay the cost of liquefaction for transportation by sea, and evaporation for use at the receiving port. Few countries are likely to find liquefied natural gas (LNG) economic for use in power generation. Nevertheless, gas may become competitive with coal in more regions, as electricity and gas networks develop and transmission costs fall. In the long run, the extent to which gas can replace coal in power generation will depend on many unpredictable factors, not least the extent to which new gas reserves continue to be developed, the degree of political stability in countries that harbour these reserves, and the willingness of these countries to export the gas, as well as developments in the subsidies and taxation policies for the energy sector. Concern about these factors was, until recently, used as a strong argument for excluding gas from baseload power generation in many countries.

Renewable and other non-fossil power supplies are supported by some of the same policies that support coal use, in particular those that favour capital-intensive power generation. Removing subsidies to capital or barriers to trade can also reduce competitiveness of these environmentally favourable or "clean" energy sources. In some countries, removing such supports might lead to a shift away from existing, non-fossil energy sources towards the use of fossil fuels, resulting in higher greenhouse gas emission. Renewable energy sources might only remain economic if such policy reforms were accompanied by other measures, such as introduction of a carbon tax, direct subsidies for renewable or stand-alone power generation, or obligations for power suppliers to purchase renewable-generated electricity. This issue highlights the difficulty in developing common approaches to policy reform.

Effects on Greenhouse Gas Emissions and other Environmental Effects of Removing Coal Supports

Greenhouse gas effects

The case studies in Appendix A (DRI, 1994; Golub *et al*., 1996; Michaelis, 1996; Shelby *et al*. 1994) indicate that removing supports to the production and use of coal and other fossil fuels can result in reductions in CO_2 emissions of tens of millions of tonnes in the main coal-using countries, at the same time as reducing the cost of electricity production. Although the case studies do not address reductions in other greenhouse gas emissions from power generation, reductions in non-CO_2 greenhouse gases, mainly methane, are likely to be larger in percentage terms than those in CO_2. This is because: a) alternatives to coal have a lower ratio of methane-to-CO_2 in full-fuel-cycle emissions (Eyre and Michaelis, 1992); and b) methane emissions are highest from deep coal mines, which are also the most heavily subsidised (Steenblik and Coroyannakis, 1995).

The time-frame for emission reduction as a result of reforming policies depends to a large degree on the replacement schedule for electricity-generating plants, which may itself be influenced by changes in policy. Removing investment supports may lead to slower replacement of capital stock, keeping inefficient or polluting-generating plants in use. Removing supports to electricity consumption may also reduce demand growth, again contributing to less construction of new plants.[2] The effects depend on the nature of the existing stock, the level of capacity reserve, and the way removing supports affects demand. In the United Kingdom, where little new power station construction or environmental upgrading occurred during the 1980s, removal of coal supports in the late 1980s and early 1990s led to construction of several new CCGT plants (Michaelis, 1996). Generating companies took the view that construction of new plants was more cost-effective than upgrading old coal-fired facilities to meet tighter acid-gas emission restrictions. In the United States and Germany, subsidy reform is likely to favour CCGT over coal in new construction, but there may be no need for new construction for some time (Lee and Darani, 1995; Böhringer, 1995). Subsidy reform initiated in 1997 is likely to have relatively little effect on emissions in the 2000-2010 period, although substantial effects could be seen by 2020. The long term effects depend on the availability of moderately priced natural gas, and on reductions in the cost of renewable energy, as well as technical developments to reduce the environmental impacts of coal-fired power generation and changes in the acceptability of nuclear power.

While removing subsidies may lead directly to reduced coal use and CO_2 emissions, the extent of this depends heavily on national circumstances. It may also depend on concurrent implementation of other market reforms, including institutional reform of the ESI, and the introduction of measures to reduce and internalise the environmental impacts of power generation. The case studies show that the greatest mitigation benefits occur where subsidy reform occurs alongside other mitigation policies. Removing subsidies and other distortions can accelerate the effects of those policies. In the cases of Australia, Germany and Italy, removing coal supports and barriers to competition from other fuels results in lower costs to meet a CO_2 constraint, or increases the effectiveness of a CO_2 tax. In some cases, the effect on CO_2 emissions is doubled, or the cost of mitigation halved, for taxes and emission constraints of the order of magnitude required to return emission levels in 2000 to 1990 levels.

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[2] although, in most cases, a major aim of policy reform in the electricity sector is to reduce electricity prices, which is likely to lead to faster demand growth.

Although it is not possible to generalise about the effects of particular types of policy reform, it is possible to some degree to generalise about the effects of fuel-switching and technology changes on greenhouse gas emissions and other pollution. In general, switching from conventional, pulverised fuel, coal-fired power generation to CCGT is likely to reduce CO_2 emissions per kWh of electricity generated by more than half. Switching between different sources of coal — for example from domestic European coal to coal imported from North America — can sometimes result in slight reductions in greenhouse gas emissions. If the coal has to be transported 5000 km by ship, this might require about 1 GJ per tonne of coal[3] in energy used by the ship and resulting in emissions of an amount of CO_2 equivalent to about 5 per cent of that from burning the coal. On the other hand, if the imported coal is surface-mined, and replaces deep-mined coal, the energy use and methane emissions during and after mining might be reduced, contributing up to about 10 per cent mitigation in full-fuel cycle CO_2-equivalent greenhouse gas emissions.

Table 3. Emissions of Pollutants for Baseload Generating Technologies in the United Kingdom (Michaelis, 1996a)

	Large Coal	Large Coal with FGD+LNB	HFO	HFO with FGD+LNB	CCGT	Nuclear AGR	Nuclear PWR
Efficiency (%) based on fuel hhv	35	34	36	35	50	nq	nq
Fuel energy content (hhv, MJ/kg)	24	24	44	44	55	nq	nq
Fuel carbon content (gC/MJ)	24.1	24.1	19.8	19.8	13.7	nq	nq
Fuel sulphur content (gS/kg)	10	10	20	20	0	nq	nq
CO_2 emissions (g/kWh)	909	936	726	747	362	nq	nq
SO_x emissions (g/kWh)	9	1	9	1	0	nq	nq
NO_x emissions (g/kWh)	3.5	2.2	3.0	2.0	0.7	nq	nq
Airborne PM emissions (g/kWh)	0.17	nq	0.41	nq	nq	nq	nq
Airborne heavy metals (g/kWh)	0.09	nq	0.02-0.08	nq	nq	nq	nq
Solid waste (g/kWh)	72	nq	0.09-0.24	nq	nq	nq	nq
Ionising radiation,							
Routine gaseous and liquid effluent, (Bq/kWh)	nq	nq	nq	nq	nq	42 000	68 000-82 000
Spent fuel, (mg/kWh)	nq	nq	nq	nq	nq	2.9-4.7	3.0-3.8

nq = not quantified
Source: Michaelis, 1996a

Acid gas emissions

Several of the case studies (DRI, 1994; Golub *et al*., 1996; Michaelis, 1996) estimate the effects of removing subsidies on acid gas emissions from the ESI. CCGT plants have negligible SO_x emissions and their NO_x emissions are likely to be 70 per cent to 80 per cent lower than those of coal-fired plants, except where the latter uses selective catalytic reduction (SCR) of NO_x. All of these studies find larger percentage reductions in acid gas emissions than in CO_2 emissions, in subsidy removal and reform scenarios.

3 Based on energy use of 0.2 MJ/tonne-km

Other Environmental Effects

There are likely to be additional environmental benefits from removing supports to coal production. The most apparent of these are reduced environmental damage associated with coal production, and reduced emissions of particulates and air toxics such as mercury and chlorine emitted during coal combustion.

Economic, Employment and Trade Effects of Removing Coal Supports

A key issue to be addressed in any process of reforming existing policies is the choice of policies to replace them. If budgetary subsidies or tax expenditures are to be removed, the government will have more funds at its disposal. The effect on the economy of removing these measures depends very much on the way the government uses any funds saved. The choice of uses for these funds is likely to depend partly on the reasons the supports existed in the first place, and whether these reasons are still important policy objectives, as well as on other policy objectives. An initial question is whether any funds should be directly re-channelled into alternative types of support, or whether they should be used to reduce taxation elsewhere in the economy or to reduce government debt. While the latter two options are likely to be the most economically efficient approaches to reforming subsidies, there may be strong political reasons for the government to maintain spending but shift its focus. Alternatively, there may be a need to establish alternative subsidies on a temporary basis, to facilitate the process of transition in affected industries and regions. These issues have not been explored in any detail in the OECD case studies, and represent an important area for additional analysis.

Changes in cost and effects on the economy

Supports to coal production usually involve excess payments from the government or measures that constrain consumers' choice of fuel or technology — often both. Where such supports are removed, government expenditure may fall, allowing for reduced taxation or increased expenditure in other areas, and electricity prices may fall, so that consumers are able to consume more electricity and spend more on other goods or to save more. Whatever form the supports take, their removal is likely to create new opportunities for consumption and investment elsewhere. This could lead to an increase or a decrease in economic growth, depending on the pattern this consumption and investment takes.

The OECD case study on the removal of United States federal energy subsidies included the results of modelling to investigate the effects of recycling subsidy funds into various types of general tax reduction. DJA (1994) finds for the United States that, where the government uses reduced expenditure on subsidies to reduce average tax on earnings, GDP falls (see Figure 1); where only *marginal* tax on wages is reduced, encouraging increased employment, GDP rises; and when taxes on capital income are reduced, encouraging investment, GDP rises. All of the GDP changes are very small. Welfare disparities between regions and household types are increased where the government reduces average tax on capital or earnings, but decreased where it reduces marginal tax on wages.

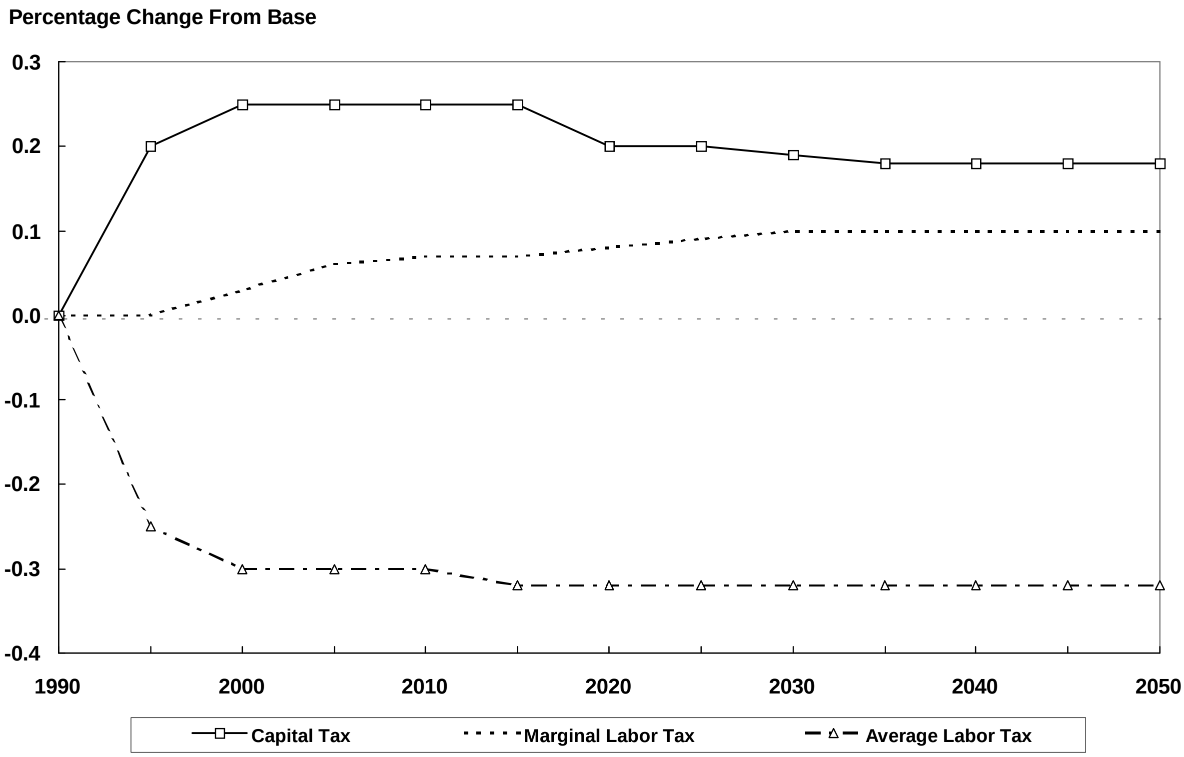

Figure 1. Effects on GNP of Different Subsidy Recycling Mechanisms in the United States
Source: DJA, 1994

Employment effects

One of the main reasons why governments support coal production is to maintain employment in coal mining communities (Böhringer, 1995). Removing supports would generally result in reduced employment in the coal industry, (DRI, 1994) although this not always be the case. Where the coal support takes the form of compulsory purchase of domestic coal by the ESI, removing it can result in lower electricity costs, as the ESI switches to cheaper imported coal or other fuels. Whether this leads to higher (domestic or imported) coal consumption depends on several factors, including the price of the substitutes. In some instances, the introduction of competition may lead the domestic coal industry to improve productivity, reducing costs and increasing supply, and possibly employment. However, high domestic coal costs do not necessarily imply that the industry is inefficient — it may simply face high costs due to difficult mining conditions or high local wages, in which case introducing competition is likely to lead to reduced domestic production and employment.

While coal industry employment may fall, removing government supports for an uncompetitive sector, and reducing the taxation burden on other, competitive sectors, is likely to increase employment in those sectors. The OECD case studies did not evaluate the extent of this effect and it is an important area for further research.

Trade effects

Trade policy is a major reason for coal policy reform, and has played an important role in the case of agricultural subsidies. Many countries that have low costs of coal production and wish to increase coal exports, advocate the removal of coal supports in potential importing countries. Certain patterns of reform, such as removing requirements to buy domestic coal but maintaining investment supports and "grandfathering" (emission standard exemptions) for existing coal-fired plant, might lead to increased demand for low-cost imported coal if implemented in Europe and Japan. Thus, trade would increase, but so might greenhouse gas emissions. The overall effect on coal use and greenhouse gas would depend on many factors. These include: the vintage of coal-burning plant in the consuming countries (one response would be to retire them); and the price elasticity of coal production in exporting countries. It is possible that coal demand in non-subsidising countries could fall more than that in countries that remove price supports (see discussion on page **39**).

More general subsidy reform might not benefit coal exporters. In the United Kingdom, the ESI has switched away from coal use towards natural gas CCGT following policy reforms, and the same might occur elsewhere in Europe (Newbery, 1995) and possibly in North America. However, trade in other energy forms, especially gas and electricity, might increase. The effects of this increased trade on regional greenhouse gas emissions depends on what are the most economic forms of power generation in the region. This issue is addressed in the IEA study on removing barriers to market entry as a common action under the UNFCCC.

There are still considerable gaps in our understanding of the environmental, economic and social effects of different approaches to policy reform. In particular, there is a need for more exploration of the effects of alternative replacement policies, using a variety of different models and approaches. There is also a need for further research to investigate the full trade implications — and hence the full economic and greenhouse gas implications — of coal subsidy reform.

Supports to Electricity Consumption

Supports to electricity consumption can include a wide variety of measures that reduce the costs of electricity. Examples include: the application of taxes and duties below the general rate; investment supports such as government loans and equity, or limited ESI liability for risk; subsidies and cross-subsidies for rural and remote electrification; regulation or subsidies that keep electricity prices below their long-run marginal cost for some or all consumers; preferential contracts between state-owned ESIs and energy-intensive industries such as aluminium smelters; and the exemption of energy-intensive industries from environmental charges or taxes. These supports tend to lower the cost of supplying electricity, at least to certain consumers, and therefore increase the amount of electricity consumed by those consumers. Remote electrification supports may also encourage grid expansion where stand-alone renewable-based supplies might have been more economic.

One or more of these supports have been identified in each of the case studies on Australia, Italy, Russia, the United Kingdom, and the United States. In most of these countries, supports for remote electricity supply exist, and the effects of their removal have been evaluated for Italy and the United States. Consumer subsidies are largest in Russia, where residential electricity prices are far below their long-run marginal cost,[4] but they also exist in one form or another for all of the other countries. In addition, Australia, Italy and Russia all have at least some cases where large industrial consumers, in particular aluminium smelters, benefit from electricity prices lower than those charged to other consumers, and sometimes below the short-run marginal cost of supply.

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[4] Even where tariffs exceed long run marginal costs, the frequent failure by consumers to pay, and forgiveness of that failure, means that *de facto* prices are lower..

To some extent, electricity consumption subsidies may be offset by other aspects of policy that lead to higher ESI costs, in particular, protection of the ESI as a public sector monopoly. This tends to lead to inefficiencies, such as low plant load factors which lead to capacity planning reserves much higher than would be found in a competitive market, and high power generation and distribution costs. Such former inefficiencies have become apparent as a result of their reduction or elimination in the Norway and United Kingdom case studies. The ESI reform process now underway in the United States may similarly result in increased load factors and reductions in capacity planning reserves (Lee and Darani, 1995). Where consumer support removal is linked to broader ESI reform, it is possible that consumer prices will not increase, and may even fall in some countries.

