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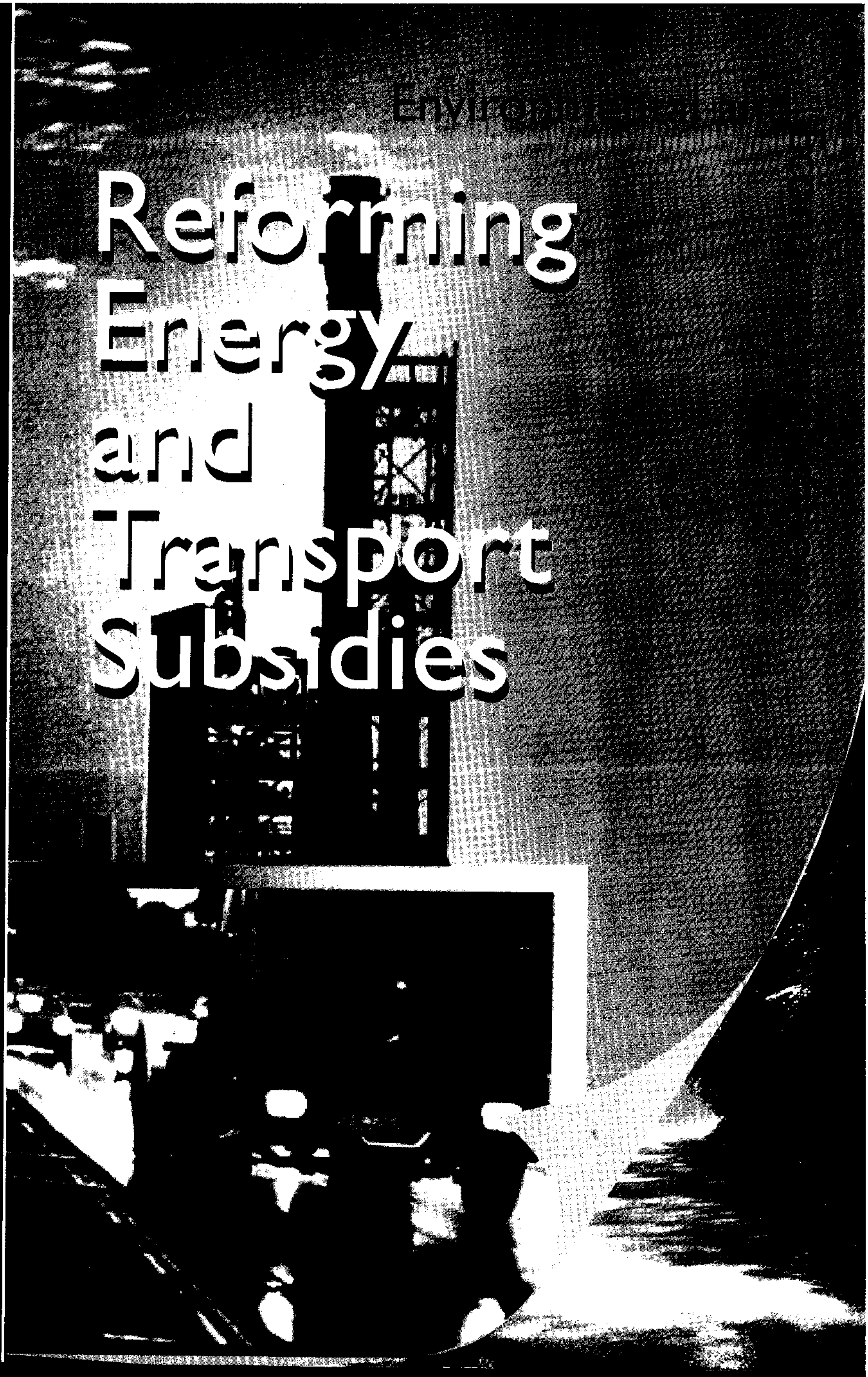

Reforming Energy and Transport Subsidies

REFORMING ENERGY AND TRANSPORT SUBSIDIES

Environmental and Economic Implications

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Implications environnementales et économiques

Foreword

In 1992, the World Bank's yearbook, the *World Development Report*, drew attention to an issue that had so far received little: the contribution of energy subsidies to environmental damage. Modelling studies at the OECD and the World Bank showed that removing energy subsidies could make a substantial contribution to the aim of returning industrialised countries' CO_2 emissions to 1990 levels in 2000. It seems to make eminent sense that before discussing carbon taxes and other measures to control pollution from coal use, subsidies for coal production should be removed.

The OECD's Group on Energy and the Environment decided in late 1992 to look into this issue in more depth, and set up an expert steering group to carry out a series of country case studies, evaluating the environmental and economic effects of removing energy subsidies. The steering group held periodic meetings over the following four years, during which the scope of the project was expanded to consider transport subsidies. A conference was held in Rome in late 1996 to discuss all of the case studies and consider the project conclusions. This book represents the final outcome, including a synthesis of the project findings along with the papers contributed to the conference by the case study authors. The full texts of the case studies are available from the OECD Secretariat and have been posted on the OECD World Wide Web site.

At times during this four-year project, it appeared that the question of the environmental impact of subsidies had disappeared from the international environment policy agenda. However, since the spring of 1995, there has been a resurgence of interest in OECD countries and in the wider international community. OECD Environment Ministers, meeting in 1996, asked the Secretariat to provide a report to them on the subject. Subsidy reform is currently being considered by the Annex I Parties of the UN Framework Convention on Climate Change as a possible common action to implement the convention. The Earth Council has also initiated a study of the environmental impacts of subsidies. The European Commission recently launched a Green Paper entitled "Towards Fair and Efficient Pricing in Transport". Preliminary results from this project have fed into all of these ongoing initiatives.

This book does not provide any easy formulae that policymakers can follow. It identifies more questions than it answers. Supports to energy and transport form part of a complex web of policies woven for social, political, economic and sometimes environmental reasons. While the project case studies have identified situations where reforming supports would have large environmental and economic benefits, they have also identified situations where the environment would suffer. National policymakers will need to make decisions based on their own national situations.

Following the ending of the mandate of the OECD Group on Energy and the Environment, the finalisation of this project has been overseen by the OECD Environment Directorate's Pollution Prevention and Control Group, which approved it for publication. It is published on the responsibility of the Secretary-General of the OECD.

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The OECD Project was guided by an Expert Steering Group, listed below, who played a crucial role in developing the project strategy and commenting on successive drafts of the case studies and the final report. Mr Alex Cristofaro, in particular, initiated the project and provided much of the impetus throughout as the Expert Steering Group Chair. National authors provided case studies from Australia, France, Italy, Japan, Norway, Russia and the United States. The majority of the project funding was provided by the United States Environmental Protection Agency (EPA). Case studies were also funded by the French Environment and Energy Agency (ADEME), the Italian Agency for Environmental Technology (ENEA), the Environment Agency of Japan, the Norwegian Ministry of Industry and Energy, and the United States Environmental Protection Agency. The project was managed from 1992-1994 by Mme. Hélène Connor-Lajambe of the OECD Secretariat, and from 1994 to its completion by Mr. Laurie Michaelis. Important contributions to the management and administration of the project were also made by Ms. Rebecca Hanmer, Head of the Pollution Prevention and Control Division of the OECD Environment Directorate, Mr. Julian Szwarcberg and Ms. Freda O'Rourke.

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Executive Summary

Subsidy reform has been one of the major political themes of the 1980s and 1990s. Several Member countries of the Organisation for Economic Co-operation and Development (OECD), from all OECD regions, have taken drastic steps to reassess and reduce subsidies to agriculture, energy, industry and transport. In central and Eastern Europe and the Commonwealth of Independent States (CIS), economic reform has involved an even more comprehensive change in the level and type of subsidies. Nevertheless, large subsidies remain in OECD and non-OECD countries alike. Many of these subsidies encourage environmentally damaging activities.

This report completes a multiyear research project on "Environmental Implications of Energy and Transport Subsidies". The project involved carrying out a series of case studies aimed at evaluating the potential for reducing environmental damage, while also achieving economic objectives. This body of analysis formed part of the background to the work of the Annex I[1] Expert Group on the UN Framework Convention on Climate Change (FCCC), for which the OECD and International Energy Agency (IEA) have carried out a series of studies on policies and measures for common action under the convention. Particular attention is given in this report to the role of subsidy reform in climate policy.

Governments have many reasons to reform subsidies. Chief among these are three economic justifications: a) the original policy objective of a subsidy is no longer a priority or the cost of the subsidy is no longer justified or affordable; b) the subsidy is poorly designed, supporting a policy objective through indirect and/or inefficient means; c) the subsidy causes distortions in patterns of trade, leading to objections from other countries and competing industries.

This report evaluates the extent to which these three justifications may be linked to the aim of reducing the environmental damage caused by energy and transport activities. It examines the social and political priorities and constraints which keep current subsidies in place, and which must be taken into account in any reform process. Finally, it suggests and evaluates ways in which energy and transport subsidy reform might be pursued in the OECD context.

What is a subsidy?

The first question to be asked in the OECD project was "what is a subsidy?" The simplest and most common meaning of the word "subsidy" is a direct government payment to support the production, sale or purchase of a good or service. However, this leaves out many types of government intervention with similar effects to those of direct payments. For example, government price controls can act as subsidies either to producers or to consumers, by causing transfers of money between market actors.

1. Annex I of the FCCC lists the OECD Member countries with the exception of Mexico and the Republic of Korea, the countries of central and Eastern Europe and three CIS countries (Belarus, Russia, Ukraine).