Effects on greenhouse gas emissions of removing consumption supports

The effect of consumer supports on greenhouse gas emissions depends mainly on how consumers respond to changes in price, but also on how the ESI responds to changes in electricity demand.

The effect of removing this type of support has been evaluated in different ways in the various case studies, ranging from the Russian input-output model, through the use of econometrically-derived elasticity estimates in the United Kingdom study, to the use of an energy system least cost approach with elastic services demand in the Italian study.

The case studies find that where policy reforms increase the electricity price, this tends to lead consumers to switch away from electricity towards other fuels in end-uses where substitution is relatively easy. This applies in particular to residential and commercial sector space and water heating, and various industrial sectors. Where electricity is the strongly preferred energy form for an end-use, for example, in lighting or operating electrical appliances such as refrigerators and computers, the effects of electricity price changes on demand are small. Removing supports may lead in the long term to improvements in energy efficiency, in technologies for electricity generation, distribution and consumption. This was found to be an important contributor to greenhouse gas emission reductions in the Italian case study (Tosato, 1996), where the presence of consumer supports was estimated to increase electricity demand by 5 per cent.

Reducing electricity demand and improving energy efficiency in electricity supply usually leads to reduced greenhouse gas emissions. In the short term, these reductions can be larger than would be expected just from the average emissions per unit of power, because marginal power demand is usually met by fossil-fuel-fired plant of only moderate efficiency. However, where reducing demand results in reduced turnover of generating plants, especially if replacement of old coal-fired plants is delayed, there can be an increase in greenhouse gas emissions relative to a scenario where consumption supports are maintained.

Economic, employment and trade effects of removing consumption supports

Electricity subsidies are often introduced to support low-income households and to reduce costs for industry to improve its competitiveness with foreign firms. Sales taxes on residential electricity use may be below the standard rate because electricity and fuel taxation are viewed as regressive (the share of energy costs in household expenditure decreases with rising household income). On the other hand, across-the-board low energy taxes are likely to be more expensive as a means of supporting low-income households than targeted subsidies, such as grants for home insulation for low-income households. One point that lobbyists have made in the debate over the application of value added tax (VAT) to residential energy use in the United Kingdom, was that home insulation is subject to VAT at the normal rate, so that the application of a reduced VAT rate for energy consumption constitutes a distortion that is likely to affect decisions on home energy management. In this case, even where low income households benefit, they do so in an inefficient way.

Similarly, electricity consumption supports for energy-intensive industries encourage inefficient practices, although energy efficiency might be encouraged by regulation to counteract this effect. Where governments wish to support such industries in international markets, a more efficient way of doing so is through direct supports such as export credits (where these do not contravene international trade agreements). In fact, the main motivation for removing this type of electricity consumption support may relate to trade liberalisation, so that the introduction of export credits is not likely to be an alternative. Where electricity subsidies are removed and the funds are recycled through reduced taxes elsewhere in the economy, there are likely to be economic benefits for other industries, whose exports can be expected to rise. Energy intensive industry might become less competitive in the short term, but more competitive in the long term as a result of restructuring that may be overdue.

As in the consideration of carbon taxation, removing subsidies for energy-intensive industries raises the possibility of "carbon leakage" — i.e. that those industrial activities may decline in countries that reduce subsidies, but increase in countries that maintain subsidies. While this could certainly occur, the outcome of removing such subsidies depends on other concurrent policy reforms and their effects on the efficiency and competitiveness of the industry. The question of carbon leakage was not explored in the OECD case studies, although it has been investigated to some extent in global modelling exercises. These are discussed by Baron (1996).

Measures that reduce the output of energy-intensive industries are also likely to reduce employment in those industries. As in the case of coal supports, electricity consumption subsidies could be recycled into various alternative measures aiming to avoid a negative impact on employment. These can include aid for the industry to support restructuring, funding for training, relocation grants, local employment or investment subsidies, and many other options. At present, there is little research into the effects of different approaches to restructuring subsidies.

PART 3. POLITICAL FEASIBILITY OF REFORMING POLICIES, AND BARRIERS TO IMPLEMENTATION

The foregoing sections have already given some indication of the original policy objectives of existing subsidies — usually related to employment, protection of domestic markets, export promotion, and support for low-income or rural households. Removing these subsidies will inevitably arouse opposition from those whose interests are served by keeping them. On the other hand, there is a growing international momentum on the path to policy reform including removing subsidies, and many countries have already travelled far along this path.

Reforming policies in recognition of changed circumstances may allow the original policy objectives to be met more effectively than before. This might be the case, for example, if subsidies for coal production or electricity consumption are converted to more direct incentives focused on the policy objective. Alternative policies might include: direct subsidies to encourage regional employment or investment; providing grants for energy efficiency improvement or for installing electricity supplies in low-income and rural households; using the reduction in expenditure on subsidies as an opportunity for reducing overall taxes so that the economy is more efficient and industry is more competitive.

The difficulty likely to be faced by governments is that they will be accused of withdrawing support for the original policy objective of the subsidies. Of course, in some cases, this accusation will be justified. One important step in reforming subsidies can be the conversion of indirect supports and tax expenditures to direct financial aid. This can greatly improve clarity about what is being paid to support the policy objective, and can facilitate a move to more efficient measures.

PART 4. OPTIONS FOR COMMON ACTION TO REFORM ELECTRICITY POLICY, THEIR ADVANTAGES AND DISADVANTAGES, POSSIBLE PARTICIPANTS AND VEHICLES FOR ACTION

This section offers some options for common action to reform subsidies to electricity, its factor inputs, and its consumers. These options are framed in the context already described. In particular: many countries are already in the process of subsidy reform; subsidy reform tends to be motivated primarily by economic policy objectives, rather than environment policy objectives; and the effects on greenhouse gas of subsidy reform are likely to depend strongly on local circumstances and the mode of implementation of the reforms, including the extent of any concurrent implementation of environment policies. Given this context, the common action options are primarily focused on facilitating existing or emerging national reform programmes, and on ensuring that they are consistent with greenhouse gas mitigation policies. We identify three levels of common action, as follows:

a) An agreement among countries engaged in subsidy reform, or interested in undertaking such processes, (i) to collect, share and monitor information on subsidy removal in their energy sectors. Information might include: descriptions of certain key government interventions in the sector including grants, loans, detailed information on fuel and electricity pricing and taxation, indicators of ESI economic and environmental performance; and (ii) to carry out and share analysis of energy policies that tend to increase greenhouse gas emissions, and of the costs of these policies. If the agreement were reached in 1997, a reporting and review format might be agreed during 1998 and could be implemented by 2000. Reporting could form a part of national communications to the UNFCCC COP.

b) As measure (a), but includes an agreement among countries engaged in subsidy reform to adopt targets for subsidy reduction according to some agreed metric, or to carry out subsidy reform in a manner that supports the objective of greenhouse gas mitigation.

c) An agreement among countries to remove certain specific types of subsidy. This might include, for example, a focus on removing coal subsidies or subsidies for electricity consumption by energy-intensive industries. Altenatively it might include an agreement to move from complex means of producer and consumer support towards more specifically targetted direct subsidies.

These options are not in any way exclusive. Indeed, the implementation of options (b) or (c) would probably depend on prior implementation of option (a). The three options are addressed in the following three sections.

ESI Policy Reporting, and Apprasial of Effects on Greenhouse Gas

This reporting and appraisal option is in fact already addressed in UNFCCC. Article 4.2. (e) (ii) specifies that Parties shall:

Identify and periodically review its own policies and practices which encourage activities that lead to greater levels of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol than would otherwise occur.

The guidelines for UNFCCC Parties' national communications to the COP do not require them to report on policies and measures that increase emissions of greenhouse gas, but do suggest that countries "may" include information on energy pricing and on policies implemented before 1990 that affect greenhouse gas emissions. There does appear to be a need for additional consideration of this issue, perhaps leading to additional guidance on reporting, and on methods for estimating the effects of subsidies on greenhouse gas emissions and the economy.

The existing OECD subsidies project does provide some basis for developing guidelines on the types of measure that would need to be reported. Based on the results from the case studies, the following pieces of information appear important in attempting to understand whether a country's electricity-related subsidies are likely to increase greenhouse gas emissions:

- the level of direct financial support to fuel production and supply, electricity generation, transmission, distribution: grants, deviations from levels of taxation that apply to other large companies, special rules for capital depreciation for tax purposes;

- direct financial supports to electricity consumers: deviations from levels of taxation and subsidy that apply to other goods, especially competing fuels, complements to electricity consumption, and alternatives to electricity consumption such as investment in energy-efficiency;

- trade policies (quotas, tariffs and credits) for fuels or equipment used in electricity generation, or for electricity;

- price regulations and price supports, including controls on procurement of fuels and equipment used in electricity generation and for electricity; also public service obligations, which require the ESI to supply electricity to all customers, or a particular class of customers;

- investment conditions for the ESI: level and conditions of government equity, government loans, debt forgiveness, controls on rate of return, and presence of government assurances to restrict company liability.

Some of this information is already collected by international organisations such as the IEA and the Energy Charter, but would need to be compiled and complemented by additional information from countries to evaluate all ESI supports. An IEA project is currently underway using a trial questionnaire to probe the extent of government intervention in the energy sector — the questionnaire is currently being completed by four "pilot" countries,[5] and the experience from this trial should be helpful in considering the potential for a more general process of collecting information.

Any attempt to improve reporting in national communications or elsewhere could involve setting up an expert group to review existing OECD, IEA and other studies, and consider what level of reporting would be appropriate. Such a group could recommend guidelines for reporting.

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5 Australia, Belgium, the Netherlands, the United Kingdom.

The OECD case studies also show some of the advantages and disadvantages of different methods for analysing the effects of subsidies on greenhouse gas emissions. As in the case of the guidelines for the first national communications, it seems unlikely that an agreement would be reached to use any one model. However, an expert group could be set up to consider what range of analysis techniques is needed for an adequate assessment of the effects of subsidies. The range would be likely to include bottom-up engineering analysis and some form of economic analysis. It would also be important to specify the way in which the synergy among subsidies and other measures is addressed.

This common action would obviously have no direct effect on subsidies, greenhouse gases or the economy. However, by exchanging information and experience, it would enhance countries' ability to assess their own situation objectively. Once countries enter into a commitment to report on their subsidies and to analyse the effects of their removal, there is an increased chance that they will, indeed, remove subsidies where analysis indicates that the results would be beneficial.

Targets and Environment/Greenhouse Gas Conditions for Policy Reform

In considering common actions in this area that might lead directly to greenhouse gas mitigation, it is important to bear in mind the differences among countries, which make it hard to generalise about the effects of subsidy reform. Many aspects of local conditions affect the choice of strategy: the policy objectives for existing subsidies and for subsidy reform; the way current subsidies are defined and implemented; the energy market conditions that apply, including the energy resources available and their costs, the availability and cost of capital, and the characteristics of existing electricity supply infrastructure. Common action (b) involves no commitment about particular types of subsidy, but simply involves countries agreeing to take greenhouse gas emissions into account when reforming subsidies.

This common action might involve deciding on a way of measuring the level of subsidies that tend to increase greenhouse gas emissions and commiting to reduce these subsidies. Alternatively, countries might decide on an approach similar to that taken to their commitments in UNFCCC Articles 4 and 12: develop electricity sector greenhouse gas projections, along with assessments of the effects of measures that <u>increase</u> greenhouse gas emissions.

The main advantage of this approach is that it allows countries to make their own decisions about the subsidy reform paths most appropriate for them, and encourages them to carry out in-depth analyses of the options available. The main disadvantages of choosing a target approach rather than picking particular subsidies for removal as a common action are: that the effort countries are making is hard to measure — some countries may need a more specific commitment to galvanize action; and the reduction in trade distortions may be smaller than where countries cooperate on a measure-by-measure basis.

Countries would be unlikely to enter into an agreement for common action of type (b) unless they had already made some form of domestic decision or commitment to reform subsidies. A large number of countries have already made such decisions, but are not necessarily examining the greenhouse gas consequences of these decisions in any detail or implementing subsidy reform with a particular view to reducing greenhouse gas emissions. Common action type (b) would involve introducing the greenhouse gas mitigation objective explicitly into the process of national subsidy reform. As the OECD case studies show, subsidy reform can lead to either an increase or a decrease in greenhouse gas emissions, depending on the type of subsidy. However, where subsidy reform is linked to the introduction of greenhouse gas mitigation policies such as CO_2 taxes, voluntary agreements between government and industry, emission caps or other measures, the result can be to increase the effectiveness of the measures in reducing emissions, and in this manner to reduce the welfare costs of these policies.

The approach would have to be closely linked to common action (a), as monitoring and appraisal is an important precondition of realistic targetting. Once subsidies and their effects on greenhouse gas emissions are reasonably well known, targets for reducing both subsidies and greenhouse gas emissions can be evaluated. Whereas common action (a) is primarily a matter of obtaining information and carrying out analysis, common action (b) requires negotiation and agreement among countries, as well as acceptance among interest groups within countries.

Development of this common action could be initiated from the UNFCCC, although it would probably be helpful, and might be necessary, to bring a new group of negotiators to the table — relevant national interests include those in the areas of trade, energy, environment and fiscal policy. Drawing on recommendations from an expert group such as that suggested for common action (a), government negotiators might also need to liaise with other bodies with an interest in subsidy reform such as the World Trade Organisation and the Energy Charter.

Reforming Certain Types of Policy

The third type of common action suggested here would probably be the most difficult to negotiate but would have the greatest chance of success in reducing greenhouse gas emissions, once negotiated, and provided the agreement was binding. This common action might be developed in much the same way as common action (b).

The choice of subsidies for removal or reform would need to be discussed and agreed by governments, but studies by the OECD and others give some indication of the most promising options. As indicated in the foregoing, some promising subsidies for reform might include (1) the system of supports for coal use in power generation, including grants and price supports for coal producers, and below-market rates of return and environmental regulations that give advantages to coal in the ESI; and (2) consumer subsidies including electricity sales tax below the general rate, grants and other types of support for rural and remote grid electrification, and subsidised electricity pricing for energy-intensive industry.

In agreeing to reform these policies, it would be important for governments to consider implementation issues, and to address the ways in which any subsidy expenditure might be rechannelled. It would also be important to address the issue of the location of responsibility for supports. In many Annex I countries, especially those that are federations of states or provinces, local governments are responsible for a considerable proportion of the supports to the ESI, the mining industry and electricity consumers. This makes it difficult for national government representatives to negotiate policy reforms in an international context.

Specific actions that might meet original policy objectives more efficiently include:

- removing coal producer grants and price supports (including market entry barriers and preferential conditions in ESI regulations) and instead providing direct limited term supports for employment, retraining or relocation of miners: this option appears from the OECD case studies to offer a large potential for greenhouse gas mitigation, of the order of hundreds of millions of tonnes of CO_2 per year by 2010 if implemented throughout the Annex I region;

- removing sales tax exemptions for electricity (and other energy forms), and instead subsidising home insulation and energy-efficient appliances in low-income households: this option appears to offer a small potential for greenhouse gas mitigation, less than one million tonnes of CO_2 per year by 2010 in the case studies where the issue was examined;

- eliminating ESI obligations and subsidies to supply remote areas, and instead providing subsidies to low income consumers or local authorities in remote areas, perhaps with incentives for the development of renewable resources: this option appears from the case studies to offer a small potential for greenhouse gas mitigation, perhaps in the region of a few million tonnes of CO_2 per year by 2010 in the Annex I region;

- removing electricity subsidies for energy-intensive industries, perhaps instead providing regional employment subsidies, or support for modernisation and efficiency improvements: again, this option appears to offer a small mitigation potential, perhaps in the region of a few million tonnes of CO_2 per year by 2010.

Some of these measures might have advantages from common action — for example, agreement to phase out the provision of subsidies to energy-intensive industry might help to address concerns about competitiveness, making subsidy removal more politically feasible. Removing supports and protection for domestic coal producers and national ESIs in Europe in particular would increase the potential for a continent-wide electricity market, with the associated flexibility to exploit the most cost-effective low-greenhouse gas-emitting power sources. Other reforms — such as eliminating subsidies for supplying remote areas, might be in the national interest but would probably not yield substantial additional benefits if adopted as common actions. All of these measures would tend to reduce trade distortions, offering economic benefits and, in the long term, increasing the competitiveness of domestic industry.

Governments, perhaps in conjunction with the expert group for common action (a) would need to carry out further detailed assessment of the economic, trade and welfare effects of these measures, and to explore implementation issues, before final agreement on this option (c) could be reached.

APPENDIX A. CASE STUDIES ON ENERGY SUBSIDIES AND THEIR REFORM

The principles of energy policy have evolved in similar ways in many Annex I countries. A country's degree of energy self-sufficiency is often seen, like food self-sufficiency, as a basic factor in national security. However, there has been a broadening of energy policy in recent years from a focus on developing and ensuring indigenous energy supply in various forms, towards policy oriented to encouraging economic efficiency and ensuring environmental sustainability. Energy ministries now emphasise different aspects of these various goals, with some continuing to place their main emphasis on energy security, and others having moved their focus to removing barriers to an efficient energy market (IEA, 1995a).