Several studies have estimated subsidies to energy consumers in a given country based on the difference between energy prices paid in that country and a set of "reference" prices, which are the estimated unsubsidised price levels. The reference price is often taken to be the border price of the energy form – either the cost of imports or the value of exports, depending whether the energy form is mostly imported or exported. This approach allows subsidies to be estimated based on readily available price data, but it is hard to link the subsidy estimates to specific government policies. Subsidy estimates depend heavily on the choice of reference price. The results can be misleading if care is not taken to identify the factors that influence prices and how those factors influence energy supply and demand. Price increments or decrements may be caused by taxes and subsidies, trade barriers, price regulations and other measures, including protection from risk and rate of return controls. Different types of policy can have very different effects on fuel consumption and its environmental impact. These effects are not always brought about through the price mechanism.

Broader concepts of "subsidy" have been accepted in the OECD context, for example in the case of the OECD Agriculture Directorate's "producer subsidy equivalent" (PSE), which measures both direct government payments to producers that support current production, and policies that support the price received by producers for their production. "Tax expenditures" – tax exemptions or reductions for particular activities – may also be considered equivalent to subsidies and are included in the PSE definition.

In the current study, the OECD has deliberately avoided choosing a single definition of "subsidy", but instead has explored the practicality of a range of definitions, and their relevance to the project's main aim. As stated above, this is to evaluate the potential for reducing environmental damage, while also achieving economic objectives.

Effects of subsidy reform on the environment

Preliminary findings from economic modelling studies by the World Bank, the OECD and others indicated that subsidies to energy production and consumption amounted worldwide to hundreds of billions of U.S. dollars, and that their removal would result in substantial reductions in CO_2 emissions and stimulate economic growth. It was predicted that the greatest economic benefits would accrue to the countries with the largest subsidies – notably the former Soviet Union. The OECD project undertook an in-depth evaluation of the promise of these findings, in particular by including a case study on the effects of reforming energy subsidies in Russia.

The OECD case studies support the findings of the earlier studies to some extent. However, they show that it is not possible to generalise about the environmental effects of removing energy and transport subsidies and supports. Countries will need to carry out their own detailed analyses to determine possible outcomes of removing the particular supports in place, given their national economic situation, market structures, factor prices and resource endowment. The economic or environmental effects of removing a subsidy may be positive or negative, depending on how a "subsidy" is defined, how subsidies are removed, the extent to which their removal is linked to other reforms and the way any additional government revenue or reduced government spending is recycled elsewhere in the economy.

Bearing in mind the above caveats, the energy and transport case studies have identified substantial potential benefits from subsidy reform. Adding up the subsidies and subsidy-equivalent market distortions identified in the studies gives a total of around \$100 billion (about 0.75% of OECD-wide GDP). The total greenhouse gas (GHG) mitigation opportunities identified in the case studies would total some 400-500 million tonnes of CO_2 in 2010 – about half of it in Russia.

Individual energy and electricity sector case studies found that removing subsidies reduced sector CO_2 emissions in 2010 by amounts ranging from 1% to 8% depending on the country and the particular scenario examined. Emissions of SO_2 and NO_x together could be reduced relative to with-subsidies levels by around 2 million tonnes per year in 2000 in the country studies. In some cases, the percentage reduction is very large. Coal consumption could be reduced by around 8%-15% or 100-200 million tonnes per year, decreasing the local environmental effects of coal mining. These effects include damage to ecosystems and disruption of human communities, emissions of heavy metals and chlorine, pollution of soil and groundwater, and release of radioactive materials and particulates.

The transport sector case studies found that full cost pricing and externality internalisation could reduce sector CO_2 emissions by amounts of the order of 10%-15%. Traffic would also be reduced, along with its broad social and environmental impacts.

The environmental benefits of reforming subsidies are likely to be larger in the longer term, as removing market distortions leads to changes in investment in electricity and transport infrastructure, with increasing effects on patterns of use.

Promising areas for subsidy reform

While few generalisations can be made about the effects of subsidy reform, certain types of subsidy deserve closer scrutiny, as their removal might help reduce environmental damage. Concerning electricity, some of the most important areas are:

- removing coal producer grants and price supports;
- reforming subsidies to electricity supply industry (ESI) investment or protection from risk, where these support investment in coal-fired power stations;
- removing barriers to trade that discourage the use of energy forms with fewer environmental effects than indigenous energy forms;
- removing sales tax exemptions for electricity (and other energy forms);
- eliminating subsidies and cross-subsidies to consumers in remote areas or to other groups;
- removing electricity subsidies for energy-intensive industries.

The effects of reform can be very variable for some types of subsidy, especially measures that reduce capital costs or encourage investment. Such subsidies may support a range of capital-intensive generating technologies, including coal, nuclear power, hydro-electric power and off-grid renewables. They may also support energy efficiency investments. Removing this type of subsidy can lead to increased use of low-capital fossil fuel options, such as natural gas-fired combined cycle gas turbine. The outcome will depend on circumstances, and could be positive or negative.

The transport sector case studies examined only road transport, where some of the most promising areas for subsidy reform and internalising externalities are:

- introducing institutional changes, where possible, to create markets in road space, strengthen insurance markets and allow markets to develop in other social and environmental "goods";
- reassessing and possibly reducing government outlays for road building and maintenance and/or funding these outlays through simple user fees such as fuel taxes. Having such taxes reflect the costs imposed by particular road users would imply a large increase in diesel taxes in many countries, including most of Europe, the CIS and Japan. Taxes on both gasoline and diesel would need to be increased in North America and in some European and CIS countries;
- introducing or increasing charges targeted to reduce the social and environmental damage caused by transport. These might include parking fees, road access charges, taxes on polluting vehicles, etc. The charges could be designed explicitly to meet public expenditure and social and environmental costs;
- introducing or strengthening regulations to limit social and environmental costs of transport. This may be the preferred approach where charges are impractical because of high administration costs (e.g. for vehicle emissions), or where attainment of objectives is paramount (e.g. excluding traffic from a shopping street).

Implementation issues

Few of the OECD case studies attempted to model macroeconomic and equity effects of subsidy reform. Those that did so found that macroeconomic effects depend heavily on the way any reduction in government spending is reflected in taxation.

Subsidy reform does not necessarily mean subsidy removal. In many instances, subsidies may exist for sound policy reasons, though they may not be the most efficient way of achieving policy objectives. Alternative measures, perhaps even different subsidies, may achieve the same objectives without environmental costs, or possibly with environmental benefits.

Thus, supports to coal producers and energy-intensive industry are often aimed at maintaining employment in the regions where these industries are located. Removing these supports can lead to negative effects on these areas. One way to reduce such negative effects (and the resulting political opposition to subsidy reform) is to convert subsidies for production into local incentives for employment. Similarly, 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. 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 aid for local initiatives to establish renewable supplies and co-generation, to encourage energy efficiency investments or simply to provide income support for rural and remote residents.

As in the case of energy subsidies, many objectives of transport subsidies – ensuring access to services, promoting economic growth, generating employment – might be met through alternative measures. For example, improving facilities for, and access to, non-motorised and public transport may offer more social and economic benefits in some circumstances than providing new roads. Net budgetary subsidies to freight transport might be converted into reduced company or wage taxation to promote economically productive activity.

Many supports are provided at the local or regional levels rather than at the national level. This can make it difficult or inappropriate for national governments to introduce reforms. Similarly, many social and environmental externalities are most acutely perceived at the local rather than at the national level, especially in the transport sector. Nevertheless, national governments can help local and regional governments that wish to reform subsidies and internalise externalities. National policies might include: reforming constraints that impede local governments from implementing full cost pricing in transport; support for networks of local authorities interested in reform; provision of information, technical support and guidelines; provision of financial and other support for local governments undertaking experiments in full-cost pricing.

Next steps

Many aspects of subsidy reform could not be fully examined within the scope of this study. Some of the most important are: the environmental and economic effects of recycling subsidy reductions in the economy; the equity and employment effects of subsidy reform; and the significance of the less quantifiable environmental effects of subsidy reform, such as impacts on habitats and biodiversity.

The greatest additional insights are likely to derive from more careful examination of specific national situations. Many OECD Member country governments have begun to evaluate their national subsidies to energy and transport since this OECD project was initiated. The results of these evaluations will be of particular value for the international community. There may also be some scope to increase the emphasis placed on examining subsidies and their effects in a number of policy review processes carried out by the OECD and related organisations.

Part One

Reforming Energy and Transport Subsidies

Chapter 1

Introduction

1.1 Context

Many of the most visible social and technological developments of the 20th century are associated with or dependent upon the widespread availability of cheap energy and motorised transport. Both have made huge contributions to our quality of life and economic development. Modern society depends in particular on electricity as an energy form, and on the car and truck as means of passenger and goods transport. Access to these depends on the existence of widespread, high-density networks, whether of power transmission lines or of roads. In addition to their social and economic importance, both roads and electric power grids have natural monopoly characteristics, and roads can be seen as "public goods"; hence most governments regulate or own both electricity and road networks to ensure adequate provision at low cost. Indigenous energy forms other than electricity have also been subsidised in many countries to reduce industry's costs and hence promote its competitiveness, and to ensure that low-income households can meet their basic energy needs. During the late 1970s and early 1980s, governments subsidised indigenous energy forms and erected barriers to energy imports to establish national energy security following the oil price rises of 1973/74 and 1979/80.

Governments support energy and transport provision and use 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 or to purchase from particular suppliers, and import and export quotas. While many of these measures do not fit the common conception of a "subsidy", all can have the same effects as a subsidy for the producers and consumers concerned.