Governments have introduced energy subsidies for many reasons, and the policy objectives for introducing subsidies continue to be high priorities: developing and maintaining what are perceived to be secure domestic energy supplies; ensuring that power supply is sufficient to meet demand; ensuring access to electricity for low income and rural households; maintaining or slowing the loss of employment in mining communities; keeping the costs of industrial inputs down so that firms can compete in international markets. The reason for questioning these subsidies is that much economic analysis indicates that energy subsidies are not the best way of achieving these policy objectives, and in some instances may actually be counterproductive. Meanwhile, many subsidies have become institutionalised so that, even if they do not achieve their original policy objective, their removal can seem impossible in the face of the objections of those who benefit from them.

Energy subsidies have become increasingly an international issue partly because of developments in international markets and the trade of coal, gas and electricity over the last twenty years. These energy forms are all less amenable to trade than oil, and it is only recently that fully-fledged international markets have developed. On the other hand, subsidies to industrial energy inputs, especially for very energy-intensive industries such as aluminium smelting, have long been a factor in international product markets.

While subsidy reform in OECD countries has been discussed for many years as a desirable, although difficult policy objective, energy subsidies in many of the countries of central and eastern Europe and the CIS are being rapidly reformed. In these countries, zero or very low pricing of energy was an aspect of a system in which governments mandated the amount of energy to be produced and supplied to different consumers. Low-priced, residential energy continues to be seen as an essential element of social policy, although industrial energy prices are now at world levels in many central and eastern European countries.

The ease of identifying energy subsidies depends very much how the subsidies are defined. Energy prices and average taxes for some fuels in OECD and some non-OECD countries are published quarterly by the IEA (e.g. IEA, 1995b). Apart from these data, understanding the extent of government policies and their subsidising effects depends on carrying out detailed analysis using national information sources, many of which may be unpublished. Some indication of national supports to coal production in certain IEA countries can be found in the IEA's annual review of policies of Member countries (e.g. IEA, 1995a) but the coverage of countries or of supports is not comprehensive.

Global Studies

Subsidy estimation

Several studies of subsidies have calculated the effect of removing "market transfer subsidies" to consumers of fuels. Market transfers for a given fuel in a given country are calculated by multiplying the quantity of the fuel traded by the difference between the domestic energy price and a reference price. The reference price is normally either the cost to the user of imported fuel or the value of the fuel to the producer if it had been exported — the choice between taking the import price or the export netback value is a matter of judging whether the country would be a net importer or exporter of the fuel without subsidies. Strictly, the size of the transfer can depend on the cost of alternatives to using the fuel — for example, it may be cheaper for power producers to use gas, rather than domestic or imported coal; in this case the correct reference price for coal used in power generation is the price at which it would compete with gas.

Two global modelling studies[6] are briefly reviewed by PHB (1993) and this review is reproduced in Appendix C. Based on these studies, most OECD countries appear to impose net consumer taxes on most forms of energy. Prices exceed internationally traded prices. Many central and eastern European and CIS ccountries appear subsidise energy consumption, and some of the largest consumer subsidies in the world are in the CIS.

The use of this price-comparison basis for estimating market transfers to consumers has limited value in evaluating the effects of subsidy removal, even if the only form of government intervention in energy markets were taxation and (cash) subsidisation of consumers. In practice, the vast majority of the subsidising effects of government policies are far less direct. In both OECD and non-OECD countries, one important reason for departures from market prices is the use of quantity controls, including import and export restrictions, requirements for energy users to purchase fuels from particular suppliers, and in the CIS in the past, central allocation of resources.

Estimation of effects on greenhouse gas emissions and the economy of removing subsidies

Using very different methods, the modelling studies reviewed by PHB (1993: see Appendix A) find that eliminating market transfers to energy consumers would reduce global greenhouse gas emissions by 9 per cent to 18 per cent, with one study finding emission reductions of 33 per cent in the CIS.

Moving on from the global studies

A number of questions are unanswered by using the approach of the two global studies. Firstly, their definition of "subsidy" measures prices, not government interventions. Prices may vary from world market levels for many reasons, not all of which are to do with the government. Perhaps more importantly, European and Japanese coal prices are above world market levels, and this is interpreted by the approach taken in these studies as a tax. In fact, as the next section will show, the coal industries in

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6 Bjorn Larsen and Anwar Shah, "World Fossil Fuel Subsidies and Global Carbon Emissions", Policy Research Working Paper Series 1002, October 1992.

J-M Burniaux, J. Martin, J. Oliveira-Martins, "The Effects of Existing Distortions in Energy Markets on the Cost of Policies to Reduce CO_2 Emissions: Evidence from GREEN", OECD Economic Studies, Winter, 1992, pp. 141-165.

these countries are supported through both budgetary subsidies and price supports. Similarly, prices may be below world market levels because of price controls.

Secondly, estimation of the effects of subsidy removal depended on the use of economic relationships based largely on energy markets in the OECD. Thus, removing energy subsidies in the CIS results in an increase in price, and hence a reduction in energy demand determined either by a price elasticity of energy demand, or the elasticity of substitution between energy and other inputs. Such elasticities are normally estimated by econometric methods from historical market data, and such data are unavailable for the CIS. Meanwhile, removing subsidies in the CIS is much more complicated than simply removing a government grant to an industry or to consumers: it involves removing a system of central planning, including price and quantity controls. The effects of relaxation of these controls is impossible to predict, and there is no reason to expect an energy model developed on the basis of OECD energy markets to provide results that are correct even within an order of magnitude. In view of this, and of the importance of the CIS in the modelling results from the global studies, one of the OECD case studies takes a closer look at energy subsidies in Russia.

Coal Subsidy Removal in Europe and Japan

An illustration of the quantity controls ignored in the global studies can be found in the form of the support provided by several OECD governments to coal producers. This support may occur through a variety of measures, including direct grants to cover losses, special forms of welfare support for miners that are not available to workers in other industries, price controls, requirements for the electricity supply industry and other users of coal to buy domestically produced coal, and other coal import constraints and disincentives. The total effective support to producers can be estimated in the form of the producer subsidy equivalent (PSE; see box on page **17**) which has been calculated annually by the IEA for several countries since 1988 (IEA, 1988). DRI (1994) used revised versions of the IEA's coal PSE estimates (Table 4) to model the effects of removing PSE-type subsidies. Table 4 indicates the share of the PSE that is made up by budgetary supports, versus that made up by price supports. Some studies (EIA, 1992) find significant federal government subsidies to coal production in the United States, including the "percentage depletion allowance" (a tax incentive for fossil fuel extraction) and federal contributions to the miners' black lung fund (a compensation fund for occupational illness due to past mining), but these do not match the PSE definition used by the IEA.

Table 4. PSEs for Coal Production in OECD Countries, 1993

	PSE per tonne $/tce	Total PSE M$	Budgetary Support	Price Support	Subsidised Production Mtce
France	43	428	100%	0%	10.0
Germany	109	6 688	40%	60%	61.5
Japan	161	1 034	12%	88%	6.4
Spain	84	856	37%	63%	10.2
Turkey	143	416	100%	0%	2.9
United Kingdom	15	873	2%	98%	57.4
United States	0	0	0	0	0

note: tce = tonne of coal-quivalent; Mtce = million tce. 1 tce = 29.308 GJ
Source: DRI, 1994a, IEA, 1994a

Table 5. Summary of German Coal Supports

Item of Support	**10^6 DM**
Direct aid to current production:	
Investment grants	0
Miners' bonuses	140
Special grants and debt payments	253
Special grants to promote sales of coking coal	3 726
Indirect aid to current production:	
special capital depreciation measures	5
excess deficit payments to miners pension fund	350
Price Support	
refunded through coal levy	5 437
estimated additional consumer payments[7]	1 181
Total PSE	**11 210**
Supports Not Included in PSE	
Aid to Promote Industry Contraction:	
Aid to companies arising from industry contraction	0
Early retirement and other redundancy payments	438
Aid in respect of water contamination and subsidence (mines closed before 1969 only)	190
research and development aid (coal production and transformation)	93
Miscellaneous:	
Maintenance of security stocks	135
Aid to CHP and district heating	31
Deficit payment to miners pension fund	9 000
Total non-PSE	**9 887**

While the effective coal producer support is clearly substantial in several of these countries, the effect of removing that support depends very much on the form it takes, and also on the alternative energy sources available to current coal consumers. Removing supports is likely, in general, to result in reduced production of coal from the sources that have been subsidised. Where the subsidy is entirely in the form of budgetary support to producers, consumers may face higher prices for coal. In some instances they may be led to switch to other fuels that can be used at lower cost. Where the subsidy includes an element of price support, such as compulsions for power generators to purchase domestically produced fuel at higher-than-market prices, its removal is likely to result in lower electricity prices to consumers, and an increase in electricity consumption, which may be provided by importing fuel or electricity, or by switching to alternative, cheaper energy sources.

Greenhouse gas emission reduction potential and costs

In DRI’s (1994) modelling study of the effects of removing the supports listed in Table 4, they found that the main effects in the time period (to 2010) examined were:

- a reduction in the total PSE in 2010 by $5.8 billion, rather less than the 1993 figure after allowing for reductions that would probably have occured even in the “subsidy” scenario;

[7] Estimated as the difference between contractual prices and external prices.

- a reduction in production of the classes of coal that are currently subsidised by 70 per cent or 80 million tce in Europe and Japan;

- an increase in imports of 67 million tce;

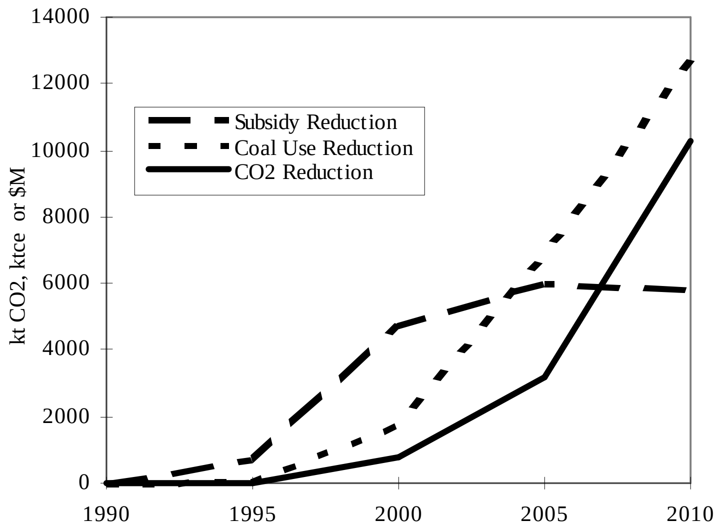
- about 13 Mtce (3 per cent) reduction in coal use, mainly as a result of substitution by gas in power generation;

- CO_2 emission reductions of 0.8 million tonnes in 2000 and 10.3 million tonnes in 2010, in the countries modelled, as well as an increase in world coal prices of about 20 per cent in 2010;

- 174 000 job losses in the mining industry relative to the 1992 level of coal mine employment in the six countries — this would be partly offset by increase employment elsewhere, including in activities associated with coal importing; if subsidies had been continued, about 70,000 job losses would have been expected as a result of natural wastage and resource exhaustion.

Figure 2 shows DRI's calculated reductions in subsidies, coal use and CO_2 emissions for the six countries. Total coal consumption decreased in all countries that removed subsidies except France, which increased coal consumption to export power to Germany. The increase in world coal price mentioned above was mainly a result of higher production costs in the United States, which was assumed to be the marginal exporter.

Figure 2. Reductions in Subsidy, Coal Use, and CO_2 Emissions, 6 OECD Countries



Source: DRI, 1994

OECD Secretariat note

The increase in world coal prices calculated by DRI would be likely to reduce coal demand in the United States and elsewhere, although this effect was not reported by DRI. An order-of-magnitude estimate of the probable effect of this price rise on coal demand in the United States can be obtained based on the 5-year own-price elasticity of coal demand in industry which is calculated by the IEA (1994b) as -0.23, and the IEA's (1995b) projection for North American solid fuels used in power generation and industry in

2010, which is 612 to 667 Mtoe (26 to 28 EJ). The reduction in coal use can be estimated[8] as 1.05 - 1.15 EJ. This in fact entails a reduction in the projected increase in coal use over the period 1990 to 2010, rather than a net decrease. CO_2 emissions associated with this coal use at 88 million tonnes per EJ would have been 92-101million tonnes. Assuming that North American utilities build gas CCGT plant instead of coal-fired plant, the greenhouse gas emissions avoided in 2010 would be approximately half those associated with the reduced coal burn or 46-51 million tonnes of CO_2 or roughly five times more than that estimated by DRI for the effects in Europe and Japan alone. Longer term effects would be larger: IEA (1994a) estimates the 15-year elasticity of industrial coal demand in the United States at -0.39.

The increase in the price of coal in international trade would be likely to lead to decreases in consumption elsewhere. However, these cannot be estimated for the current study. We can conclude based on the DRI study that removing $5.8 billion of PSE-type coal subsidies in Europe and Japan would probably reduce global CO_2 emissions by a *minimum* of 55 million tonnes in 2010, assuming that the DRI finding of very little fuel switching in these countries is correct.

Removing Subsidies to Electricity Production and Use in Australia, Italy, Norway, Russia, the United Kingdom and the United States

Even the PSE-based approach to evaluating subsidies, described above, has shortcomings in that it does not distinguish among the factors that contribute to price support. An alternative approach, that has been developed in several case studies for the OECD, is to examine subsidy removal on a measure-by-measure basis. As the design of subsidies varies considerably between countries, the evaluation can only be carried out on a country-by-country basis, and depends on insight into the exact conditions that obtain in the energy markets of the various countries. These OECD case studies have therefore been carried out by nationals of the countries concerned, in many cases using models that have been developed and fine-tuned in those countries over a long period.

Methodology for Analysing Electricity Subsidies

In 1994, the OECD commissioned Prof. Alain Haurie of the University of Geneva to develop a framework for electricity sector case studies, aiming to examine the wide range of interventions in this sector, using the linear programming (cost minimisation) energy system model, MARKAL. This model is appropriate for investigating certain types of intervention, such as fuel price controls, taxes, quantity controls and capital subsidies in the ESI. MARKAL is also useful for developing “without interventions”, least-cost scenarios of ESI technology choices and costs. A strength of the model is in simulating technology choice in an electricity sector, with the energy sector as a whole managed to minimise cost. No model, including MARKAL, can directly capture the effects of research and development subsidies, or of monopoly control and state ownership, although it can simulate assumed effects of these interventions, such as falling technology costs resulting from research and development, high overheads in monopolies and low required rates of return that may exist under state ownership. MARKAL is able to model the ESI itself more effectively than most energy market models, which normally have least-cost electricity supply modules with less detail and flexibility. In this report, the Haurie framework was used with the existing MARKAL model configured for Italy, and the Australian MENSA model, which is version of MARKAL modified to incorporate a regional structure.

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8 $E'=E(p'/p)^{\eta}$, where E=base projection of coal use, E’=coal use reduced by price increase, p= base price projection, p’=price increased by expanded European coal imports, η=price elasticity of coal demand.

Case studies were also drafted for Norway and the United Kingdom, drawing on the experience of electricity industry deregulation in those countries, and exploring the effects of some of the interventions that are harder to model. While it may be too early for detailed forecasts of the long-term effects of electricity supply industry deregulation in either country, the deregulation process has shed considerable light on the level and nature of past interventions.

Australia

The Australian case study (ABARE, 1996) follows the Haurie (1994) analytical framework. It identifies a wide range of government interventions that could have a subsidising effect on the electricity supply industry, its customers or its suppliers. These interventions are outlined below.

Research and development grants are provided for development of coal and other electricity generation technologies. Of about A$330 million[9] per year that is spent on electricity-related research and development in Australia, the government contributes about $26 million. No attempt was made to model the effects of this expenditure because of the difficulties in distinguishing research and development that acts as a support to current electricity production from research and development that attempts to address some market failure.

Indirect aid includes the effects of policies relating to vertical integration in the ESI and to government procurement. One instance where this type of aid may occur is in the use of coal from State mines in electricity generation. The study explores one case, in which the Western Australia State Government has supported the construction of the Collie coal fired power station where it has been argued that a gas-fired station would have been more economic. The total additional discounted cost is calculated to be A$170 million,[10] and system CO_2 emissions are increased by 0.2 percent over the period 1990-2020. However, if Australia were to attempt to meet a target of CO_2 stabilisation at 1990 levels from 2000, the discounted cost of retaining the coal fired station would double to A$330 million, because of the additional mitigation costs elsewhere in the energy system. The study notes that this may not be a typical or representative case, and that such cases are unlikely to arise in the future as a result of Australian electricity market reform.