1.2 Reasons for subsidy reform

In most OECD countries, access to road and electricity infrastructure is now near-universal, so there is no longer an urgent need for infrastructure development to provide basic needs. Meanwhile, developments in information technology are reducing the transaction costs and technical difficulties involved in charging for their use of infrastructure. In this context, many governments, with the encouragement of the OECD, the European Commission, the World Bank and other such institutions, are endeavouring to reduce their role in these sectors and to reduce or eliminate supports. This policy reform agenda is motivated by concerns such as balancing the budget, improving economic efficiency and promoting fairness – making sure that people and firms pay a fair price for the resources, goods and services they consume.

At the same time, growing concern about the environmental impact of energy production and transport has fuelled debate about governments' involvement in these sectors. Support to environmentally damaging activities seems particularly inappropriate in the context of increasing government expenditure and regulation to reduce environmental damage.

Most studies find that removing subsidies and tax expenditures, and recycling the revenues through reduced taxes on marginal earnings or capital investment would have a beneficial effect for the economy. However, findings regarding the social and environmental effects are mixed. Removing some subsidies would have a large environmental benefit, while removing others might lead to increased environmental damage, in the absence of additional environmental regulations or charges.

Interest in removing subsidies stems from many areas of government policy. Removing energy subsidies could further policy objectives such as: reducing greenhouse gas emissions and other environmental effects of energy use, increasing flexibility in the energy sector, increasing economic growth, improving the targeting of employment and other social/economic policies, improving the conditions for and benefits of international trade and reducing government spending or increasing revenue. Removing transport subsidies could help achieve such objectives as reducing greenhouse gas emissions and other environmental and social effects of road transport, bringing about a more efficient allocation of roads and urban space and reducing government spending or increasing revenue.

1.3 The OECD project

It is unlikely that environmental concerns will have much influence in the short term on the trend towards subsidy reform, which is already underway in many OECD Member countries for economic reasons. However, depending on the implications of subsidies for the environment, environment policy-makers might wish to add their voices to those arguing for

Box 1.1: **Policies that can be interpreted as "supports" or "subsidies"**

I. DIRECT PAYMENTS THAT SUPPORT CURRENT PRODUCTION

- Deficiency payments (grants to cover losses) and operating subsidies to producers
- Consumer subsidies provided via retailers
- Price premiums

II. TAX POLICIES

- Preferential treatment under the general tax code
- Exemption from excise tax
- Tax credits
- Preferential treatment in local rates and franchise fees

III. POLICIES THAT REDUCE THE COSTS OF INPUTS AND COMPLEMENTS

- Budgetary subsidies to inputs and complements
- Price controls for inputs and complements
- Land expropriation for roads, plant sites

Investment subsidies

- Equity participation
- Loans at preferential rates
- Loan guarantees
- Habitual debt forgiveness
- Infrastructure financing
- R & D funding
- Liability guarantees (sometimes combined with rate-of-return controls)

IV. POLICIES THAT CREATE TRANSFERS THROUGH MARKET PRICES

Trade policies

- Import and export taxes and subsidies
- Non-tariff trade barriers, e.g. import and export quotas; procurement preference

Domestic energy and related policies

- Procurement preference
- Managed non-commercial contracts
- Energy planning
- Price regulation (ceilings, floors, rate-basing)
- Protection for monopolies

reform, or perhaps to re-examine environment policy in the light of ongoing subsidy reform processes.

In 1992, the OECD initiated a project on "Environmental Implications of Supports to the Energy Sector", aiming to identify "win-win" opportunities where removing subsidies would lead to both environmental and economic benefits. The project also aimed to develop insight into the advantages and disadvantages of different methods for assessing the environmental, economic and other effects of energy subsidies. A steering group consisting of experts from most OECD Member countries on the energy sector and economic modelling was convened, and included analysts who had already carried out studies of subsidies and the effects of their reform. The project steering group decided to proceed by first commissioning a scoping study, and then carrying out a series of case studies examining subsidy reforms in specific sectors of individual countries. As some of these case studies addressed transport subsidies, the title of the project was broadened in 1995 to "Environmental Implications of Energy and Transport Subsidies".

This publication, the final report of the project, aims to provide information to environment policy-makers and policy analysts on the potential for removing or reforming subsidies, the possible environmental and economic costs and benefits of doing so, some possible approaches to assessing and carrying out policy reforms, and areas where further research and analysis are needed to develop a better understanding of these issues.

1.4 Defining and measuring subsidies

The OECD project started with a "scoping study" (PHB, 1993), which raised an issue that has resurfaced repeatedly throughout the project and in other forums: what is a subsidy? In practice, the answer depends on the reason for asking the question:

1. If a government wishes to remove subsidies because they are a drain on the budget, it makes sense to look at grants, tax exemptions, and various forms of investment support.
2. If the motivation for removing subsidies is related to removing distortions in the economy that might deter the efficient use of resources, or that might act as barriers to trade or market entry, it might be more useful to look at the overall effects of policies on energy or transport prices. Several studies (e.g. Larsen and Shah, 1992; Burniaux *et al.*, 1992; Gurvich *et al.*, 1996) use a definition of "subsidy" based on the prices of goods and services, where the existence and size of a subsidy are indicated by the divergence between actual prices and the "reference" prices that would obtain in an undistorted market[1].

These two views lead to a fairly long list of the kinds of government intervention that might be classed as subsidies or supports to energy production and consumption. A list is provided in Box 1.1. The most obvious subsidies of the first type above (budgetary subsidies) can be seen to fall in the first three categories in Box 1.1 although import tariffs and export subsidies (in the fourth category) also have budgetary implications. All of the policies in the Box can be considered to fall under the second type (market distortions).

Although this list includes most of the types of policy that could reasonably be thought to have a "subsidising" effect, the OECD project failed to find a list that would satisfy all members of the project steering group. Some of the group debated whether all of these policies should be included in a list of subsidies; furthermore, a few policies sometimes described as subsidies are left out. In particular, the list excludes some types of government expenditure that are not linked to levels of production or consumption, such as one-off debt forgiveness and payments for redundancy and retraining when industries are being restructured. Some members of the OECD project steering group also argued that governments' failure to internalise environmental and social externalities should be considered as a form of subsidy: activities that cause external costs are supported by the failure to internalise those costs. The various policies are considered in a little more detail below.

1. The greatest difficulty in this case is in deciding what is meant by an "undistorted" market. For commonly traded goods such as oil, world market prices are often taken as the "undistorted" level. For goods that are traded less, such as electricity, "undistorted" prices are often based on those in a country thought to have relatively intervention-free markets. However, such reference prices are sometimes distorted. Furthermore, it is very hard to distinguish between deviations from "undistorted" prices that arise from government policies, and deviations that arise from other local circumstances.

1.4.1 Direct payments to producers or consumers

Direct payments from government to producers or consumers are the most obvious form of subsidy and are easy to measure. Payments to producers tend to reduce market prices, while payments to consumers tend to increase them. Subsidies to inputs and complements are often harder to identify on a comprehensive basis. Subsidies to inputs have the same effect as payments to producers, while subsidies to complements have the same effect as subsidies to consumers.

In the energy sector, subsidies have often been provided by OECD governments for public sector industries, including electric and gas utilities and coal producers. In the transport sector, roads are usually built using public funds, and many services related to roads (policing, maintenance, cleaning) are provided by local or national governments.

Cash subsidies to producers will reduce product prices, whereas subsidies to consumers tend to increase product prices. The volume of the subsidised good produced and consumed tends to increase in either case. However, where subsidies are provided to producers or consumers in a market that is very open to trade, prices may not be visibly affected. In that case, the main effect is to change the quantities produced by the subsidised producers, or consumed by the subsidised consumers.

In identifying existing subsidies, some of the case studies have attempted to distinguish between regular, ongoing payments linked to current production and consumption, and one-off payments associated with past production and consumption. Thus, they have included ongoing annual payments to coal producers to cover operating losses, but excluded payments made in settlement of disability claims by ex-miners. This distinction is somewhat ambiguous, because in some circumstances, the ex-miners worked for companies which still exist, and which would normally have been liable for health damages. In this case, payment of damages would have raised those companies overall costs and would have been reflected in the price of current production.

1.4.2 Tax expenditures

One of the largest sources of support provided by governments to both producers and consumers takes the form of "tax expenditures" – exemptions, rebates or reductions in the tax rate for particular individuals or firms, or for producers or consumers of particular goods. Tax expenditures are much harder to define and identify than cash subsidies. Their definition depends on determining a reference tax rate, which is not necessarily the "normal" tax rate. For example, many countries have a "normal" rate of sales tax, but tax electricity consumption at a lower rate. Yet, that lower rate may be a standard rate for a certain type of goods – e.g. residential fuels or other "essential needs". It is not obvious whether the reference tax rate should be the higher rate, the lower rate, or somewhere between the two.

Tax expenditures can have an environmental impact where the tax rate varies between fuels, different types of energy-using equipment or different types of transport. Similarly, if energy-efficient equipment or insulation materials are taxed at a higher rate than energy, there is a distortion that will tend to reduce investment in energy conservation and increase energy consumption. Thus, the most important questions relate to the relative taxation of substitute goods.

Within the case studies, differential rates of taxation have been considered most systematically for the transport sector. In the transport case studies, the normal rate of sales tax is taken as the reference tax rate for vehicles and fuels. Actual tax rates in this sector are generally higher than the normal rate; the difference is treated in the studies as payment to redress government spending on transport infrastructure and services. Differential rates of taxation are also important in some of the energy and electricity sector case studies, which consider a wide range of policies including tax exemptions for utility bonds and accelerated capital depreciation for tax purposes, as well as reduced tax for residential consumers.

1.4.3 Policies that create transfers through market prices

Several studies (e.g. Larsen, 1993; Burniaux *et al.*, 1992) use reported domestic prices as the main indicator of the existence and size of subsidies. Where energy price levels in a country are below world market levels, or below the levels commonly found in other countries, this is taken to indicate the presence of a subsidy. This form of "subsidy" is particularly common in energy markets in developing countries and countries with economies in transition, and has been common in the past in OECD countries where prices were controlled by governments in one way or another, usually for social or political purposes. Price controls such as these act as consumer subsidies, but unless some recompense is provided to producers, they act as producer taxes.

In OECD countries, it is perhaps more common now for prices to be supported, rather than suppressed. Governments use a variety of mechanisms to protect the markets of domestic producers, by setting up barriers to trade and competition, or by purchasing their excess produce. These measures have been best documented in the agriculture sector, but are also used to protect coal producers, electric and gas utilities, car manufacturers, freight hauliers and airlines.

Non-budgetary supports of this type may apply to markets for consumer goods, or markets for the inputs that produce those goods.

Price controls can also result in cross-subsidies among consumers. Electricity prices are usually set with some involvement from the government or a regulatory body, rather than being freely determined by the market. Prices will usually be set at a level that recovers long-run marginal production costs (less any subsidy). However, even where the electric utility and the regulator aim to set prices to different groups of users at levels that reflect long-run marginal costs for those groups, they are unlikely to be able to do so as efficiently as a competitive market. This is likely to lead to cross-subsidies among consumers in different regions, among different types of consumer (industrial, commercial, residential) and among consumers using electricity at different times of day. Cross-subsidies could lead to higher or lower consumption of electricity, depending on the price elasticities of demand by the different user groups concerned.

Cross subsidies are also very important in the road transport sector, where the main instruments for recovering the costs of road provision are vehicle purchase and ownership taxes, and fuel taxes. While these taxes may be differentiated to some extent among different types of vehicle and fuel, they are very poorly correlated with the actual costs of road provision.

Where prices are regulated, it is also possible for cross-subsidies to arise among producers. While this is not demonstrated in the OECD project, it has been taken into consideration, in particular in the case study on the Italian electricity sector.

1.4.4 Failure to internalise externalities

Just as activities can be supported through distortions in market prices, they can also be supported by market failures. Several members of the OECD project's Expert Steering Group thought that governments' failure to internalise externalities should be considered a kind of subsidy. While there is no consensus on this point the transport case studies and the U.K. electricity sector case study provide estimates of externalities and consider the possible effects of their internalisation.

1.5 Measuring subsidies

It may be relatively straightforward to observe prices and direct cash subsidies. However, as the previous section indicated, supports can take many forms and their effects on prices and the quantities of goods produced and consumed may not be obvious. Larsen and Shah (1992) and Burniaux *et al.* (1992) use the difference between domestic and border prices as the metric for subsidies, but this can be a very poor indicator of the level of government support for polluting activities. In particular, it measures price supports for coal and other commodities as *negative* subsidies or taxes, whereas in fact they tend to increase domestic production and may favour those commodities over cleaner substitutes.

The OECD has developed considerable experience in identifying and measuring supports, most notably through the work of the OECD Agriculture Directorate, which produces annual estimates of the level of support for agricultural production and consumption in OECD countries. The metrics employed – the "producer subsidy equivalent" (PSE; see Box 1.2) and "consumer subsidy equivalent" (CSE) – aim to measure the effects of several of the policies listed above to the extent that they support current production or consumption. The main motivation for measuring agricultural subsidies has been concern about trade distortions. The International Energy Agency (IEA) annually estimates the PSE associated with coal in eight Member countries[2] (see, for instance, IEA, 1995*a*, 1994*a*).

As predicted by the OECD project scoping study (PHB, 1994), and demonstrated in the case studies, looking for policies that have a negative impact on the environment implies a rather different

2. Belgium, Canada, France, Germany, Japan, Spain, Turkey, United Kingdom

Box 1.2: **Producer and subsidy equivalents**

The PSE concept covers all state aid, direct and indirect, that has an effect on the current costs of, and prices paid to, domestic producers. In general, it encompasses direct government payments to support current production, indirect supports to current production, and any price support, measured as the difference between the price received by domestic producers and the price paid for imports. It is not always obvious what policies are acting as price supports. Some policies are quite transparent – e.g. import tariffs and procurement policies (such as requiring utilities to buy domestic coal). Others are less obvious, such as rate-of-return controls for utilities that affect their choice of technology and fuel, and thus can support coal production.

At first sight, the way the PSE measures 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 or 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. To identify which distortions tend to lead to environmental damage, however, one must evaluate the effects of the different measures included in the PSE, and as these can be difficult to identify, the PSE may not be a good indicator of the existence of policies that increase environmental damage. Payments from governments to producers, for example, encourage increased domestic production along with any attendant environmental damage. Similarly, flows from consumers to producers as a result of price supports tend to reduce domestic consumption, along with its attendant environmental effects. In the latter case, however, the actual net effect will depend on whether consumers are free to switch to cleaner fuel and have an interest in doing so. Often, 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).

focus from that of budgetary subsidies or producer supports: it also involves looking for policies that support the use of goods and services that tend to be polluting, or that influence the manner of production and use. This may mean that the CSE is often more relevant than the PSE. Policies that influence the choice of energy source have more effect on the environment than those that affect the volume of energy use. Thus it is important to look at *relative* subsidies and rates of taxation for different energy forms. Barriers to trade and competition (which are included in the PSE definition) can support polluting activities such as coal mining, but they can also work in the opposite direction: they can support the development of indigenous renewable energy sources, and they can also support the development of nuclear power, which produces fewer greenhouse gas and acid emissions compared with fossil fuels but which involves other environmental consequences and risks.

The case studies in the OECD project used a range of different indicators to measure the level of support to fuels, electricity or road use, including price distortions, PSEs, and net budgetary transfers to consumers or producers. No one of these indicators appears to be good at predicting the environmental impacts of government policies. There seems to be no obvious substitute for carrying out a careful evaluation of the full range of policies and market conditions that influence competition among producers and the volume of demand by consumers.

1.6 Approach and methodology for this report

Part One of this report is based mainly on the set of country case studies produced in the OECD project. The case studies, summarised in Part Two, use a range of energy market, energy system and macroeconomic models to evaluate the effects of removing various types of government intervention that can be classed as subsidies. The study also compares other relevant literature with the case study evidence.

Following the scoping study used to develop the methodology for the project, case studies were carried out to analyse environmental and economic effects of:

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

- removing a wide range of direct and indirect supports affecting the electricity sectors of Australia, Italy, the U.K. and Norway;

- removing a wide range of federal subsidies to energy production and use in the USA;

- removing direct subsidies and price controls in energy markets in Russia;

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

Table 1.1 summarises the subsidies and supports covered and the methodology used in each case study.

As the Table indicates, the studies used a wide range of methods. This mix of methodologies may be seen by some as a weakness: it rules out direct comparisons of the results for different countries and different sectors. However, the mix was partly intentional, as one aim of the project is to evaluate which methodologies might be used for more systematic subsidy appraisal. It was also necessary, because within the budget constraints of 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 and analysis.

It should also be emphasised that the intention of this project is not to rank countries according to the "goodness" or "badness" of their subsidies, but to identify promising areas for closer examination by national governments. The use of several methodologies, looking at the issue from different angles, provides some insight into these opportunities.

1.7 Scope of case studies

The case studies examine environmental, economic, employment and trade effects of removing several types of subsidy. The studies on coal, the electricity sector and the whole energy sector examine:

- Budgetary subsidies, such as: government grants towards operation, investment or R&D costs of the ESI and its suppliers; tax

Table 1.1: **Summary of case studies**

Studies	Countries	Principal Author	Type of Supports Covered	Methodology for Assessment
Coal	France, Germany, Japan, Spain, Turkey, United Kingdom	DRI, Paris office	Operating subsidies and "price supports" (prices in excess of world market prices)	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), market barriers, R&D	Bottom-up electricity generation or energy system analysis; assessment of existing market reform
Whole Energy Sector	United States Russia	M. Shelby, US EPA E. Gurvich, A. Golub IEF, IMEP, Moscow	Budgetary subsidies and price controls	General equilibrium and combined engineering/ economic models for the USA, input-output model for Russia
Road Transport	France Japan United States	J-P Orfeuil, INRETS H. Morisugi Susan Haltmaier, DRI	Net budgetary subsidies to different user groups, failure to internalise full social costs	Transport and transport energy demand models, general equilibrium model for the USA

exemptions and differential taxation of fuels and electricity; government financing at below market prices, government collateral for loans for energy supply projects, tax exemptions for bonds issued by utilities or government controls on rates of return from energy investments.

- Cross-subsidies among energy consumers, mainly resulting from charge structures that do not fully reflect the costs associated with supplying them certain groups. Most of the examples of cross-subsidies in OECD countries relate to electricity pricing. There are also instances of cross subsidies among fuel consumers, for example from power sector consumers of coal to other industrial consumers.

- Measures, or packages of measures, that result in energy suppliers receiving prices that are higher, or paying input prices that are lower, than would apply without the measures. The main category of such measures identified in the case studies are price supports for energy forms such as deep-mined coal, and measures that reduce the cost of capital.

The transport sector studies examine:

- Budgetary subsidies to the road transport sector, in the form of net excesses in government spending over receipts from users. Government spending is mainly for provision and maintenance of roads but also for services such as policing and road cleaning. Receipts from users include tolls, parking charges, and special taxes on fuels and vehicles (although these may have originated for general revenue-raising purposes rather than to provide road funds). The study excludes taxes levied at normal rates (e.g. sales or value-added taxes).

- Cross-subsidies between road users in the form of charge structures that do not fully reflect the costs associated with different types of road use or transport (urban/rural, car/truck, diesel/gasoline).