Capital subsidies take the form of government loans at interest rates that do not fully represent the opportunity cost of funds and the risk of default, and loan guarantees. Government owned undertakings have used a discount rate of the order of 8 per cent for project appraisal, whereas 15 per cent is more typical of private investment appraisal in Australia. This implicit support to generating technology with high capital cost per kW and long lead times for planning and construction tends to favour coal vis-a-vis, for example, combined cycle gas-fired generation. The effects of moving to a 15 per cent discount rate have not been directly modelled in the current study, but are reflected indirectly in the modelling of cogeneration.

Tax policies that have some subsidising effect include corporate profits tax exemption and other preferential tax treatment to government-owned utilities, as well as income tax concessions to consumers for the costs associated with grid supply in remote areas. These have not been modelled.

9 Australian prices are given in 1990 Australian dollars. Aus$1 = US$0.78 in 1990

10 All costs are discounted to 1990 at an 8% discount rate, and summed over the period 1990 to 2020.

Interstate trade in electricity and gas has tended to be limited, with transmission networks developed on a state basis, and regulatory and physical barriers to interstate trade. These barriers act as a support to local energy suppliers by limiting the level of competition in electricity and gas markets, as well as the fuel input options available to utilities. Scope for enhanced interstate trade in electricity and gas is an important aspect of ongoing energy market reform. The possible effects of this have been modelled in MENSA, which finds that removing obstacles to gas trade alone reduces discounted costs by A$1.0 billion, but does not reduce CO_2 emissions in the absence of a policy-induced emission limit. However, in the event of a hypothetical target for CO_2 stabilisation by 2000 at 1990, removing obstacles to interstate gas trade reduces the total energy system cost of meeting that target by A$4.4 bn: that is, from A$10.1 billion to A$5.73 billion, or 0.11 per cent of discounted GDP.

Efficient pricing and consumer subsidies. Environmental effects of more efficient pricing could be mixed. In general, pricing of electricity to reflect removal of subsidies, including subsidies to inputs, could be expected to increase the unit cost of energy services. This would tend to both reduce their consumption and encourage the use of more energy efficient equipment, thereby reducing environmental impacts. However, to the extent that improved resource efficiency in the ESI reduces costs or enhances national income, any resulting increase in electricity consumption could tend to increase environmental impacts.

Consumer subsidies include cross-subsidies between consumer classes and between regions. For example, domestic tariffs in New South Wales have been generally 10 per cent or more below cost recovery levels, while businesses have paid as much as 64 per cent over cost recovery levels. Subsidies to rural electrification may have adverse environmental effects where the alternative might have been stand-alone renewables. Another possible form of consumer subsidy is the underpricing of electricity from state-owned utilities to large industrial consumers, in particular aluminium smelters. While this may have occurred in Australia, most utilities have renegotiated contracts with smelters on more commercial terms. Nevertheless, in Victoria, one contract has been estimated by the State Government to have cost the State Aus$1bn since 1984, with a forecast additional cost of $5.4bn over the next 20 years. However, any such subsidy estimates need to be assessed carefully — the relevant comparison being between the existing arrangement and one that would have been arrived at in a competitive market.

Limited market access for new technology, and for independent producers to sell power to the grid, can act as a support for existing electricity, fuel and equipment suppliers. In the case study, access limitations are found to be a barrier to the uptake of economically viable cogeneration options. It is suggested in the study that a combination of effects from micro-economic reform in the energy sector may encourage technological progress in cogeneration — the “new” cogeneration — reflecting higher efficiencies of conversion to electricity from this technology. As well as improved market access to the state and national grids, the “new” cogeneration is seen as reflecting two other results of micro-economic reform mentioned above. These are higher required rates of return (favouring cogeneration along with other technologies that are less capital-intensive and more modular); and the cheaper and more freely available natural gas input to cogeneration consequent on reform of interstate gas markets.

The study evaluates the effect of allowing cogeneration to be introduced to the extent that it is cost-effective, and finds that CO_2 emissions are reduced by 0.7 percent as a result of its availability; and that total system wide disounted costs are reduced aby A$0.65 billion where interstate gas pipelines are assumed present. In a hypothetical case of 1990 stabilisation from 2000, the absence of “new”cogeneration would increase the cost of meeting such a target by 0.44 per cent of discounted GDP.

Table 6. MENSA Simulations for Australia: Selected Energy System-Wide Results

	Discounted cost relative to unconstrained case			cumulative CO_2 to 2020
	$ bn	$ bn	per cent	per cent increase
No upper limit imposed on system CO_2 emissions:				
:				
Examples of 'intervention failure'				
Collie coal PS required to be constructed	0.17		0.003	0.2
Cogeneration limited to no more than BAU projections	0.65		0.012	0.7
Cogeneration limited to BAU plus no new gas links	1.77		0.033	0.5
No new interState gas links	0.96		0.018	-0.5
Example of 'market failure'[a]	1.84		0.035	1.5
1990 Stabilisation target[b]	5.73		0.11	-12.5
	discounted costs relative to 1990 stabilisation			
Examples of 'intervention failure':				
Collie coal PS required to be constructed	6.05	0.32	0.006	-12.5
Cogeneration limited to no more than BAU projections	8.07	2.34	0.044	-12.5
No new interState natural gas links	10.12	4.39	0.082	-12.5

a. No 'high efficiency' end–use appliances available to the solution in the residential sector, gross of as yet unquantified implementation costs of 'energy efficiency' programs. These estimates must be read in the light of the qualifications discussed in this Report .
b . Emissions are required to be limited to 1990 levels from 2000 and subsequently

Italy

In the Italian case study, an attempt has been made to draw up a comprehensive list of subsidies and cross-subsidies associated with electricity production and use, and to model the effects of the removal of these subsidies using the energy systems model, MARKAL.

Table 7 summarises the estimates in the study of supports and transfers arising from market distortions that affect the ESI in Italy. Producing this set of estimates was a formidable task, involving research into electricity industry accounts, a comprehensive review of national taxation policies that affect electricity, its inputs, and the energy forms with which it competes.

Table 7. Transfers Associated with Electricity-Related Policies in Italy (US$ million)

Policy	**1990**	**1991**	**1992**	**1993**	**1994**
Spending Programmes (R,D, D&D; rural electrification)	33	41	158	127	83
Indirect Aid (procurement preference, support for nuclear phase-out)	794	367	843	1080	1063
Capital Subsidies (gov't equity, low interest loans, loan guarantees, debt forgiveness)	1738	1154	1767	1338	708
Tax Policies (preferential tax treatment, exemptions, tax credits)	1732	2418	2034	2035	1719
Trade Policies (import/export taxes/subsidies, non-tariff barriers)	872	1262	1119	1641	0
Energy and Related Policies (non-commercial contracts, renewables, cogen, price regulation)	3621	4159	3614	3968	971
Subsidies to Customers (reduced rates to employees)	54	70	77	81	93
Total transfers	4050	3919	4226	3806	3229
Total cross-subsidies	4794	5552	5388	6464	na
Total value of ENEL production	16750	18610	20398	21305	23431
Total electricity sector taxes	na	na	3388	na	na

The case study develops a base scenario for five 5-year periods starting from 1990 to 2010, with none of the subsidies in place. In this scenario, MARKAL is unconstrained by government policies and is allowed to determine the least-cost development of the energy system to meet demand for energy end-use. Twenty-two alternative scenarios are tested, in which various subsidies are added. Alongside the subsidies, the scenarios test the effects of a CO_2 stabilisation constraint and a US$50/tonne tax on CO_2 emissions. Most of the scenarios are summarised in Table 8, which also summarises the results of the MARKAL runs for total energy system costs, and CO_2 emissions averaged over the period covered by the scenarios.

Table 8. Incremental Costs and CO_2 Emissions Resulting from Electricity Subsidies in Italy

	Average Annual System Costs (M$/y) relative to system in base case, $441bn; 1990 ESI costs were $16.75 bn			CO_2 Emissions (Mt CO_2/y) relative to system in base case, 387 Mt; 1990 ESI emissions were 122 Mt		
Subsidies in place	No tax	$50/t CO_2 tax		No tax	$50/t CO_2 tax	
		relative to base	relative to no subsidies with tax		relative to base	relative to no subsidies with tax
None	0 (base)	200	0	0.0	-40.1	0.0
Cross subsidies: to imported electricity	165	474	274	-5.0	-43.3	-3.2
Cross subsidies: non-fossil to fossil fuel generation	831	584	384	9.2	-33.0	7.2
Cross subsidies: consumer cross-subsidies between regions	1	221	21	0.0	-40.7	-0.6
Cross subsidies: all	826	1047	847	6.7	-39.2	0.9
Net subsidies: 9 per cent VAT on resid. sales vs. 19 per cent general rate	19	359	159	0.6	-39.5	0.6
Net subsidies: subsidies to capital investment in ESI	1229	1760	1560	3.3	-45.4	-5.3
Net subsidies: no excise tax on fossil fuel use	218	133	-67	5.9	-37.2	3.0
Net subsidies: all	1392	1773	1574	11.0	-36.0	4.2
All subsidies	3005	3164	2964	19.2	-26.3	13.8

A number of observations can be made:

First, the direction of the effects of subsidies on CO_2 emissions varies, especially in the CO_2 tax cases. Subsidies to imported electricity, cross-subsidies between regions and subsidies to investment all tend to reduce CO_2 emissions with a tax in place. Without the tax, only subsidies to electricity imports tend to reduce emissions[11] and all of the budgetary subsidies tend to increase emissions.

Second, all of the interventions tend to increase system costs in the tax-free cases. Only one subsidy tends to decrease costs in the tax cases: the excise tax exemption for fossil fuels used in power generation.

Third, the largest single cost is that of subsidies to capital. However, this type of subsidy tends to increase CO_2 emissions without a carbon tax, but to decrease emissions when a tax is in place.

Removing all of the net subsidies would reduce costs by about US$2179 million/year (the difference between the all subsidies case and the all cross subsidies case) and reduce CO_2 emissions by about 12.5 million tonnes per year.

Norway

Norway was the second country in Europe (After the United Kingdom) to deregulate its electricity industry, and several other countries (Sweden, Netherlands, Finland) seem to be following the example. Norway implemented a new Energy Act in 1991. This Act introduced reforms aimed at removing market imperfections in the electricity sector; it did not focus particularly on removing subsidies. Nevertheless, several explicit and implicit subsidies were removed.

- Statkraft was the state-owned monopoly power producer in Norway, and still has a dominant market share, with the majority of its electricity sold under bilateral contracts to energy intensive industries. One important change was the removal of Statkraft from the government budget, and its reorganisation as a competitive company.

- Another change that involved the removal of an implicit subsidy was the ending of regional power companies' exclusive right to supply local customers. This right to supply meant that power producers did not incur risk when investing in new capacity. It also meant that they faced few incentives for cost-efficient production and management. Thus, it was possible for regional companies to finance non-profit investment and inefficient practices by increasing prices to end-users (especially households). Prices to households rose annually prior to the reform, even in years when large power surpluses existed in Norway.

- A third type of market distortion that was removed by ESI reorganisation was the monopoly on foreign trade held by Statkraft. Statkraft still regulates long-run bilateral contracts between Norway and foreign parties.

As Norway's electricity supply is almost completely based on hydroelectricity, the reform was not expected to have a significant impact on greenhouse gas emissions. The environmental impacts of hydroelectric plant and transmission line construction are expected to be reduced, because liberalisation of the power market has reduced investment in the ESI. However, the case study identifies two mechanisms whereby greenhouse gas emissions could be affected: 1) through competition between electricity and other fuels in end-use; and 2) through the restructuring of foreign trade.

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[11] This is because the main source of imports is France, and imported electricity is mostly generated from nuclear power. Domestically generated electricity has a much higher carbon emission intensity.

Effects on end-use

The removal of exclusive rights to supply power within regions has been combined with third party access to the grid, giving all consumers the option of choosing their supplier. Wholesale prices fell significantly after the Energy Act as a result of this new competition, and many commercial customers renegotiated their electricity contracts at lower prices. Little change has occured in the residential electricity market, although households have organised themselves to negotiate lower prices from either local suppliers or alternative suppliers.

Changes in electricity prices tend to lead to fuel-switching in end-use. So far this has mainly occured away from fossil fuels in end-use towards electricity, although upward swings in electricity prices, and hence substitution back towards fossil fuels, are possible.

Effects on trade

In addition to removing the export monopoly of Statkraft, three new agreements allow for power-exchange outside the Nordic area after 2000. A common power pool for the Nordic countries was opened at the beginning of 1996. The environmental impacts of increased trade depend whether Norway is a net exporter or a net importer. In the past, Norway's large hydropower surplus has made it a net exporter, substituting for fossil fuel-fired generation elsewhere and resulting in lower greenhouse gas emissions.

ESI Futures in Norway (OECD Secretariat note)

A number of features of market reform may combine in the future to affect greenhouse gas emissions from Norway's ESI. These are: the move towards market pricing of capital and risk for ESI investments; falling real electricity prices; the opening up of trade with other countries; and the opening up of electricity supply to domestic competition.

ESI investments have historically been made using a real discount rate of 7 per cent. It is not clear whether this is a reasonable indication of the rate of return that will be expected in the deregulated market. Little new investment has been made since the reforms, partly because of overcapacity but also because of the increased exposure to risk, which would normally be reflected in higher required rates of return on investment. An increase in the rate of return on investment sought by the Norwegian ESI might affect the choice of new generating capacity, and might increase the likelihood that new capacity would be gas-fired. This chance is increased by the introduction of third-party access, which means that Norway's large oil and gas industry has the opportunity to construct CCGT plant to sell to the grid.

The combination of increased electricity trade, increased domestic electricity demand and reduced investment in Norway are likely to lead to increased net imports of power. Where this power is generated from fossil fuels, the result is likely to be an increase in global CO_2 emissions.

A study by Bye and Johnsen (1995) explores the effects of various possible market conditions on CO_2 emissions from electricity in the Nordic countries to 2010. The study examines the effects of introducing free trade in electricity, or of introducing trade in electricity and gas both with and without a common carbon tax.

In Bye and Johnsen's reference case, Norway increases its power supply by 19 TWh between 1991 and 2010. Of this, 14 TWh is hydro, and 5 TWh natural gas-fired. We should note that Bye and Johnsen use a

7 per cent discount rate to assess new investment decisions. A higher 11 per cent rate would lead to more gas and less hydro being built.

Under a free electricity trade scenario, Norwegian generation, and exports to Sweden, Finland and Denmark are greatly increased. Norwegian generation in this scenario is 26 TWh higher than in the reference scenario, but power generation in the other three countries is lower than in the reference scenario. This implies that Norwegian gas-fired generation (amounting to 32 TWh in this scenario in 2010) substitutes for coal, oil and gas-fired generation in the other three countries. Overall greenhouse gas emissions in the region are substantially reduced, but Norwegian emissions are increased relative to the reference scenario.

Under a free electricity and gas trade scenario, Sweden and Denmark import Norwegian gas and generate their own electricity from it, rather than importing Norwegian electricity. Norwegian gas-fired generation in this scenario is only 3 TWh (lower than in the reference scenario and probably too low to result in a gas-fired plant being built). Thus, both Nordic region, and Norwegian greenhouse gas emissions are lower than in the reference scenario. Overall CO_2 emissions are 8 million tonnes lower than in the reference scenario.

In a fourth scenario, CO_2 taxes converge in the four countries to 350 NKr (about $50) per tonne of CO_2 in 2000 and thereafter. The tax results in a reduction of coal and oil use in the region, with increased use of natural gas apart from Norway, where gas-fired power generation is eliminated in favour of hydro. Biomass use is also increased in Sweden and Finland. Norwegian exports to the other countries are increased in this scenario.

Russia

Given the attention drawn to the CIS in the global modelling studies mentioned above, the Russia case study is particularly important in indicating the extent to which subsidy removal might play a role in greenhouse gas mitigation on a global scale.

The Russian economy is currently far from equilibrium. Conventional econometric energy market models cannot be used to discern the effects of incomes or prices on production and consumption of fuels and electricity. Such models would depend on the economy being in a near-equilibrium state, with price and income changes resulting in small perturbations of the equilibrium. It is even harder to model the effects of any changes in government policy.

The historical situation in Russia was one in which the government planned both the quantities of energy produced and consumed, and the prices at which it was traded. The situation now is one in which the government no longer controls consumption and production, but does play a role in planning and price-setting. The electricity supply industry is viewed as a natural monopoly and, although it has been privatised, remains under government control. Prices for users are set at the regional level by electricity boards, based on the local power generation mix.

The principal remaining energy subsidies in Russia are:

1. direct budgetary subsidies to coal production;

2. low energy prices for households, as a result of local government subsidies and cross-subsidies from industrial consumers;

3. domestic prices below world levels as a result of export quotas and duties;

4. cross-subsidies from export revenues to domestic consumers.