The transport case studies also explore the existence and valuation of road transport externalities and evaluate the effects of regulations, charges and other measures to reduce those externalities, or reflect them to road users through prices for fuels, road use or parking.

1.8 Structure of the report

After this introduction, the main body of the report contains two major parts: Chapter 2 explores the findings and implications of the case studies on the effects of energy supports, and Chapter 3 discusses the findings of the case studies on full cost pricing and reducing road transport externalities. Chapter 4 then briefly sums up conclusions from the study and identifies some priorities for future work in this area.

The OECD project case studies have been summarised in papers that were presented and discussed at a conference on "Environmental Implications of Energy and Transport Subsidies" in Rome, 11-12 September, 1996. These papers are included as the second part of this volume (Chapters 5-14).

Chapter 2

Energy Policy Reform

Governments of OECD Member countries often support the production of indigenous sources of energy, including renewable and other non-fossil sources as well as fossil fuels. Following the oil "crises" of 1973/74 and 1979/80, support was given in particular to alternatives to oil and to domestic production of oil, as a means of reducing demand for imported oil. The energy sources most favoured by this support have been coal and nuclear energy. Until the oil crises, coal production had in fact been shrinking as households and industry switched to cleaner forms of energy. Thus, for energy security reasons, and to protect employment in the coal industry, some governments attempted to sustain coal production, partly through direct producer supports and partly by encouraging coal consumption. Others, especially those with limited or expensive coal resources, paid more attention to developing nuclear power production capacity.

In the late 1980s, governments began to reconsider their priorities. The fall in the price of oil after 1985 meant there was no longer such an incentive to develop indigenous energy sources, and these resources were often unable to compete in the market with energy imports. The establishment of international treaties limiting transboundary pollution and the emergence of climate change as a credible political concern led to further questioning of policies that supported coal production: the acid rain precursor and greenhouse gas emissions from coal use are higher than those from most other energy sources. Nuclear support policies were also brought into question, partly on economic grounds in the face of rising nuclear costs and the falling prices of the alternatives, and partly as a result of public concern about safety, accentuated by the accidents at Three Mile Island and Chernobyl. Nuclear power and coal appear less competitive as the trend towards ESI reform spreads; privatisation and the ending of government financing and security result in higher interest rates and risk exposure, and hence higher required rates of return for new ESI investment.

Because of this background, the case studies have paid particular attention to policies that support indigenous coal production. Policies that support nuclear power have also been addressed to some extent in the U.K. and U.S. studies.

Table 2.1 summarises a few key findings of the OECD case studies along with those from some other major studies on energy subsidy reform. It should be emphasised that due to the complexity of the analyses and differences in method, the figures are not directly comparable but rather 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.

There are considerable variations in the findings, even among studies of subsidies in a given country. For the conclusions of the current project it is important to note these variations. For example, analysis of this issue has probably been more thorough and subject to more peer review in the United States than in any other country. The two analyses commissioned for the U.S. energy sector case studies give figures for total federal energy subsidies that differ by a factor of

Table 2.1: **Summary of results from OECD and other studies on energy subsidy removal**

STUDY	Subsidy or Group of Subsidies Removed	Monetary Equivalent of Distortion	Decrease in Annual CO_2 Emissions Relative to Reference Scenarios Resulting from Reforms by 2010		Other Economic Effects
		($ million, various years, 1988-95)	Million tonnes CO_2	% in Sector Concerned	
World Bank (Larsen ,1993)	Global price subsidies to consumers of fossil fuels (difference between domestic and world prices)[b]	215 000	1 366[a]	9%	Enhanced economic growth
GREEN (Burniaux *et al.*, 1992)	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	18%	Enhanced economic growth in most regions, largest in CIS. Improved terms of trade for non-OECD countries.
DRI (1997*a*)	Coal PSEs in Europe and Japan	5 800	10 (DRI estimate) >50 (OECD estimate)	1%	Job loss in coal industry, increased coal trade.
Böhringer (1995)	Coal in Germany	6 700	NQ	NQ	Nearly 1% 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 (Naughten *et al.* 1996)	State procurement/planning	133	0.3		Reduced cost of meeting CO_2 target.
	Barriers to gas and electricity trade	1 400	0.8	NQ	Reduced cost of meeting CO_2 target.
	Below-market cost financing	NQ	NQ	NQ	
Italy (Tosato *et al.*, 1996)	Net budgetary subsidies to ESI	4 000	12.5		Reduced cost of meeting CO_2 target. More effective CO_2 tax
	–VAT below market rate	300	0.6		
	–Subsidies to capital	1 500	3.3		
	–Excise tax exemption for fossil fuels use by ESI	700	5.9		
	Total net and cross-subsidies	10 000	19.2	5%	
Norway (Jensen and Vetlesen, 1997)	Barriers to trade	NQ	8 for Nordic region		
Russia (Gurvich *et al.*, 1996)	Direct subsidies and price controls for fossil fuels Price control/debt forgiveness for electricity consumers	52 000, of which 42 000 for heat & power	336 (about half due to shift from coal to other fuels, half to reduced final energy demand)	16%	1% drop in employment (but note that model included no subsidy recycling mechanism).
U.K. (Michaelis, 1997)	Grants and price supports for coal and nuclear producers Below-market required rate of return for ESI	2 500	0 to 40	0-8%	
	VAT on electricity below general rate	1 200	0.2		
USA (Shelby *et al.*, 1996)	DFI (1993) analysis of federal subsidies	8 500[c]	40	0.7%	
	DJA (1994) analysis of federal subsidies	15 400[c]	235	4%	Increase of 0.2% in GNP if revenue used to reduce capital taxes.

Notes: Subsidies are defined in various non-comparable ways: none of the figures in this table can be taken as a reliable indication of total energy subsidies in the country or region concerned.

a) Model used is comparatively 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.

NQ = not quantified

two. The estimated effects of removing these subsidies differ by a factor of six. In all countries, attempts to reform subsidies are likely to come up against disagreement among stakeholders regarding the size and effects of subsidies. Such disagreement may reflect legitimate differences of opinion that can be elucidated but not necessarily resolved by analysis.

Uncertainty in the current assessment starts with estimating the size of supports. Direct grants are usually clearly identifiable and measurable, although disputes arise over whether grants are ongoing or one-off. Tax expenditures are harder to identify, and their measurement depends on deciding on a reference level of taxation; meanwhile, some analysts may disagree on the philosophical basis for considering them to be subsidies or supports. Other forms of support are still harder to quantify. Measuring the size of the support associated with coal or electricity price controls, for example, depends on determining a reference "free market" price with which the controlled price can be compared. Estimating a reference price may depend in turn on estimating transport and handling costs, transaction costs, the responses to the risk and uncertainty associated with operating in a free market and the responses (perhaps world-wide) of suppliers and consumers to changes in price. Similar uncertainties arise in attempting to estimate the size of investment support.

The factors that lead to uncertainty in the size of the supports also lead to uncertainty in the effects of removing support. These effects depend on the response of market actors to changes in the pricing and regulatory environment, as well as upon technological developments.

The uncertainty in market analysis is such that experts are unlikely to agree on a "correct" method for estimating levels of support or the effects of removing or reforming that support. They might be able to agree on an acceptable albeit imperfect method, provided they shared a desire to find solutions to the policy challenges addressed in this study. However, opponents of change would usually be able to find flaws in any one method. An alternative for government analysis is to recognise the uncertainty explicitly, and always to use a range of indicators or methods.

2.1 Scope of the case studies

The effects of removing supports have been evaluated in different ways in the various case studies:

- The case study on coal supports uses the DRI world coal trade model along with national energy market models to investigate the effects of removing supports to coal producers falling within the PSE definition. DRI modelled the effects of putting coal prices at world market levels and eliminating grants to coal producers.

- The Australian study uses MENSA, an Australian development of the MARKAL energy sector optimisation model, to estimate the effects on energy sector costs and CO_2 emissions of reforming a few specific supports to coal use, ESI investment and electricity consumption.

- The Italian study estimates electricity sector supports and cross-subsidies in considerable detail, then uses MARKAL in a similar way to the Australian study to estimate the effects of reforming these supports and cross-subsidies.

- The Norwegian case study explores the experience of electricity market reform, including the creation of competitive electricity pool systems, since the 1991 Energy Act.

- The Russian study estimates the divergence between domestic energy prices and estimated unsubsidised prices for the residential and industrial sector in 1990 (before market reforms had progressed far) and in 1994 (close to the current situation). The study uses an input-output model to estimate the effects of a move to unsubsidised prices for fuels and electricity on industrial activity and technology, and hence on the environment.

- The U.K. case study draws on the experience of ESI and energy market reform to identify supports, most of which have been removed, and to estimate what might have occurred had they not been removed. It uses a bottom-up spreadsheet model to evaluate the effects of supports on power plant construction and deployment, and estimates changes in electricity demand using econometrically derived price elasticities.

- The U.S. studies draw on literature estimating the size of a variety of federal subsidies to fossil fuel producers, electricity utilities and energy consumers, basing the results on studies using GEMINI, an energy sector model combining engineering, bottom-up and economic, top-down features, and the Jorgenson-Wilcoxen-Slesnick (J-W-S) general equilibrium model.

While the case studies evaluate the effects of removing a wide range of energy production supports, most of the environmental benefits identified result from reductions in coal use. These reductions derive from either a reduced share of coal in the fuel mix for power generation or a reduction in the amount of power consumed. The present report therefore highlights subsidy reform focused on these two types of change: reform of support for coal use in power generation, and reform of support for electricity consumption.