Subsidies that affect the electricity sector include:

- Budgetary subsidies to coal production, which amounted to 93-149 per cent of the pithead coal price in 1990-1994. In 1993 the subsidy was about $2 bn, and in 1994 it was possibly as high as $3.6 bn. It amounted to US$27.8/toe or 144 per cent of the pithead price of about $19.3/toe, on production of 271 Mt (176 Mt hard coal, 95Mt brown coal) or 131 Mtoe. The electricity sector consumed 113 Mt (25 Mt hard coal, 88 Mt brown coal) or roughly 57 Mtoe. Depending whether subsidies apply only to hard coal, or are spread evenly over coal production, the overall 1994 subsidy for coal used for electricity was in the range $0.5 to $1.6 bn.

- Market transfers to consumers (measured as the differences between the actual energy prices and the estimated opportunity costs of each fuel, mainly based on netback values for exports) amounted to about 4 per cent of GDP for the Russian energy sector overall, with about half of this for the electricity sector.

Prices for both fuels and electricity have grown substantially in real (PPP) terms since 1990. Table 9 summarises price levels in 1990 compared with OECD average and United States levels.

Table 9. 1990 Prices for Power Sector Fuels and Electricity to Industry, Russia and Other Countries

	Russia (US$ at PPP exchange rate)	OECD average (at actual exchange rates)	United States
Steam coal for power generation, US$/tonne	18	45.6	33.6
Natural gas for power generation, US$/’000 m^3	35	107	82
Heavy fuel oil for power generation US$/t	47	159	139
Electricity for industry, US¢/kWh	2.3	7.1	4.8
Gasoline, US$/litre	0.31	0.50	0.31
Natural gas for households, US$/’000 m^3	54	295	208
Electricity for households, US¢/kWh	2.3	10.2	7.9

(US$1990)

Table 10. Development of Energy Prices for Industry, Russia, 1990-1995

	1990	1991	1992	1993	1994	1995
Steam coal	38	34	49	51	60	73
Gas	44	40	36	42	56	100
Heavy fuel oil	49	50	168	106	89	112
Electricity	267	238	510	672	463	576
Heat	94	103	176	185	199	263

(current $/toe, PPP basis)

Table 11. Estimated Unsubsidised Industry Energy Prices, Russia, 1995-2010

	1995	2000	2005	2010
Crude oil	132	149	160	175
Oil products	127	119	112	108
Gas	153	166	184	205
Steam coal	153	153	153	171
Electricity	127	129	133	140

(1994 actual price = 100)

Based on Tables 6 and 7, unsubsidised industrial fuel prices would be $2.7/GJ for HFO, $2.2/GJ for coal, and $2/GJ for natural gas and 5 ¢/kWh for electricity.

Energy inputs to power generation in 1995 were: hydroelectric, 20.5 per cent, nuclear, 11.5 per cent, thermal, 68 per cent. The breakdown of fuel used by thermal plant in 1995 is not available, but in 1994 the breakdown was 20.9 per cent solid fuels, 64.2 per cent natural gas and 14.9 per cent heavy fuel oil.

The effects of a move to unsubsidised consumer price levels are assessed using an input-output model developed by Gordon Hughes at the World Bank. The study also investigates the effects of pollution fees, which have already been introduced by the Russian government, on emissions associated with energy use.

The model incorporates the effects of energy price changes on the level of energy use (short run price response in demand) and technology choice (influencing the longer term response). It also incorporates the potential for responding to pollution fees by introducing emission controls. Model results include energy use, emissions and pollution fee revenues. Later results will include the regional breakdown of these, as well as that of economic output.

The study starts from an economic and energy sector scenario, in which Russian GDP begins to recover from 1996, but only passes the 1990 level in 2010. The energy sector is an important component of the Russian economy, and the power sector is especially important. In the base-case scenario, a somewhat modified version of the Government's December 1994 "Energy Strategy for Russia" leads to:

- accelerated development of the gas industry with an expansion of gas use in households, although not so much in power generation where a high proportion is already gas-fired;
- reconstruction of the oil refineries;
- restructuring of the coal industry and substitution of coal from European Russia with Siberian coal, at a lower overall level of coal use to meet environmental restrictions;
- concentration in the nuclear sector on investments in safety and control systems, with limited investment in small and medium-sized nuclear heat and power plant.

Five pricing scenarios are superimposed on these underlying assumptions:

1. a base scenario with high consumer subsidies (1990 levels of real energy prices);
2. a scenario with reduced subsidies (1994 levels of industry prices, 1990 levels of household prices);
3. one with subsidies eliminated (estimated unsubsidised prices);
4. one with increased emission fees (to three times the real level of fees set in 1990) and;
5. one with a carbon tax of $10/tonne of carbon emitted.

Table 12 summarises the results of these five scenarios for energy use and environmental impacts, while Figure 3 shows the trajectory of CO_2 emissions from 1990 to 2010, under scenarios 1 to 3. Figure 4 shows the emission reductions in Scenarios 2 and 3 relative to Scenario 1.

Table 12. Scenario Analysis: Subsidy Removal in Russia: Effect on Emissions in 2010

Year	1990	2010				
Scenario		1	2	3	4	5
Real Energy Prices to Industry	1990 levels	1990 levels	1994 levels	Unsubsidised	1994 levels	1994 levels
Real Energy Prices to Households	1990 levels	1990 levels	1990 levels	Unsubsidised	1990 levels	1990 levels
Pollution Fees	Low	Low	Low	Low	High	Low
Carbon Tax	No	No	No	No	No	Introduced
Emissions of:	*Mt*					
CO_2	2400	1754.4	1668	1480.8	1560	1524
NO_x	5500	3767.5	3542	3157	3245	3162.5
SO_2	19000	8702	8113	6517	6973	6840
TSP	28000	10164	9380	6748	7616	7532

Figure 3. Trajectory of CO_2 Emissions from Russian Electricity Use, With and Without Subsidies

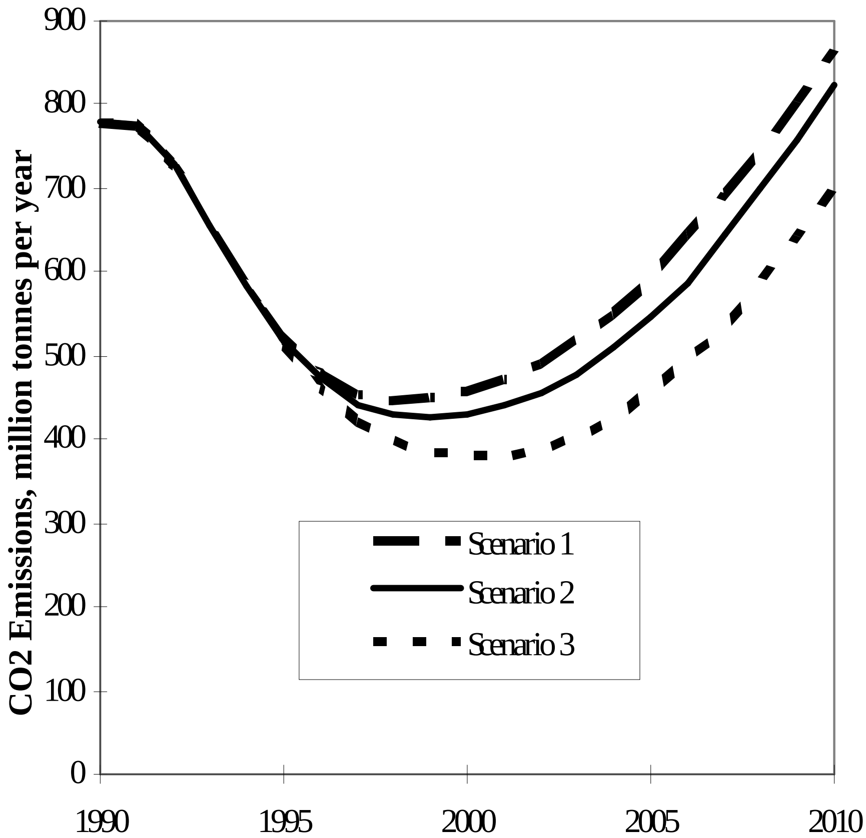
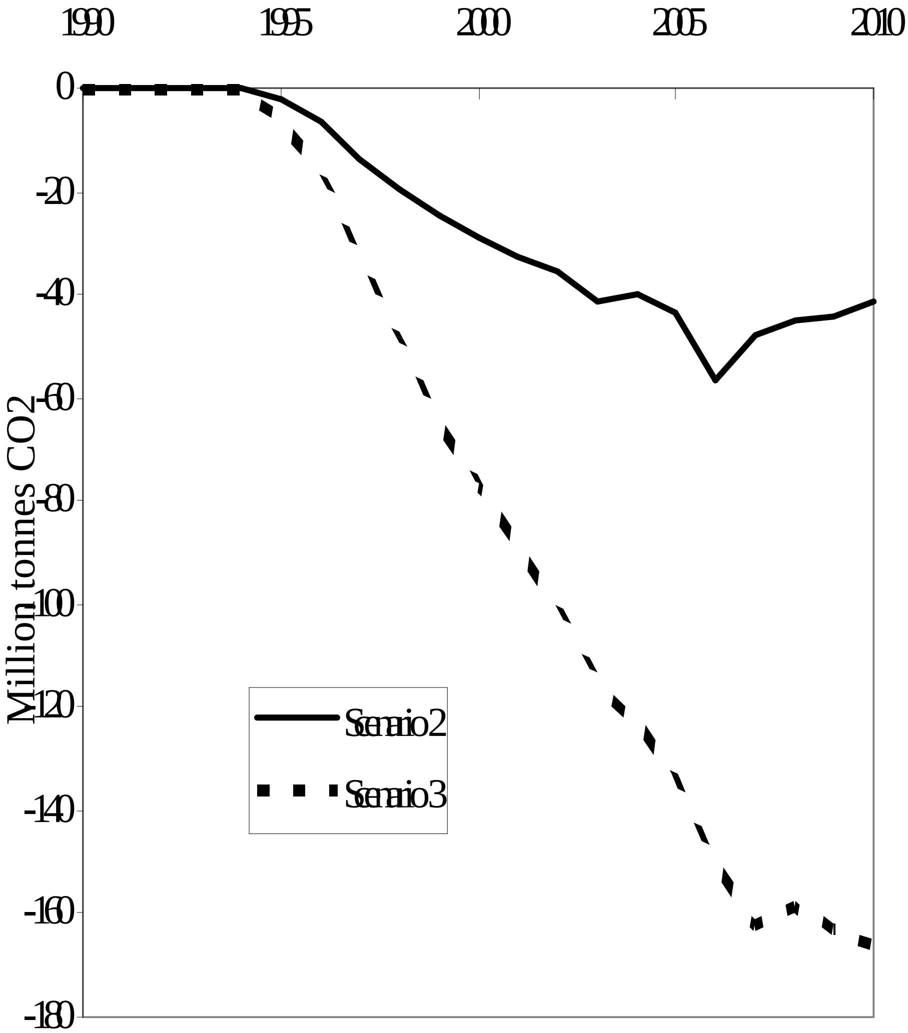


Figure 4. Russian ESI CO_2 Emission Reductions In Reduced Subsidy Scenarios Changes in Scenarios 2 and 3 Relative to Scenario 1

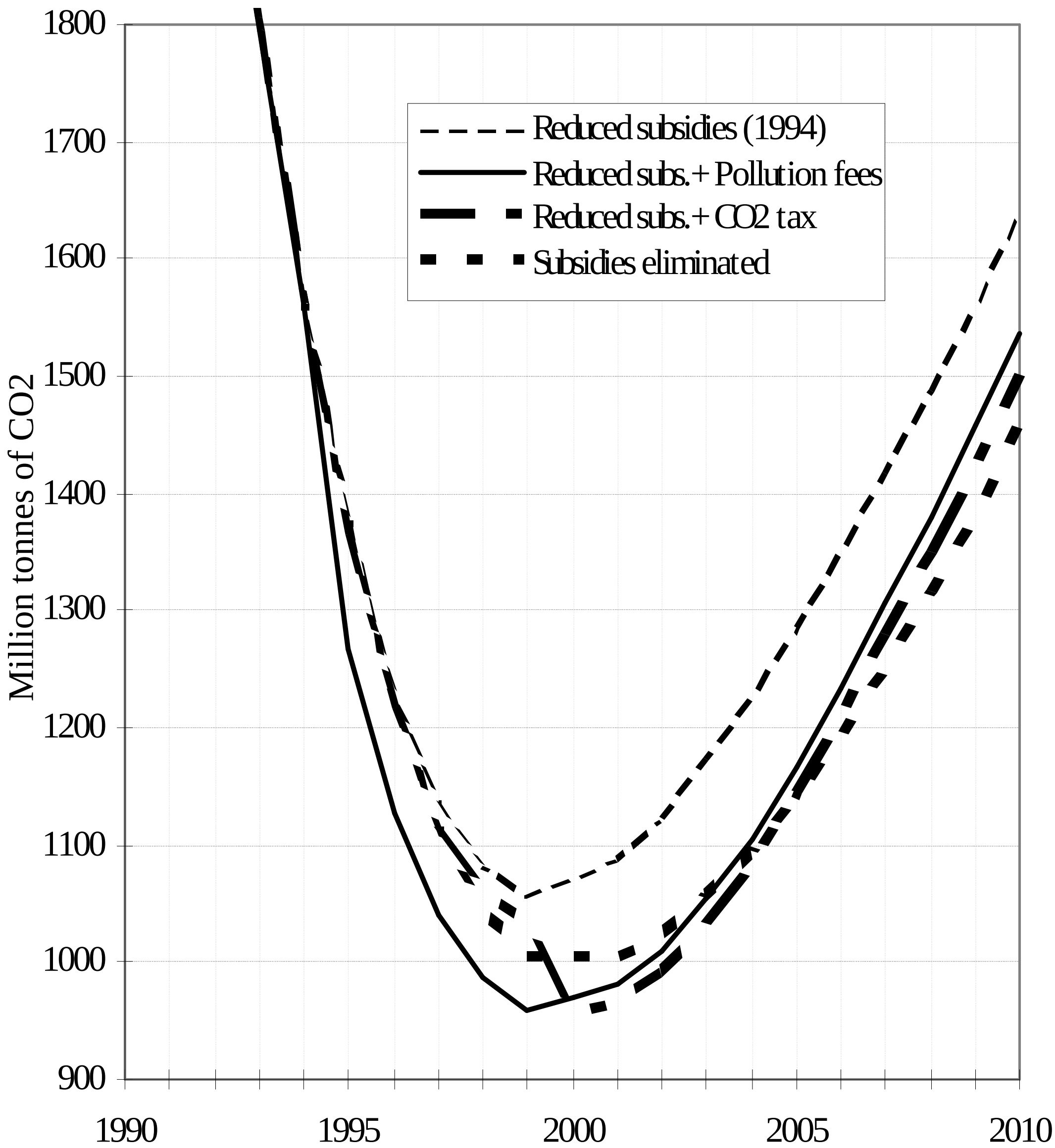


Eliminating consumer subsidies results in a reduction in energy demand, reflected in the lower CO_2 emissions in all of the variant scenarios (Scenarios 2-5); in fact, all emissions are reduced in each of the variant scenarios.

Coal use is reduced in Scenario 3 (unsubsidised) but not in Scenario 2 (1994 levels of consumer subsidy). The effects of this are visible in the SO_2 and TSP emissions, as well as those of CO_2. Raising pollution fees in Scenario 4 not surprisingly has a slightly higher proportional effect on controlled emissions than on CO_2, while the CO_2 tax, by reducing coal use, also has a strong influence on non-CO_2 emissions.

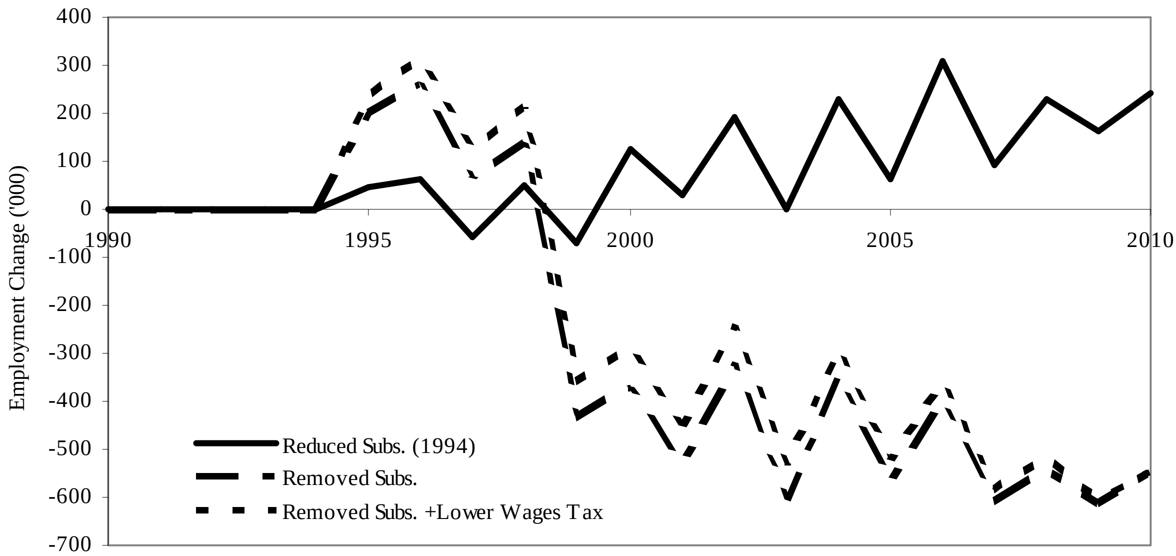
Figure 5 shows the effects of the subsidy removal scenarios compared with the emission fee scenarios. This shows that the different types of measure take effect over different timescales. Thus, both CO_2 taxes and pollution fees take effect more rapidly than subsidy removal, but subsidy removal has a larger long-term effect.

Figure 5. Effects of Subsidy Removal vs. Other Policies on Russian Energy Sector CO_2 Emissions



Employment effects of removing Russian electricity subsidies have also been estimated. They indicate that the move to 1994 subsidy levels results in increased employment, whereas completely removing subsidies would result in reduced employment (by about 1 per cent). Recycling energy subsidies as reduced labour taxes offsets this reduction only slightly, leading mainly to lower industry costs and more rapid technology replacement. However, this result is probably an artefact of the input-output model used: there is no mechanism for increased wage income to lead to higher demand for consumer goods, and other types of model (e.g. a general equilibrium model) would be expected to give more positive results.

Figure 6. Employment Effects of Russian Subsidy Removal



The effects of subsidy removal on energy trade in Russia are expected to be minimal; however, reducing electricity subsidies to energy-intensive industry would affect competitiveness for production of some commodities, such as aluminium.

The United Kingdom

The Electricity Sector in the United Kingdom is of particular interest for a study of the effects of removing government interventions. The United Kingdom is in the process of a radical restructuring of its ESI. This has involved unbundling of the former nationalised "Central Electricity Generating Board" and privatisation of many of its components, along with the Regional Electricity Companies responsible for distribution of electricity. At the same time the market conditions facing the ESI have changed, with the privatisation of British Gas in 1986 and British Coal in 1994, and preparations for privatisation of the nuclear industry in the near future.

The restructuring process has resulted in increased transparency of institutional and governmental supports for the various parts of the ESI, as well as other market imperfections. Most of these supports are in the process of being removed.

Energy market developments and projections for the United Kingdom indicate a rapid reduction in coal use and its associated environmental impacts over the period 1990 to 2010, although a subsequent increase is possible. A particular task of this case study is to explore the extent to which the reduction in coal use can be considered a result of removing government subsidies and, if so, which are the subsidies and market conditions that are critical to any change in direction that has occurred.

Major policies identified in the study that might support coal or electricity consumption include:

- government grants and price support for coal producers;
- government funding for nuclear power research and development and price support for nuclear power;

- low-cost government financing for power sector investments;
- consumer subsidies in the form of zero VAT on residential energy use to 1994, when a VAT rate of 8 per cent was introduced; the general rate is 17.5 per cent;
- cross-subsidies between industrial and residential electricity consumers;
- additional effects of the state-monopoly status of the ESI prior to restructuring, which included a very high capacity planning margin, low plant load factors.

The study also discusses the non-fossil fuel obligations (NFFO), which are mechanisms whereby funds for nuclear power and renewable energy are raised through a surcharge on fossil-fuel-generated electricity. The NFFO is the mechanism by which nuclear subsidies have been made transparent prior to being phased out (the main element of the nuclear NFFO is expected to end in 1996) and so is used as part of the basis for estimating the size of previous nuclear subsidies. The effects of the renewable NFFOs are not analysed in the study.

Table 13 Examples of Subsidies and Externalities for Power Generation, United Kingdom, 1980s
(UK prices in 1990 £ sterling. £1 = US$1.79 in 1990).

	Coal	Nuclear Power	Natural Gas
Annual grant to cover losses	approx £1 bn	Not evaluated	Not evaluated
Discount rate for investment appraisal (5% vs. 11%), p/kWh†	0.8	1.8	0.3
Effective price support (p/kWh)	0.50	2-3	small
Externalities (working values, current generation, p/kWh)	2.0	0.1	0.2
Government Annual R & D Spending	£3M to £13M	£100 M to £300 M	Oil & Gas, £1M to £37M, assumed mainly for oil

† This represents a bias in investment decision-making rather than a financial transfer: the latter depends on actual rates of return, which have not been estimated in the case study.

Approximate amounts of subsidy associated with each of the main energy sources for power generation are summarised in Table 13. These approximate data hide considerable variation in individual subsidy levels. For example, Figure 7 shows how coal production support has varied over a twelve-year period.

The UK case study explores the effects of market reform through a set of scenarios of ESI investment and plant deployment to meet electricity demand to 2020.

Reference scenarios (in which the market is reformed and subsidies are removed[12]) are taken from the United Kingdom's government's 1995 projections of energy use and CO_2 emissions (DTI, 1995). The government developed several scenarios based on various GDP and energy price levels. The United Kingdom case study uses only two of these, both assuming "central" GDP growth, with low and high energy price levels.

Four "with subsidies" scenarios are developed, based on the same two price scenarios as the DTI scenarios, and using two alternative sets of assumptions about the relative capital costs of coal-fired power stations, nuclear power, and combined cycle gas turbine. Key common assumptions in these scenarios are:

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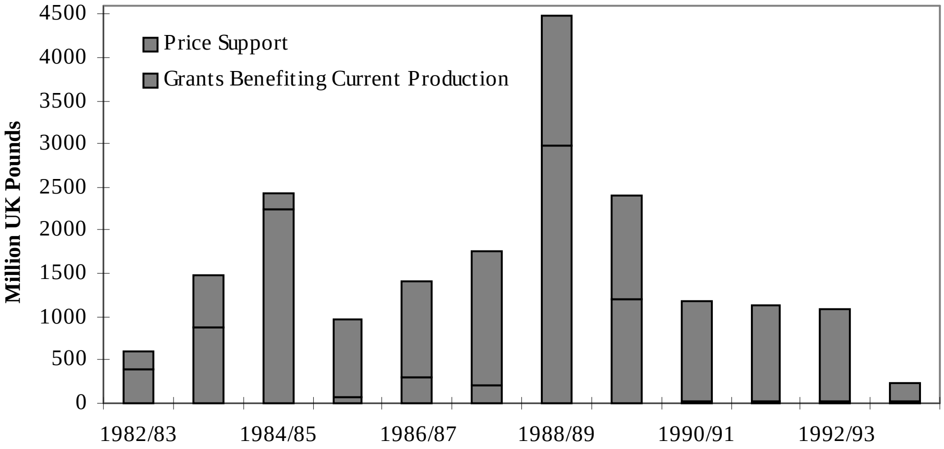
[12] although some supports are retained in these scenarios

Figure 7. Estimated Support to British Coal, 1982 to 1994



Source: IEA, 1991, 1994, 1995

- coal supports are phased out gradually, as opposed to a rapid removal in the reference scenarios, so that the industry does not fall below its historical (1960 to 1980) rate of decline in output;

- nuclear supports are also gradually reduced, as opposed to rapid removal in the reference scenarios, consistent with a view of nuclear power as an emerging technology requiring support to enter the market;

- the ESI remains a public sector monopoly, able to make construction decisions based on discounted cash flow at a 5 per cent discount rate[13]; the reference scenarios take account of the effects of privatisation and competition, including increased autogeneration by industry, and ESI construction decisions are based on an 8 per cent discount rate;[14]

- the pre-1985 capacity-to-demand ratio is maintained, implying a load factor for baseload plant in the region of 60-70 per cent, and construction of a combination of the cheapest and the second-cheapest supply option at any time, to maintain flexibility in the generating mix; in the reference scenarios, the capacity-to-demand ratio declines considerably, with baseload plant operating at its design limit of around 85 per cent and with most new construction being CCGT;

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13 This was the "required rate of return" for public sector projects in the United Kingdom until it was raised to 8 per cent in 1989. A 5 per cent discount rate was used to assess investment choices in new generating plant in the early 1980s, prior to the reform of ESI policies in the United Kingdom. It might be argued that an 8 per cent discount rate should be used for the "with subsidies" scenarios, taking the increase in required rate of return to be part of more general policy changes independent of ESI-related policy. Alternatively, the revision of the required rate of return and the process of ESI policy reforms can be seen as part of the same, broader set of policy reforms that were undertaken in the United Kingdom during the 1980s, aiming, *inter alia,* to bring the public sector on a more equal footing with the private sector.

14 this may be below the rate of return actually sought by the privatised and competitive ESI in the United Kingdom

- renewable energy subsidies (NFFO) are retained as in the reference scenarios, resulting in the same level of deployment; similarly, power imports are assumed at the same level;

- aggregate electricity demand responds to changes in generation costs with an elasticity of -0.2 (generation costs make up approximately half of the electricity price, and the overall long-run price elasticity of electricity demand in the United Kingdom is approximately -0.4).

No attempt is made in the scenarios themselves to distinguish among the effects of individual aspects of the market reform and subsidy removal process, but the process of scenario construction has allowed the author to make certain observations regarding the effects of individual subsidies:

- The use of a 5 per cent discount rate is an essential component of ESI support. Without it, no new construction of coal-fired or nuclear capacity would occur.

- The removal of the subsidies to coal and nuclear power would not necessarily have had much effect on the use of these energy sources, had a 5 per cent required rate of return been retained. If we assume relatively high costs of construction for coal and nuclear, such as existed in the United Kingdom prior to the recent market reforms, CCGT would be the technology of choice even with high gas prices. On the other hand, if lower estimates of costs of construction are used, imported coal and unsubsidised nuclear power are cheaper than CCGT in the high gas price case.

- The maintenance of coal supports, declining at the historic rate, results in substantially higher coal use and hence greenhouse gas emissions than would otherwise occur in 2000, but not beyond 2020.

- The maintenance of nuclear supports would have led to additional construction of nuclear power plants only to 2000 in most scenarios; only in the scenario with high oil and gas prices and low plant construction costs do nuclear subsidies result in new nuclear construction beyond 2000.

The implications for CO_2 emissions are summarised in Figure 8, which compares annual ESI emissions between the various scenarios. Note that it is possible to identify situations in which subsidies result in very much higher CO_2 emissions — this can result from a combination of capital subsidies (low required rate of return) and direct or indirect subsidies to coal — and situations where subsidies lead to lower CO_2 emissions — in the case of nuclear subsidies combined with low required rate of return. In all of the with-subsidies scenarios, CO_2 emissions are higher in $_2$000 than they are in the EP65 scenarios. This is essentially a result of the assumption that domestic coal production would be allowed to decline no faster than historical trends in the with-subsidies scenarios.

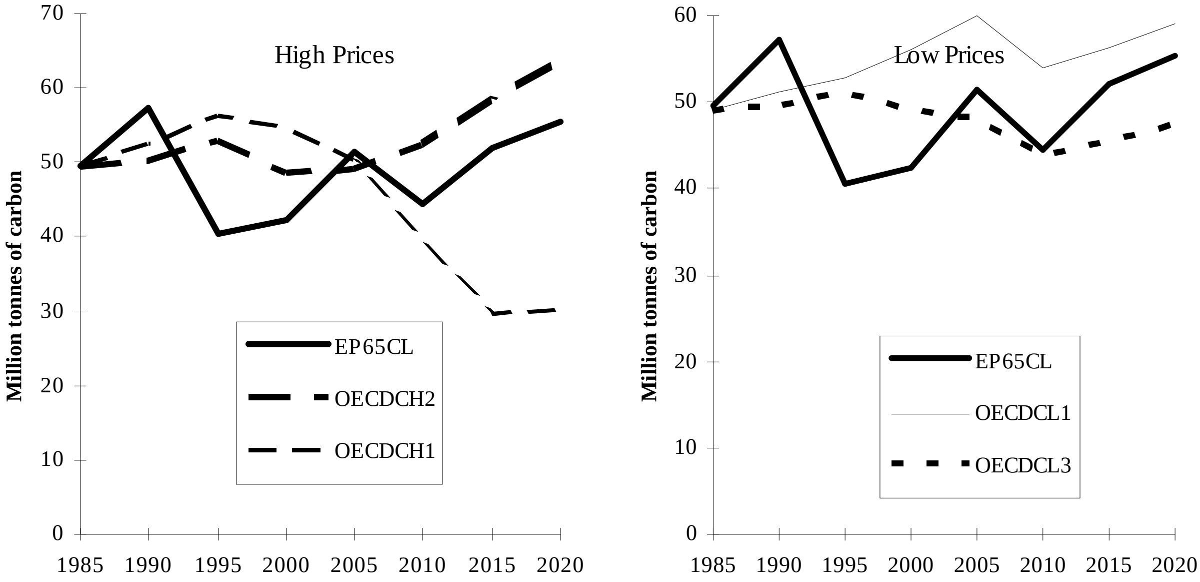

Figure 8. Emissions of CO_2 from the UK ESI With and Without Subsidies

Average electricity generation costs are increased in the with-subsidies scenarios by up to 40 per cent, or 1 p/kWh, depending on the scenario and time (see Figure 9). Much of this increase is due to the larger capacity planning margin in the with-subsidies scenarios, which results in roughly 40 per cent more capacity in 2020 than is built in the EP65 scenarios.

The total subsidy in the form of transfers from consumers to the ESI through electricity prices is in the range £1.5-1.9 billion in 2010, depending on the scenario. The effect of market and subsidy reform on total CO_2 emissions ranges from a 10 million tonne increase to a 10 million tonne decrease, depending on the scenario.

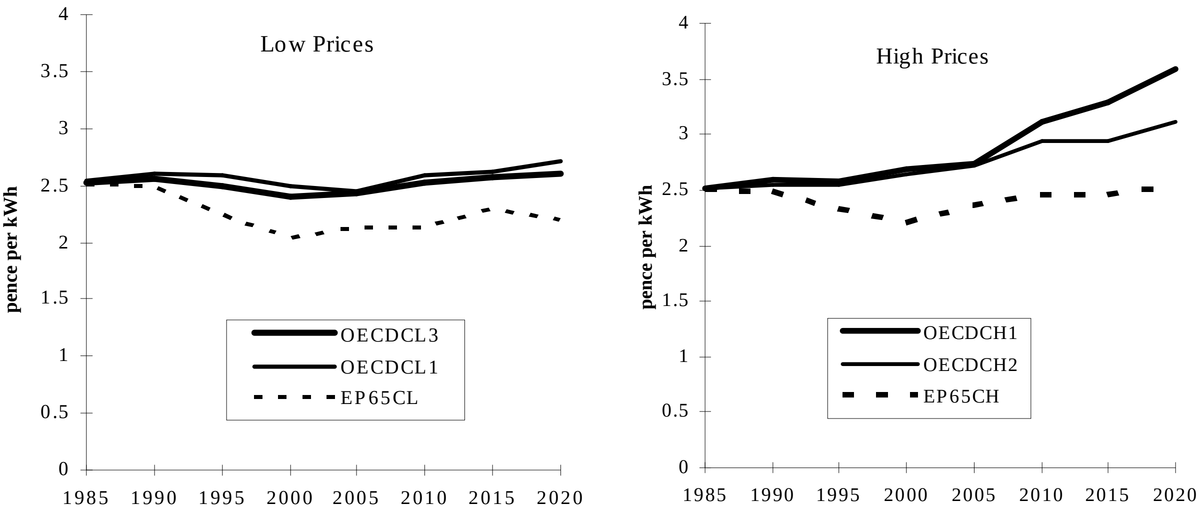

Figure 9. Average Cost of Electricity Generated by the UK ESI Under Several Scenarios.

The study makes several very rough estimates of the effects on consumers of producer and consumer subsidies and cross subsidies:

- In the with-subsidies scenarios, higher electricity costs, resulting from ESI price supports and the large capacity planning margin, are likely to result in roughly 12-14 per cent higher electricity prices and 5 per cent lower electricity demand, with some additional use of fuels in end use. CO_2 emissions might be reduced by about 4 million tonnes in 2010. This is small but significant, compared with the effects of the coal supports on the electricity generation mix and associated emissions.

- Price swings are such that the balance of revenue between industrial and residential consumers has shifted about £500 million ($800 million) either way over the last ten years. Assuming a cross-subsidy exists of about half of this amount, it would be expected to result in around 0.3 per cent lower electricity use but higher consumption of fuels in end-use, resulting in a reduction in CO_2 emissions by about 0.6 million tonnes.

- The reduced rate of VAT on the residential use of energy, at 8 per cent instead of the general rate of 17.5 per cent, amounts to a tax expenditure of about £700 million ($1.2 billion) and results in increased CO_2 emissions in the region of 0.2 million tonnes. Less fuel switching occurs in this case than in the case of electricity cross-subsidies because the subsidy applies to all residential energy use, so that price changes affect all fuels.