2.2 Identifying supports to coal production and consumption

Coal supports have become one of the most important classes of policy for reform as greenhouse gas mitigation is incorporated into the broader set of policy objectives in the energy sector. Such supports include budgetary subsidies to coal production and use, constraints on the ESI to buy domestic coal, import tariffs and quotas, and other forms of market protection which allow domestic prices to stay above the cost of imported and other alternative sources of energy. Investment subsidies and regulation in the ESI, implying real rates of return on capital below the market rate, can also act as supports to coal use, as can differential environmental constraints on different fuels (e.g. when countries apply weaker emission standards to coal than to other fuels for large combustion plants). While it is debatable which of these should be described as "subsidies", any policy reform process with both environmental and economic objectives needs to consider the full range of such measures, as removing only one type of support may have economic benefits but no effect on coal use and its environmental impact.

2.2.1 *Coal producer subsidy equivalents*

Table 2.2 shows estimates of the effective support to current coal production in several countries, in the form of PSEs. Coal PSEs have been calculated annually by the IEA for many countries since 1988 (IEA, 1988).

DRI (1997*a*) used revised versions of the IEA's coal PSE estimates to model the effects of removing PSE-type supports. Table 2.2 indicates the share of the PSE that is made up of budgetary support, and that made up of price support. While the PSE for the United States is given here as zero, some studies (e.g. EIA, 1992) identify significant federal subsidies to coal production in the United States. These subsidies include the "percentage depletion allowance" (a tax incentive for fossil fuel extraction) and federal contributions to a compensation fund for occupational illness due to past mining.

While the effective coal producer support is clearly substantial in several of the countries in Table 2.2, the effect of removing it depends very much on the form the support takes, and also on the alternative energy sources available to current coal consumers.

Table 2.2: **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 equivalent; Mtce = million tce (1 tce = 29.308 GJ)
Source: (DRI, 1997*a*; IEA, 1994*a*)

In general, removing support is likely 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 requiring power generators to buy domestically produced fuel at higher than market prices, its removal might result in lower electricity prices to consumers, and an increase in electricity demand, which may be met by importing coal or electricity, or by switching to alternative, cheaper energy sources.

2.2.2 *Capital supports and risk protection for ESI*

Policies that result in real rates of return on capital below the market rate are discussed further below in the context of subsidies to electricity consumers. They include public financing at interest rates below the market rate, habitual debt forgiveness, tax exemptions on bonds issued by utilities, and protected monopoly status (allowing utilities to determine their prices on a historical cost basis rather than through competition in the market). Such policies may be aimed at ensuring secure and perhaps low-cost electricity supplies, but can also lead to over-investment and can bias ESI investments towards the use of coal. They influence the coal PSE where they increase demand for coal at higher than world market prices. In considering the effects of policy reform, it is important to understand how much this type of support contributes to high domestic coal prices; removing investment support may reduce the potential market for both imported and domestic coal; removing other types of price support, such as import barriers, might increase the market for coal.

The DRI coal case study did not consider the effects of removing capital supports on fuel choice, but the case studies for Italy, the United Kingdom and the United States do estimate the size and effect of some investment supports. In the last two cases, the case studies find that this type of support has a substantial influence on the environmental impact of the electricity sector.

The U.K. electricity case study notes that the required annual rate of return on public sector investments in the United Kingdom is 8%. This is roughly in line with real market interest rates, but far lower than the rates of return typically demanded on equity by private sector investors. A private sector ESI might need to achieve a real annual rate of return on new investments in excess of 11% and sometimes higher than 20%, depending on the perceived level of risk and the ratio of debt to equity used for financing. The lower required rate of return makes a public sector ESI more likely than a private sector industry to invest in coal-fired capacity rather than gas, which has higher fuel costs than coal per kilowatt-hour generated but lower capital costs per kilowatt of installed capacity. The size of this incentive to choose coal is comparable with that of the support measured by the coal PSE. Financing arrangements for the electricity sector in many countries result in similar, or larger, incentives to opt for technology with high capital costs. Such arrangements have often been justified on the grounds that high capital expenditure is needed to achieve physical economies of scale and to enable the use of indigenous, cheap or reliable energy sources, improving energy security. This implies that governments need to address failures in the markets for capital and risk. However, it is no longer apparent that economies of scale apply in power generation, as was assumed in the 1960s and 1970s. Meanwhile, concern about long-term energy security (and the environmental sustainability of energy use) could be more efficiently met through measures to internalise or reduce externalities, such as fiscal and regulatory disincentives against using unsustainable energy sources and against pollution.

2.2.3 *Uneven environmental regulation*

Coal use may be supported by environmental policies. According to economic theory, the most efficient means of reducing the environmental impacts of energy use would be through application of environmental taxes reflecting the marginal external cost associated with those impacts. Such taxes would vary according to the fuel used, the combustion technology, the location of the combustion plant and the time of operation. In practice, most governments control the environmental impacts of fuel use through emission standards and through industrial plant licensing. The extent of any support for the use of specific fuels or technologies can be considered by comparing the effects of the standards on fuel and technology choice with those of environmental taxes.

Countries with emission standards for large combustion plants often apply weaker standards to coal than to other fuels, following the "best available technology" (BAT) or "best available technology not entailing excessive cost" (BATNEEC) principles. In some cases, tighter standards or environmental taxes might have led to fuel switching from coal to gas or non-fossil sources.

Environmental constraints may also differ among plants burning the same fuel, particularly in the case of "grandfathering", where environmental standards are applied only to plants built after the standards come into force. While grandfathering may make sense in the short term in a BATNEEC framework, allowing plants built to earlier standards to be used for peak supply without retrofitting expensive emission controls, environmental problems may arise in the longer term as markets and technology change. In the USA, the current move towards liberalisation of electricity markets may lead to an increasing load factor for grandfathered plants in areas where coal is cheap (Lee and Darani, 1995). More generally, grandfathering can act as a barrier to entry for cleaner but more expensive technology, and thus can impede competition.

2.3 Effects of removing coal support

The effects of removing coal supports depend on many factors, such as the type of supports, the availability of alternative energy sources (including imported coal), the markets in which the coal is used, consumers' responsiveness to price and their ability to switch fuels. Some of these may vary considerably within countries.

2.3.1 Fuel switching

Removing support for domestic and local coal producers may lead to imports of cheaper coal, or switching to other fuels if these are cheaper. While in the past coal was the cheapest fuel for power generation in many regions, it is now much less able to compete with natural gas, which can be used in combined cycle gas turbine (CCGT) plant. CCGT has many advantages over coal-fired plant for the ESI: low capital cost per kilowatt of generating capacity, high thermal conversion efficiency, short construction time

Table 2.3: **Environmental impact of coal fuel cycle**

Source of Impact	*Type of Impact*
Coal Production	Disturbance of Local Habitat
	Solid Waste Generation
	Groundwater Pollution
	Subsidence
	Dust
	Land Dereliction
	Miners' health Problems
	Methane Emissions
Coal Transportation	Dust
	Noise and Visual Intrusion
Coal Combustion	CO_2 Emissions
	CO Emissions
	SO_2 Emissions
	NO_x Emissions
	Particulate Emissions
	Ash
	Radioactivity Release
Ash Disposal	Land Use
	Groundwater Pollution
	Dust

Source: DRI, 1997*a*

and short start-up times; and an ability to be supplied as "turnkey" plant on a modular basis. It also has environmental advantages over coal, including less land use, fewer emissions of regulated (conventional) pollutants and about half the CO_2 emissions of coal-fired plant per unit of electricity generated (Eyre and Michaelis, 1992). In parts of Europe, Australia, New Zealand and North America, where gas is available at moderate prices (below $5/GJ), the use of coal at prices above $1/GJ in new generating capacity is unlikely to continue without some form of support. 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. Until recently, concern about these factors was used as a strong argument for excluding gas from baseload power generation in many countries.

While subsidies to capital can favour investment in coal-fired plant over gas-fired plant, they can also favour investment in renewable and other non-fossil power supplies. Thus, in some countries, removing capital subsidies might lead to environmental benefits. In others, it might lead to a shift away from existing non-fossil energy sources towards fossil fuels, resulting in higher environmental damage. Non-fossil energy sources might remain economic only if such policy reforms were accompanied by other measures, including introduction of externality adders in electricity prices, direct subsidies for renewable or stand-alone power generation, and obligations for power suppliers to purchase renewable-generated electricity. This issue highlights the pitfalls of trying to reach simple conclusions about the "win-win" effects of subsidy removal.

2.3.2 *Demand reduction*

Removing domestic coal supports may result in higher or lower demand for coal. Where domestic coal producers are protected by constraints on the ESI to buy coal at more than the world price, removing those constraints may result in the ESI choosing imported coal or switching to cheaper natural gas. At lower imported coal prices, domestic coal demand could rise, while increased imports will tend in turn to raise coal prices on the world market. The size of this price increase will depend on the amount of coal imported and the supply curve for coal on the world market. The DRI (1997*a*) study on the effects of removing European and Japanese coal subsidies found that the world coal price might be about 15% higher in 2010 relative to a reference scenario in which subsidies were maintained. In this case, other regions would probably see a slowing of increase in coal demand, with more expansion in the use of other fuels, such as natural gas, than would otherwise have occurred.

Most of the environmental benefit of removing coal supports is thus likely to be obtained through effects on the fuel mix, rather than through reductions in the final demand for energy. Fuel switching could occur in the country that removes the supports, or elsewhere.

Where coal use is supported in ways that tend to reduce consumer prices, for example through capital subsidies in the ESI, removing these subsidies may increase consumer prices. On the other hand, such support is often linked to market structures (public monopoly industries) that tend to lead to inefficiencies in the ESI. In such cases, removing capital subsidies and introducing competition could lead to either higher or lower consumer prices.