The United States

Many estimates have been made of the size of federal subsidies in the energy sector in the United States. The United States case study identified two analyses in particular, one by the United States Department of Energy (EIA, 1992), which estimated energy subsidies in the range $4.9bn to $14.1bn, and one by the Alliance to Save Energy (ASE), which came out with an estimate of $21bn to $36bn. The size of the estimate depends very much on how subsidies are defined — for example, the definition may, or may not, include government compensation for occupational diseases associated with past production, special capital depreciation rules, or government-funded research and development. None of these studies provide an estimate of State subsidies.

For the United States case study, the US Environmental Protection Agency (EPA) commissioned two studies, employing different models: Gemini, an energy sector model developed and used by Decision Focus Inc. (DFI, 1993) for EPA, and the Jorgenson-Wilcoxen-Slesnick (J-W-S) general equilibrium model developed by Dale Jorgenson Associates (DJA, 1994). These two studies made use of the EIA and Alliance to Save Energy reports, estimating the subsidies as shown in Table 14. DFI (1993) found the EIA (1992) to be much more reliable than the ASE study and so adopted these estimates of the size of subsidies. They expected only 13 out of 46 energy subsidies they examined to raise greenhouse gas emissions. The rest supported nuclear energy, renewables and energy conservation, and so were expected to decrease greenhouse gas emissions. However, the subsidies that were expected to increase emissions were generally the largest.

The Gemini model contains a combination of technology and market information, choosing energy technologies to supply and consume energy, and calculating the quantities consumed and prices of fuel and electricity to allow the market to clear, given demand functions and the supply curves for primary energy resources.

DFI modelled the effects of removing seven of the subsidies individually and all of them simultaneously, as variations on a base case scenario of the period 1990 to 2035. They found that the two subsidies with the largest effects were the availability of low interest loans to the Rural Electrification Authority; and the

Table 14. US Federal Energy Subsidies: Reconciliation of Estimates (Millions of 1992 $)

	DOE/EIA "Direct"	DOE/EIA "High"	ASE Low	ASE High	DJA (1994)	DFI (1993)
TOTAL	**4 879.9**	**14 111.2**	**21 231.0**	**36 074.2**	**15 444.9**	**9 385.7**
DIRECT TRANSFERS	**2 842.3**	**1 280.3**	**2 865.8**	**3 928.8**	**1 477.3**	**1 172.0**
Grants	**1 477.3**	**1 477.3**	**1 513.0**	**1 513.0**	**1 477.3**	**1 172.0**
Low Income Home Energy						
Assistance Program (LIHEAP)	1 477.3	1 477.3	1 513.0	1 513.0	1 477.3	1 172.0
Provision of Energy Services	**1 365.0**	**(197.0)**	**1 352.8**	**2 415.8**	**-**	**-**
TAX POLICIES	**(572.0)**	**1 859.0**	**8 840.0**	**19 568.1**	**5 011.0**	**4 059.0**
Tax Credits	**1 275.0**	**1 275.0**	**1 212.7**	**2 716.6**	**1 275.0**	**-**
Tax Exemptions	**285.0**	**1 965.0**	**2 589.2**	**3 344.3**	**1 985.0**	**1 700.0**
Public Power Facilities' Bonds	-	1 680.0	1 137.5	1 387.5	1 700.0	1 700.0
Tax Deferrals	**(35.0)**	**(35.0)**	**130.6**	**15.8**	**(35.0)**	**-**
Preferential Tax Rates	**10.0**	**10.0**	**-**	**-**	**10.0**	**-**
Tax Exclusions & Deductions	**1 025.0**	**1 025.0**	**925.0**	**2 287.4**	**1 025.0**	**1 025.0**
Percent Depletion Allowance	1 025.0	1 025.0	925.0	2 287.4	1 025.0	1 025.0
Accelerated Depreciation (Residual)	**-**	**-**	**2 830.4**	**9 781.6**	**-**	**-**
Trust Funds & Excise Taxes	**(3 132.0)**	**(2 381.0)**	**1 152.1**	**1 422.4**	**751.0**	**1 174.0**
Excise Taxes to General Revenues	(3 132.0)	(3 132.0)	-	-	-	-
SSA Black Lung	-	831.0	892.0	892.0	831.0	831.0
Other	**-**	**-**	**-**	**-**	**-**	**160.0**
POLICIES THAT REDUCE INPUT						
COSTS	**44.0**	**6 226.4**	**2 176.8**	**4 471.6**	**6 226.4**	**3 226.0**
Federal Risk Assumption	**-**	**3 000.0**	**832.0**	**2 947.3**	**3 000.0**	**-**
Loans & Guarantees	**44.0**	**3 226.4**	**1 344.8**	**1 524.3**	**3 226.4**	**3 226.0**
Power Marketing Associations	-	2 026.4	-	-	2 026.4	2 026.0
Rural Utility Service						
Interest Rate Subsidies	-	1 200.0	1 123.2	1 183.9	1 200.0	1 200.0
INDIRECT EXPENDITURES	**2 565.6**	**4 745.5**	**7 348.4**	**8 105.7**	**2 730.2**	**928.7**
Provision of Infrastructure	**523.0**	**545.2**	**4 525.1**	**5 133.6**	**231.2**	**878.7**
Surface Mine Reclamation	108.0	108.0	878.7	878.7	108.0	878.7
Strategic Petroleum Reserve	-	-	1 736.7	2 061.9	-	-
Research and Development	**2 042.6**	**4 200.3**	**2 823.3**	**2 972.1**	**2 499.0**	**50.0**
Nuclear	889.5	1 654.2	1 426.2	1 425.9	1 159.5	-
Coal	472.5	472.5	462.6	611.7	472.5	50.0
Oil Gas & Unallocated Fossil	174.5	174.5	225.9	225.9	174.5	-
Renewables	243.6	243.6	468.5	468.5	241.7	-
End-Use	262.5	262.5	240.1	240.1	259.8	-
Other	-	1 393.0	-	-	191.0	-

Note: This table includes supports for sectors other than electricity. It also includes items which might not be considered to be subsidies to current energy production, or which might legitimately be viewed as public goods that should be subsidised, such as research and development on pre-commercial technology. Estimates of subsidies differ among sources partly because of differences in the definitions adopted of “subsidies”.

tax exempt status of bonds issued by municipal utilities. In each of these cases, the effects of the subsidies were modelled by increasing the interest rate (cost of capital) for relevant utilities by 2 per cent. This had the effect of encouraging switching away from coal and nuclear power to gas. Municipal utilities cover a larger segment of the market than the rural electricification cooperatives which receive REA loans, but the latter use a larger share of coal, so the effect of removing subsidies on greenhouse gas is larger (see Figure 10).

The effect of removing the percentage depletion allowance for owners of property containing fossil fuel reserves[15] was modelled by increasing the cost of production from these reserves. Similarly, the ending of contributions to the abandoned mine reclamation fund and the miners' Black Lung Trust Fund[16] are modelled by increasing the costs of coal production. Part of the Low Income Home Energy Assistance Program (LIHEAP) is assumed to be for weatherstripping and is not assumed to be removed. The remainder is modelled as an energy price reduction low-income households, but on removal, part of the subsidy is assumed to be rechannelled into energy conservation — thus, its elimination has mixed effects. Ending subsidised research and development for clean coal technologies is assumed to slow the rate of technical improvement and cost reduction in technology to convert coal to liquid fuels.

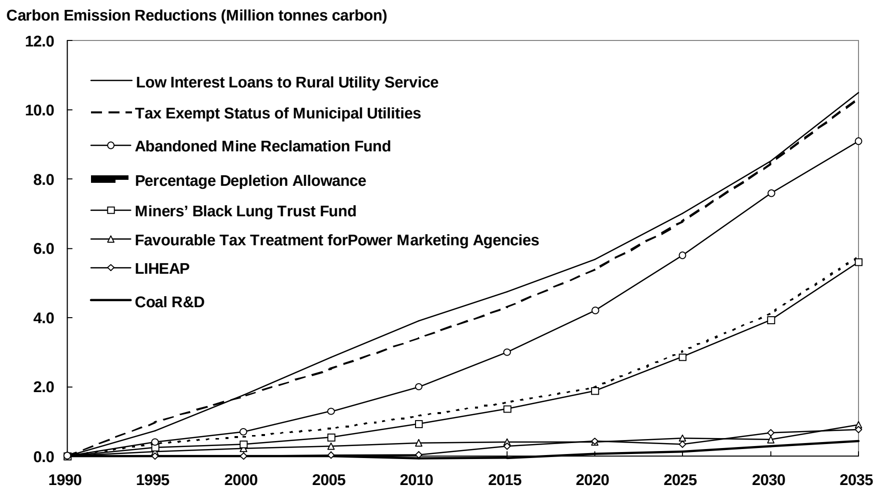

Figure 10. Carbon Emission Reductions from Removing Individual US Federal Subsidies
Source: DFI, 1993

Overall, DFI finds that eliminating \$8.5 billion in energy subsidies results in a 10 million tonne reduction in carbon emissions by 2010, and a 37 million tonne reduction by 2035 (see Figure 11). The axis in Figure 11 is chosen to demonstrate the size of this reduction in relation to <u>growth</u> in United States CO_2 emissions in the base case. The reduction represents only 2 per cent of US CO_2 emissions in 2035. Although this appears to be a small figure, it should be emphasised that this study addressed only federal government subsidies. State government and other local subsidies have not been estimated in this study.

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15 This is a tax expenditure implemented during the First World War to encourage fossil fuel extraction. It allows owners of property containing fossil fuels reserves to claim a tax allowance related to depletion of the reserves, as an alternative to the normal process of capital amortisation. This means that they are effectively allowed to amortise capital in excess of the original value of the property.

16 Note that this is not a subsidy to current production but a government contribution to a compensation scheme for health-related illness that was caused before 1970. This measure would not form part of an assessment of the coal PSE in the United States.

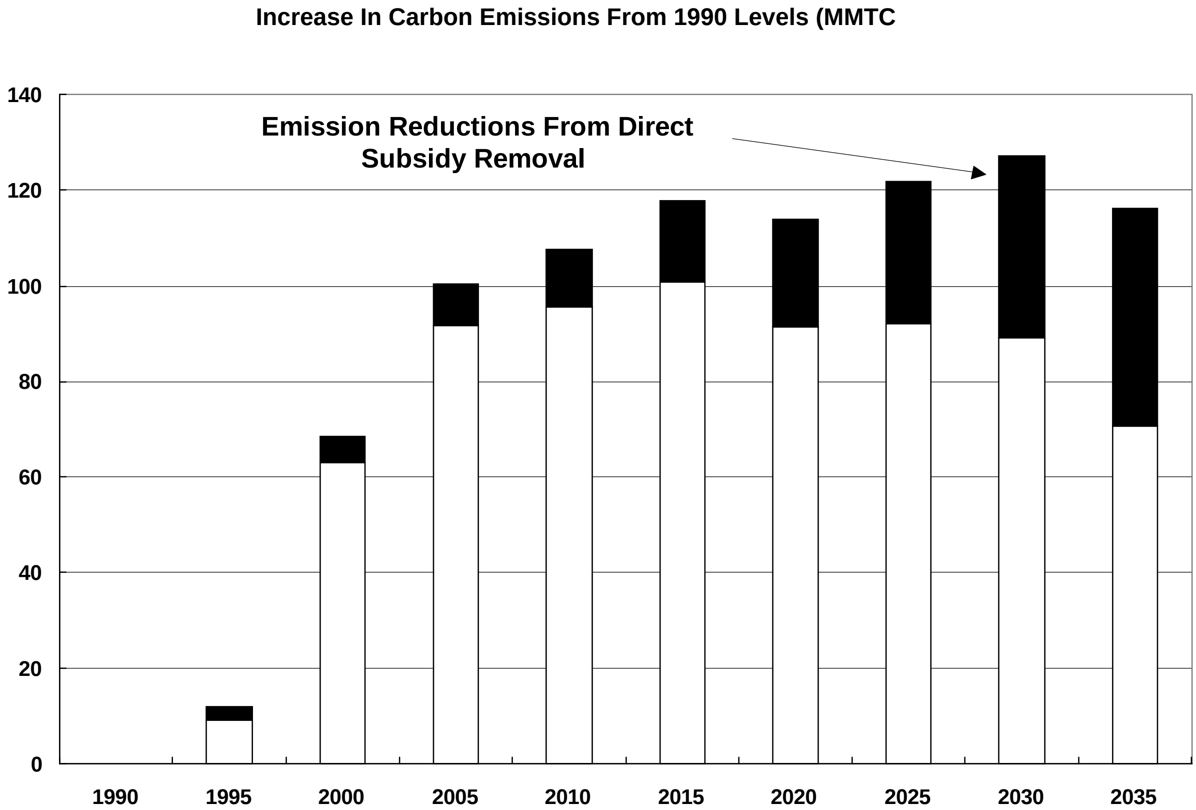

Figure 11. Effect of US Federal Subsidy Removal on Carbon Emission Growth

DJA (1994), using the J-W-S general equilibrium model, estimates that removing $15.4 billion in subsidies would result in emission reductions of 64 million tonnes in 2010. DJA produces other interesting results: eliminating subsidies to conservation, renewables and nuclear power results in carbon emission reductions: according to the J-W-S model, these subsidies reduce overall energy prices and increase energy consumption and carbon emissions.

Macroeconomic effects of subsidy removal are also estimated by DJA, but are found to be extremely small. The effect of removing subsidies on the economy depends on the way the government uses the funds saved. Where the government uses reduced expenditure on subsidies to reduce average tax on earnings, GDP falls. This fall may be a peculiarity of the model used: the reason for the fall in GDP is that households respond to reduced income tax by demanding more leisure (i.e. working less), as well as spending more on goods and services. Where only *marginal* tax on wages is reduced, encouraging people to work harder, GDP rises. When taxes on capital income are reduced, encouraging investment, GDP rises. Welfare disparities between regions and household types are increased where the government reduces average tax on capital or earnings, but are decreased where it reduces marginal tax on wages.

Although differences in GDP among the three cases are small, differences in the patterns of production are larger. In particular, real investment is increased by over 0.4 per cent in 2020, in the reduced capital income tax case, whereas it is reduced by about 0.4 per cent in the reduced average wage tax case. In the marginal wage tax case, labour inputs in most sectors of the economy are increased by about 1 per cent, falling in the energy sectors as follows: coal mining, 6 per cent; oil and gas extraction, 1.5 per cent; electricity services, 4 per cent; and gas services, 1 per cent.

DJA (1994) also evaluates the effects of subsidy removal on the welfare of different types of households, based on utility functions imputed from consumption preferences estimated in the model. In the average labour tax case, all household types experience reduced welfare. In the marginal labour tax case, all household types experience increased welfare, although there are variations among household types in the size of the gain. In the capital income tax case, the effects are mixed, with smaller, younger households, households headed by whites or women, and urban households gaining more. The effects are also regionally dependent. Some households experience losses in welfare. In all the cases examined, eliminating federal subsidies was found to be regressive, increasing differences in income. However, the welfare loss associated with this effect was more than compensated by absolute income gains in the capital income tax and marginal labour tax cases. Recycling the subsidies into reduced marginal labour tax was found to offer the largest overall welfare benefit.

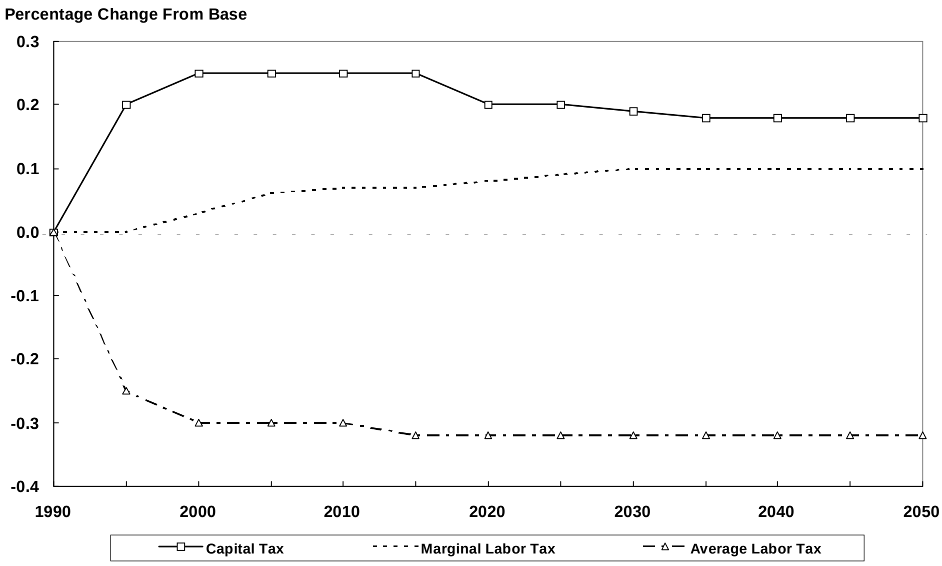

Figure 12. Impacts on US GNP of Subsidy Removal with Different Revenue Recycling Mechanisms

The United States case study finds that subsidies to other goods and services may have more effect on energy use than direct energy subsidies. For example, in the transport sector, the case study identifies subsidies to roads, transit provision and parking at $47bn, and finds that reflecting this cost to drivers through a gasoline tax would reduce carbon emissions by 40 million tonnes. Employer-provided parking, which constitutes a tax-free benefit in-kind to workers, receives an effective subsidy of $19 billion per year. Eliminating this would reduce annual emissions by 19 million tonnes of carbon. The study also identifies subsidies to housing, in the form of home mortgage tax relief and other benefits, at $95bn, and estimates that removing these subsidies would reduce United States carbon emissions by 18 million tonnes.

Unlike federal subsidies, there are few estimates of state and local government subsidies. These may be quite significant — indeed, Kosmo (1987) estimated the difference between US 1984 average electricity revenues and the long run marginal cost (LRMC) at 2.41 ¢/kWh (1984 prices), implying a total market transfer to consumers of $78 bn in 1991 dollars (EIA, 1992). While Kosmo provides no detail of the methodology for estimating LRMC, our calculations indicate that this estimated subsidy could be consistent with that which would arise from utility rates of return on capital being about 7-8 per cent below competitive market rates.

APPENDIX B. OTHER STUDIES OF THE GREENHOUSE GAS EFFECTS OF ENERGY SUBSIDIES

The following studies were reviewed in: Environmental Implications of Supports to the Energy Sector: Report of the Scoping Stud, yPutnam Hayes & Bartlett Ltd. under contract to OECD.

The World Bank Study

A 1992 World Bank study[17] estimates that primary fossil energy subsidies to consumption, via domestic prices that are below world prices, amounted to $230 billion. The study ignored other transfers, including those to support production. Coverage of only market transfers excludes budgetary support to energy-use (including electric power energy conversion) and subsidies to non-fossil energy. Non-price subsidies and consumer-borne subsidies that may have adverse environmental effects but do not result in underpricing of energy (for example, a reserved market for national coal) and their environmental effects also were not counted. Further, the aggregation of energy to its main categories, for example, oil and oil products, may have masked subsidies to particular products, though the authors seek to take this into account. Subsidies to energy complements also were not counted. These assumptions could lead to an underestimate of total subsidies. However, because low consumer prices are also often accompanied by delivery problems or rationing, the effect of these subsidies on final demand is probably less than might otherwise be indicated.

Coverage of the study included countries accounting for 80 per cent of oil-derived carbon emissions and 90 per cent of CO_2 emissions derived from natural gas and coal. Results were extended to the remainder of the world; however the extension added only $8 billion to the estimate of subsidy amounts.

According to study results, essentially all positive market transfers are in non-OECD countries, particularly countries with non-convertible currencies that are only weakly connected to international markets. In particular, the CIS accounted for more than two-thirds of total world subsidies.

First order consumption effects[18] were estimated using elasticities in the range of -0.15 to -0.25 for large subsidies and -0.6 for small subsidies. Compared against the range of estimates of long run energy price elasticities, these estimates are conservative. Cross elasticity effects were ignored. For the CIS, it was argued that this is of little consequence, as consumption of all forms of energy is subsidised in like proportion. It was found that the carbon emission reductions from repricing energy to world market levels in subsidising countries would be 9 per cent of world totals. The reduction as a percentage of current emission levels for the individual countries is, of course, greater, reaching 33 per cent for the CIS.

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17 Bjorn Larsen and Anwar Shah, "World Fossil Fuel Subsidies and Global Carbon Emissions", Policy Research Working Paper Series 1002, October 1992. Extended in April 1993 to account for interfuel substitution from subsidy removal.

18 First order effects measure only the consumption effects of subsidy reduction in subsidizing countries. General equilibrium effects take into account the effect of subsidy reduction on world energy prices and the effect of world price reductions on world consumption.

The authors recognised that increasing energy prices in countries that subsidise consumption would reduce demand and make additional supplies available for export from those countries. Assuming aggregate demand and supply elasticities of -0.8[19] and 0.5 respectively, it was estimated that lower world prices would lower the amount by which carbon emissions would be reduced to 5 per cent of current world levels. The assumption of a much higher rest-of-the-world demand elasticity than was assumed for subsidising countries may also be a conservatism of the estimate.

Taking into account the world trade price effects, net GDP gains were estimated at $36 billion per year. The CIS would be the largest winner, at $22 billion. Nearly 40 percent of the gain would be realised OECD countries. Oil and gas exporting countries would suffer small welfare losses. It was recognised that these welfare gains excluded transitional losses, which could be substantial. Energy use and environmental consequences of these income changes were not taken into account. Given the relatively small magnitudes involved, this would not appear to be a major problem.

For comparison purposes, the authors estimate that an equivalent emissions reduction would require an OECD carbon tax ranging from $50 to $90 per ton.

A main policy concern noted in the study is that the impact of removing consumption subsidies falls almost entirely on non-OECD countries. Particularly notable is the assumption of a 31 per cent reduction in energy use in the CIS. This is associated with a more-than-order of magnitude increase in real energy prices.

The form of the World Bank study is "comparative static". This means that it examines two different states of nature: a) present conditions and prices, and b) present conditions with unsubsidised prices. Implicitly, this type of study assumes that all transitional actions will have occurred and that a new equilibrium will have been reached. By its nature, such a study cannot examine transitional paths and costs.

The OECD GREEN Study

A 1992 OECD study[20] examined the same general issues as were covered by the World Bank study. Like the World Bank study, it focused on the effects of policies that artificially maintained domestic end-use prices for energy below comparable prices on world markets. Neither market price support to production nor budgetary support to either production or consumption were considered.

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19 For subsidising countries, the demand elasticities used to model first order effects were also used in this second stage.

20 J-M Burniaux, J. Martin, J. Oliveira-Martins, "The Effects of Existing Distortions in Energy Markets on the Cost of Policies to Reduce CO_2 Emissions: Evidence from GREEN", OECD Economic Studies, Winter, 1992, pp. 141-165. A companion article by P. Hoeller and J. Coppel, (op. cit.) in the same issue of OECD Economic Studies discusses methodologies for estimating "price wedges" for energy. In all of the countries studied (limited to the OECD), the domestic price of energy was above the world-trade reference price. While taxes, principally on oil products, account for much of the wedge, the residual wedge was still positive and substantial for many countries. This was ascribed variously to non-tax producer subsidies, import restrictions, monopoly rents of national producers and measurement error arising principally from product mix differences. A further key finding of this latter study is that the elasticity of carbon emissions with respect to the price of energy, when measured across 20 OECD countries is -7, even if the share of non-fossil energy (hydro and nuclear) is treated as exogenous. This suggests a considerable scope for carbon taxes to reduce emission levels.

Using somewhat different methods than the World Bank, and 1985 (rather than 1990) data, the study calculates $235 billion in transfers to consumers of primary fossil energy through lower prices. Such consumption subsidies were concentrated in non-OECD countries (subsidies of $254 billion), though the United States was found to have a small net subsidy for oil and gas.[21] Price-related consumption subsidies were found for all energy forms in energy-producing less-developed countries (LDCs), China, CIS, Central and Eastern European Countries (CEECs) and India with mixed results for the Asian "tigers", Brazil and the Rest of the World. Small net taxes on primary energy in the OECD account for the difference between the world net consumer subsidy of $235 billion and the non-OECD consumer subsidy of $254 billion. The pattern of consumer subsidies was generally similar to that found by the World Bank; an annex confirms that differences are due principally to the data year for the study. The CIS accounted for more than 60 per cent of consumer subsidies.

The authors then used OECD's GREEN model to estimate the impact of removing distortions that keep prices below world levels (over the 1990-2000 period) on real GDP and carbon emissions. The "no-price distortion" case also repriced energy to world prices in countries with domestic primary energy product prices higher than world prices. Results were derived relative to a "business as usual" (BAU) case, where existing subsidy levels were maintained.

In both the BAU and distortion removal case, there are backstop technologies - coal-based, synthetic oil, carbonless fuel and carbonless electricity - that set top limits on product prices. In the BAU case, oil exhaustion begins to lead to fuel-switching by 2030; by 2050, the OECD uses essentially natural gas, since taxes make oil too expensive. The remaining oil is burned in countries that subsidise consumption. Carbon emissions in the BAU case increase by more than three-fold from 1990 levels for the world as a whole.

Simply removing such existing energy price distortions improves cumulative discounted world real income by 0.7 per cent over the 1990-2050 period, while reducing 2050 carbon emissions by 18 per cent, caused principally by a 16 per cent fall in energy use.

These world results mask very significant differences among countries. In the OECD, energy consumption increases by 21 per cent relative to BAU levels. This is partly due to the removal of net energy taxes, partly to lower energy prices arising from lower non-OECD demand. Carbon emissions increase by 0.5 billion tonnes per year by 2050. This is much less than proportionate to the increase in energy use; a major cause is a lower share for high carbon synthetics.

Energy use falls in the non-OECD area by 28 percent relative to the BAU scenario. The reduction is, of course, concentrated in the countries with large consumer subsidies.

Whilst the pattern of change in energy use would seem to suggest that removal of distortions would favour OECD Member countries, the opposite is the case. Cumulative present value gains in real income are only 0.1 per cent for OECD Member countries, but are 1.6 percent for the non-OECD countries. Gains are largest in the CIS (26.5 per cent) and the CEECs (7.1 per cent). For the CIS, the primary source of gain is terms of trade - with lower domestic consumption, this region remains a net exporter throughout the period. Brazil and India also benefit significantly from terms of trade advantages, with resulting gains in real income. China and the energy exporting countries are the only losers. China loses, since the

[21] Price wedges were computed for primary energy only, with relatively crude adjustments for coal transport costs. This procedure misses taxes and subsidies for refined petroleum products and for electricity. This accounts for the low tax rates shown for oil even for countries with very high oil product tax rates.

withdrawal of domestic subsidies for coal consumption worsens the terms of trade (due to higher oil imports); the oil exporters lose due to lower pre-2030 prices occasioned by greater supply from the CIS.

Because of the dynamic nature of the GREEN model, it is possible to observe the time pattern of gains. The OECD nations gain, primarily at the expense of oil exporters, through 2030. Thereafter, higher than BAU crude imports turn the terms of trade against them and income losses occur. The oil exporters show the opposite pattern. All others show broadly trend-wise improvements. For the CIS, the increase in income is most rapid in the near term due to massive terms of trade improvements from energy sales. However, the economy continues to improve to reach a 35 per cent real income improvement relative to BAU by 2050.

A second piece of analysis models the effects of a Toronto-type agreement (carbon taxes used to reduce OECD emissions by 20 percent by 2010; non-OECD emissions capped at a 50 per cent increase). The study explores the real income effects under two subsidy assumptions. The "optimal" case assumes that existing price level differences actually reflect the (unsubsidised) real resource costs of energy. The second assumes that price differences are due to positive and negative market transfers (i.e. the world price is the actual real resource cost in each country). To summarise briefly, if existing consumer price levels are assumed to be optimal, the carbon tax required to implement the agreement would reduce world GDP by 2.3 percent cumulatively over the 60 year period. Even the CIS is a small loser. Under the latter interpretation, worldwide cost of compliance with the agreement is reduced to 1.9 per cent of real income. The most significant improvements are in energy exporting countries, China and the CEECs. The CIS shows a slight improvement relative to BAU, but attains almost none of the gains seen from the removal of distortions. The reason is that the tax needed to meet its quota of carbon reductions is small relative to the existing consumer subsidy. This, combined with the depressive effect of the carbon tax on world energy use reduces its terms of trade gain.

An alternative case explores a common world carbon tax, set at approximately $160 per tonne of carbon. With existing taxes and consumer subsidies treated as distortions, the world income loss falls to 0.4 per cent of income. The CIS achieves a 12 per cent gain in income. This is less than the gain from subsidy removal alone, principally because the existing pattern of consumer subsidies does not match the carbon intensity of the different fuels. As a result, oil and gas remain subsidised, but coal is taxed, with negative implications for terms of trade.

The Kosmo and Burgess Studies

One of the earliest studies to survey energy subsidies over a broad sample of countries was conducted by Mark Kosmo in 1987.[22] While rudimentary relative to the studies discussed above, it can be regarded as the seminal attempt to quantify energy subsidies in the context of a concern for their environmental consequences.

The study examined oil product prices for 1981 and 1985 for a sample of 30 countries, with the focus on oil producing countries outside the then-Soviet bloc. Using border prices as a reference price, it found that in most developed countries, the domestic price inclusive of taxes was at least as high as the border price for all products. A number of developing countries subsidised oil products other than motor gasoline. Subsidies were largest in oil exporting countries; some of these also subsidised motor gasoline.

[22] Mark Kosmo, Money to Burn? The High Cost of Energy Subsidies, World Resources Institute, Oct. 1987. The results most relevant to this study were later republished in: Mark Kosmo, "Commercial Energy Subsidies in Developing Countries" Energy Policy, Vol XVII, June 1989, pp. 244-253.

The study also reported data on the relationship between average electricity prices and long-run marginal costs for 11 countries (the United States and 10 developing countries).[23] Prices were found to range from 15 to 95 per cent of marginal cost. Subsidy amounts also were computed, with the United States found to subsidise electricity consumption by $60 billion.[24]

For this sample of 11 countries, the reduction in electricity consumption consistent with eliminating subsidies was computed, using a unitary demand elasticity. Given the elasticity assumption, it is not surprising that the reduction in consumption was proportional to the percentage increase in prices.

Fragmentary data on gas and on coal also found that developing countries subsidise consumption of these fuels. For these fuels, subsidies were measured relative to domestic production costs rather than border prices.

Kosmo discussed links between energy subsidies and their various effects, including negative effects on the environment. However, this linkage was purely qualitative; no attempt at quantification was made.

Joanne Burgess[25] used the Kosmo estimates of subsidies to electricity consumers to estimate the carbon emissions that would be saved by raising prices to long-run marginal cost level. It was assumed that all consumption reductions would come from carbon-based production (as opposed to hydro-electric or nuclear power) and that the reduction would be in proportion to pre-existing fossil fuel shares. It was found that the carbon reduction would total 144.5 tonnes, roughly 3 per cent of worldwide emissions. Of the total, 124 million tonnes was from reduced coal use in the United States, China and India. The United States accounted for more than two-thirds of the total reduction.

While scepticism has been expressed concerning the measurement of electricity subsidies, the Burgess result does suggest that the environmental effects of subsidies to energy conversion may be significant. It

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23 Long-run marginal cost and average revenue estimates were taken from secondary sources that have not been reviewed. Generally, these are by now dated by about 10 years. Changes in energy markets and pricing policies means that the estimates are likely to be of little current relevance.

24 While we have not reviewed the underlying estimate of the US LRMC for electricity, we note that the US result is most surprising. In the US, electricity tariffs are set so as to recover operating cost plus a market rate of return on the depreciated historic cost of investments. As Kosmo found that fuel cost in the US was not subsidised, there is little likely subsidy in the operating cost component. US utility accounting "front loads" the cost of generating plant relative to the levelised real accounting used in many other countries. Over the life of the generating station, the two will be equal in present value. Whether prices will be too low or too high at any point in time depends on the age profile of plant. At the time the estimate was made, the US was just completing a tranche of very expensive nuclear plant. On a cost-weighted average basis, plant was not particularly old.

US-style accounting (and even the accounting used in Current Cost Accounting countries) will undervalue non-reproducible hydro-electric plant. For this reason alone, electricity prices will tend to be below LRMC. However, regulated prices in the US and elsewhere also allow the cost of plant that may be excess capacity and may be non-optimal to be recovered in prices. Technological change in electricity has been both fuel and capital saving in the last several years. This will tend to lower LRMC relative to the embedded cost of existing plant. These excess allowed costs will tend to offset hydro subsidies. While the issue deserves to be researched, we would be surprised if privately owned regulated utilities' prices are below private LRMC in developed countries that are not heavily reliant on hydroelectric power. However, there are significant subsidies to state-owned electric power in both developed and developing countries.

25 Joanne Burgess, "The Contribution of Efficient Energy Pricing to Reducing Carbon Dioxide Emissions", Energy Policy, Vol XVIII, June 1990, pp 449-455.

can be noted that one of the limitations of this study is that it does not consider to what extent marginal electricity production is likely to be fossil-fuel based. An extended study of this issue and the difference it may make to the emissions results could be an interesting exercise.

Böhringer: Removing German Coal Subsidies

Böhringer (1995) has examined the effects on CO_2 emissions of reforming supports to coal production, using a general equilibrium model for Germany. His study evaluates income and other economic effects of various possible modifications of the current coal support system, subject to different national CO_2 emission constraints (or carbon taxes). The paper focuses on the short term: the current power generation and transmission system is assumed to be fixed, so that the potential for fuel switching and electricity imports is limited.

The study examines the German economy in 1990, including the existing coal support system, as its benchmark. In alternative equilibrium solutions, it finds that subsidies to coal production become increasingly expensive as carbon constraints become tighter. Removing these subsidies without any additional controls on CO_2 emissions would increase aggregate income by 0.8 per cent, although the effects on CO_2 emissions are not reported. The study finds that emissions could then be reduced by a carbon tax by nearly 35 per cent, without reducing income below the benchmark level.

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