2.3.3 *Environmental effects*

As Table 2.3 shows, coal use has a wide range of negative environmental effects and removing support for it might be expected to have many benefits. Environmental policy may be one of the motivating factors in reforming coal support, especially as requirements to install SO_x and NO_x emission controls increase the cost of using coal relative to other fuels.

Most of the OECD project case studies evaluate the various effects of policy reforms on energy demand, fuel and technology choice. Based on this information, reductions in CO_2 emissions can easily be calculated. Other emissions depend heavily on the technology used for power generation. Table 2.4 shows differences in emission factors for some major pollutants, for a range of fuels and technologies.

As Table 2.4 shows, policy changes that lead to the substitution of coal-fired plant by natural-gas fired CCGT can reduce CO_2 emissions by more than 50% and NO_x emissions by a factor of three to five, and can almost eliminate SO_2 emissions. Particulate matter and heavy metal emissions are also almost eliminated, although these are shown here as "not quantified" for CCGT. Switching from coal to nuclear

Table 2.4: **Pollutant emissions for baseload generating technologies**

	Large Coal	Large Coal with FGD+LNB[a]	Heavy Fuel Oil	Heavy Fuel Oil with FGD+LNB	Combined Cycle Gas Turbine	Nuclear AGR[b]	Nuclear PWR[c]
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 unit	-	-	-	-	-	-	-
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

a) Flue gas desulphurisation and low-NO_x burners.
b) Advanced gas-cooled reactor
c) Pressurised water reactor
NQ = not quantified
Source: (Michaelis, 1997)

power also achieves near-elimination of all of these emissions, but results in routine and accidental (not shown here) release of radioactive material[3].

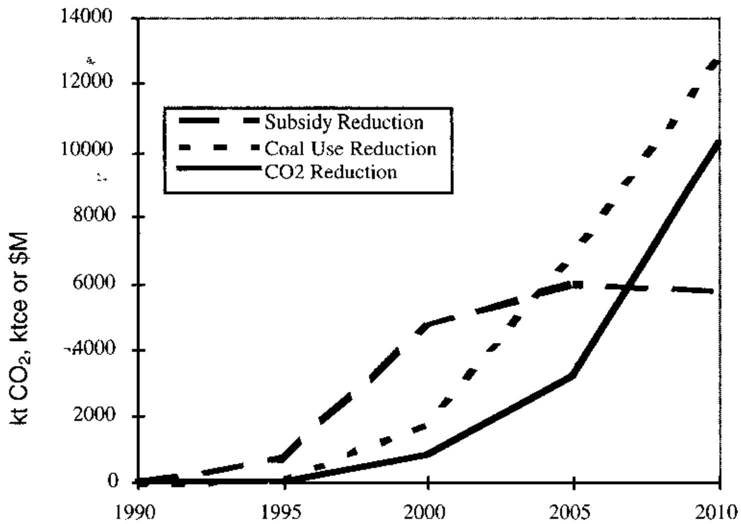
2.3.3.1 *Effects on greenhouse gas*

The case studies (DRI, 1997*a*; Gurvich *et al.*, 1996; Michaelis, 1997; Shelby *et al.*, 1994) indicate that removing support for the production and use of coal and other fossil fuels can result in reductions in CO_2 emissions amounting to tens of millions of tonnes in the main coal-using countries, while also reducing the cost of electricity production. Although the case studies do not address reductions in other greenhouse gas emissions from power generation, such reductions, mainly of methane, are likely to be larger in percentage terms than those for 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).

Figure 2.1 shows DRI's (1997*a*) calculations of reductions in subsidies, coal use and CO_2 emissions for the six countries modelled in that study. Total coal consumption decreases in all countries that remove subsidies except France, which increases coal consumption to export power to Germany. The total reduction in coal use amounts to about 13 Mtce. At the same time, electricity demand increases. Additional demand, and the gap left by the reduction in coal-fired generation, is met by natural gas-fired CCGT.

3. Coal combustion also results in the release of radioactive material. This has not been quantified in Table 2.4.

Figure 2.1: **Reductions in subsidies, coal use and CO_2 emissions for six OECD countries**



Source: DRI, 1997*a*

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 using the five-year own-price elasticity of coal demand in industry, which is calculated by the IEA (1994*c*) as -0.23, and the IEA's (1995*c*) projection for North American solid fuels used in power generation and industry in 2010, which is 612-667 Mtoe (26 to 28 EJ). The reduction in coal use can be estimated[4] as 0.82-0.89 EJ. This in fact entails a reduction in the projected increase in coal use from 1990 to 2010, rather than a net decrease. CO_2 emissions associated with this coal use at 88 Mt/EJ would have totalled 72-78 Mt. Assuming that North American utilities build gas CCGT plant instead of coal-fired plant, the greenhouse gas emissions avoided in 2010 would be about half those associated with the reduced coal burn: 36-39 million tonnes of CO_2, or roughly four times more than the DRI estimate for Europe and Japan alone. Longer-term effects would be larger: IEA (1994*c*) estimates the 15-year elasticity of industrial coal demand in the United States at -0.39. The effects of coal price increases on consumption in non-OECD countries might also be significant, but these cannot be estimated for the current study. Based on the DRI study it does appear 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 50 million tonnes by 2010.

The time-frame for emission reduction as a result of policy reform depends to a large degree on the replacement schedule for electricity generating plant, which may itself be influenced by changes in policy. Removing investment supports may lead to slower replacement of capital stock, keeping inefficient or polluting plant in use. Removing supports to electricity consumption may also reduce demand growth, again probably meaning less plant construction[5]. The effects depend on the nature of the existing stock, the level of capacity reserve and the way removing the supports affects demand. In the United Kingdom, where little power station construction or environ-

4. $E'=E(p'/p)^{\eta}$, 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.

5. In most cases, however, a major aim of policy reform in the electricity sector is to reduce electricity prices, which is likely to lead to faster demand growth.

mental upgrading occurred during the 1980s, removal of coal supports in the late 1980s and early 1990s, along with increasing environmental constraints, led to construction of several new CCGT plants (Michaelis, 1997). Investment in CCGT, along with long-term contracts for cheap gas supplies, appeared to generating companies to be more cost-effective and less risky 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 plants, but there may be no need for new construction for some time if reforms lead to more efficient practices and higher load factors in existing plants (Lee and Darani, 1995; Böhringer, 1995). Subsidy reform initiated in 1997 would be likely to have relatively little effect on emissions in 2000-2010, although substantial results could be seen by 2020 when growing electricity demand and plant obsolescence necessitate new investment. The long-term effects depend on the availability of moderately priced natural gas, reductions in the cost of renewables, technical developments to reduce the environmental impact 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 reduction depends heavily on national circumstances. It may also depend on concurrent implementation of other market reforms, including institutional reform of the ESI, and the concurrent introduction of measures to reduce and internalise the environmental impact of power generation. The case studies show that the greatest environmental benefits occur where subsidy reform is accompanied by other environmental policies. Removing subsidies and other distortions can accelerate the effects of those policies. In the cases of Australia, Germany and Italy, removing coal support and barriers to competition from other fuels results in lower costs to meet a CO_2 constraint, or enhances the effectiveness of a CO_2 tax. In some cases, the effect on CO_2 emissions is doubled, or the cost of abatement halved, for taxes and emission constraints of the order of magnitude required to return emission levels in 2000 to 1990 levels.

2.3.3.2 *Acid gas emissions*

Three of the case studies (DRI, 1997*a*; Gurvich *et al.*, 1996; Michaelis, 1997) estimate the effects of subsidy reform on acid gas emissions from the ESI. These estimates must be treated with care, as changing market conditions may not affect SO_x emissions where these are capped by regulations. Nevertheless, where regulations are not enforced, or where actual emissions are lower than the regulated limit, policy reforms can have an effect on SO_x emissions.

As Table 2.4 showed above, CCGT plants have negligible SO_x emissions and their NO_x emissions are likely to be 70-80% lower than those of coal-fired plant, except where the latter uses selective catalytic reduction (SCR) of NO_x. Switching from domestic to imported coal would also have a substantial effect on SO_x emissions in some countries, notably the United Kingdom and Spain, where domestically produced coal has a relatively high sulphur content (see Table 2.5). DRI (1997*a*) finds that SO_2 emissions in 2010 would be 0.5 million tonnes lower than in 1990 in the United Kingdom, and nearly as much lower in Spain, as a result of subsidy removal.

Michaelis (1997), assuming that SO_x and NO_x emissions would in any case be limited by regulations in a "with subsidies" scenario, finds that the effects of coal subsidy removal and ESI reform on these emissions in the United Kingdom are not so clear-cut. It is true that emissions of both pollutants were quickly reduced in the first half of the 1990s by the rapid switch from coal to gas. If coal support had been maintained, sulphur emissions would probably have been reduced more slowly, but they might have reached a lower level by 2010 than is now anticipated. This might have occurred as a result of: a) the fitting of FGD to a higher proportion of existing coal-fired power stations, and b) a higher rate of investment in new generating technology with lower emission factors, possibly including advanced coal technology and nuclear power.

2.3.4 *Economic, employment, environmental and trade effects*

A key issue to be addressed in the process of reform is the choice of new measures to replace existing policies. If budgetary subsidies or tax expenditures are removed, the government will have more funds at its disposal. The effect on the economy of removing the supports depends very much on how the government uses any funds saved. The way these funds are used is likely to depend partly on the original reasons for the support, 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

Table 2.5: **Sulphur content of coal**

Coal Exporter	**Sulphur Content (% wt)**
Australia	0.3-1.2
United States	0.2->4 (low-sulphur grades widely available)
Canada	0.2-0.5
South Africa	0.3-1.0 (export grades)
Colombia	0.4-0.8
Venezuela	0.6
Indonesia	0.1-0.9
Poland	0.8-1.8
Czech Republic	1.0-2.0
CIS	0.3->4.0
China	0.2-1.0 (export grades)
Coal Importer	
Germany	0.7
Spain	1-7
United Kingdom	1.5-2.0

used to reduce taxation elsewhere in the economy or to reduce government debt. While the last two options can provide an economic boost, they may not be effective in addressing the broader range of government policy objectives. There may be strong political reasons for the government to maintain spending but shift its focus, or establish alternative subsidies temporarily, to facilitate transition in affected industries and regions. These issues are not explored in any detail in the OECD case studies, and thus represent an important area for additional analysis.

2.3.4.1 *Changes in cost and effects on the economy*

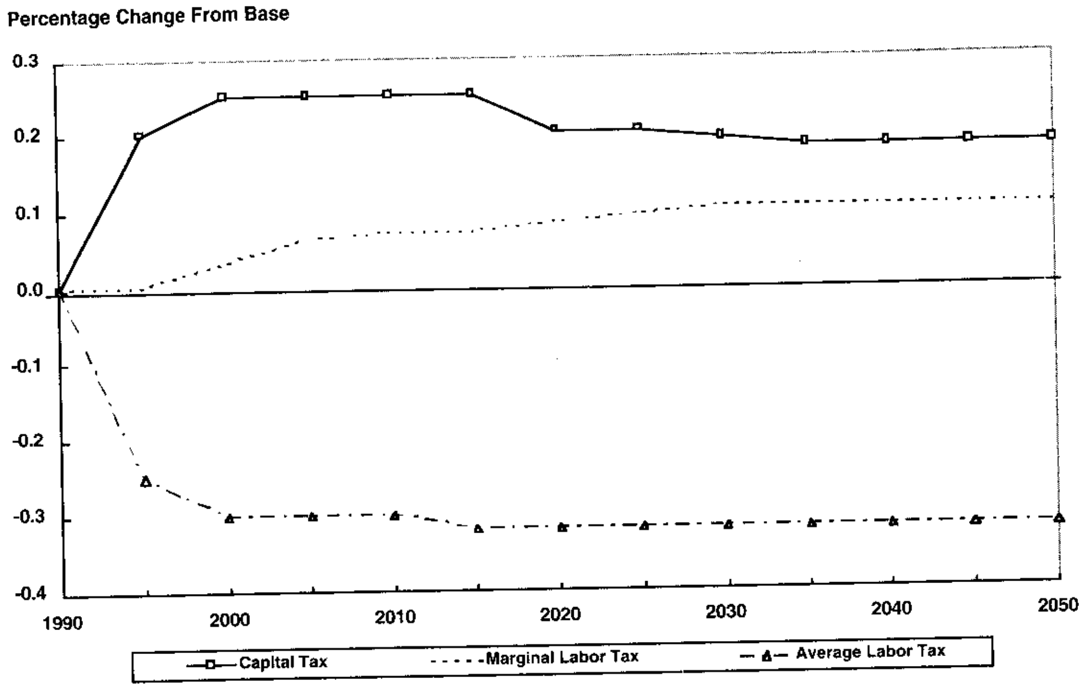
Support to coal production usually involves either excess payments from the government or measures that constrain consumers' choice of fuel or technology – sometimes both. Where such support is removed, government expenditure may fall, allowing for reduced taxation or increased expenditure in other areas; and electricity prices may fall, enabling consumers to use more electricity and spend more on other goods or to save more. Whatever form the support takes, its removal is likely to create alternative opportunities for consumption and investment. This new consumption and investment could lead to an increase or a decrease in economic growth, depending on the pattern it takes.

The OECD case study on the removal of U.S. federal energy subsidies included the results of modelling to investigate the effects of recycling funds into various types of general tax reduction. DJA (1994) finds that, where the U.S. government uses reduced expenditure on subsidies to reduce *average* tax on earnings, GDP falls (see Figure 2.2); 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 the GDP changes are very small. Welfare disparities among regions and household types increase where the government reduces average tax on capital or earnings, but decrease where it reduces marginal tax on wages.

2.3.4.2 *Employment effects*

A key reason that governments support coal production is to maintain employment in coal mining communities (Böhringer, 1995). Removing support would generally result in reduced employment in the coal industry (DRI, 1997*a*), although this may not

Figure 2.2: **Effects on GNP of subsidy recycling mechanisms, United States**



Source: DJA, 1994

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. Whether this leads to higher consumption of domestic or imported coal depends on several factors, including the price of the substitutes. In some instances, introducing 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 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 support for an uncompetitive sector, and reducing the taxation burden on competitive sectors, is likely to increase employment in the latter. The OECD case studies did not evaluate the potential extent of this effect; it is an important area for further research.

2.3.4.3 Trade effects

Trade objectives constitute a major reason for coal policy reform, and have played an important role in the case of agricultural subsidies. Many countries that have low-cost coal production and wish to increase coal exports advocate the removal of coal support in potential importing countries. Certain patterns of reform, such as removing requirements to buy domestic coal but maintaining investment supports and grandfathering of 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 gases would depend on many factors. These include the age structure of coal-burning plant in the consuming countries and the price elasticity of coal production in exporting countries. As discussed above with regard to the United States, coal demand in some non-subsidising countries could fall as world coal prices increase. It is also possible that demand would increase in countries that remove coal price supports (i.e. allow domestic prices to fall to the level of import prices). Overall effects depend on local options for power generation and their relative economics.

More general subsidy reform might not benefit coal exporting countries. In the United Kingdom, the ESI has switched away from coal use towards natural gas CCGT following policy reforms; the same might occur elsewhere in Europe (Newbery, 1995) and possibly in North America in the long term. However, trade in other energy forms, especially gas and electricity, might increase. The effects of this increased trade on the environment might vary locally, with some regions negatively affected and some positively affected, depending on the patterns of energy supply favoured by the reforms.

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

2.4 Identifying supports to electricity production and consumption

Supports to electricity production and consumption can include a wide variety of measures that reduce the costs of electricity. For example:

- the application of taxes and duties below the general rate for electricity consumers, or for the ESI;
- subsidies to capital, such as government loans and equity, or limited ESI liability for risk;
- regulations limiting the rate of return the ESI can achieve on capital;
- subsidies and cross-subsidies for rural and remote electrification and electricity consumption;
- regulation or subsidies that keep electricity prices below their long-run marginal cost for some or all consumers;
- preferential contracts between a state-owned ESI and energy-intensive industries, such as aluminium smelters.

Such supports tend to lower either the cost of supplying electricity or the electricity price for certain consumers, thereby increasing the amount of electricity consumed. Many of the measures also tend to distort the conditions faced by the ESI, encouraging technology choices that would have not been made in an undistorted market; just as it has already been observed that subsidies to capital encourage the choice of capital-intensive technology, support of rural electrification may encourage grid extensions where remote generation would have been cheaper.

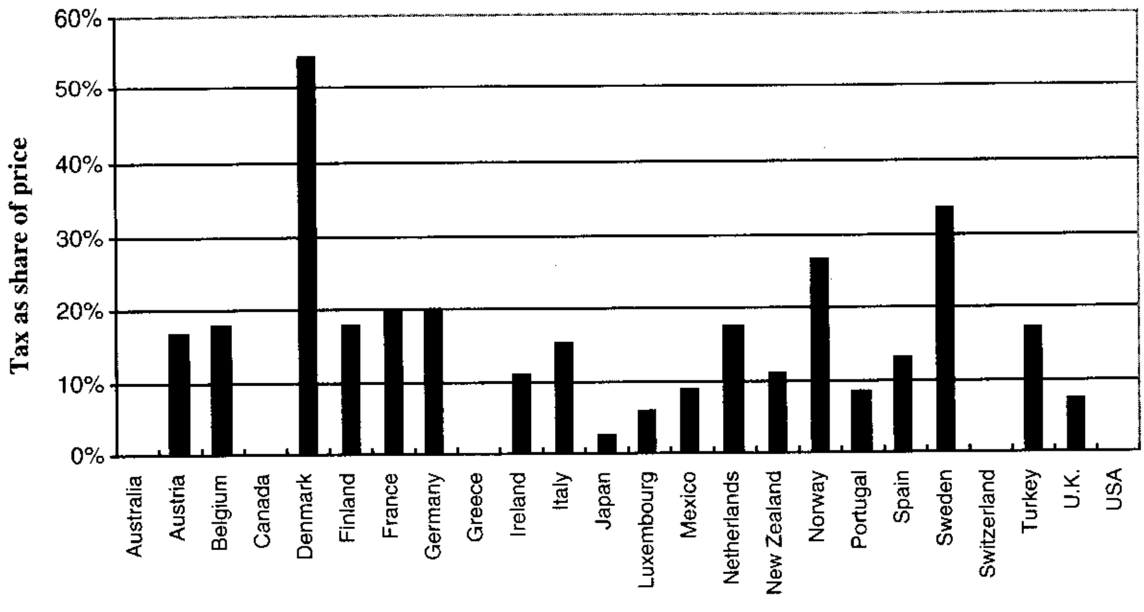
One or more of the measures listed above have been identified in each of the case studies on Australia, Italy, Russia, the United Kingdom and the United States. In most of these countries, support is provided for remote electricity supply. Consumer subsidies are largest in Russia, where residential electricity prices are far below their long-run marginal cost, but they also exist in one form or another for all the other countries. In addition, Australia, Italy and Russia have at least some cases where large electricity consumers, such as aluminium smelters, benefit from electricity prices below the opportunity cost of supply.

To some extent, as mentioned earlier, electricity consumption subsidies may be offset by other supports 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, much higher capacity planning reserves than would be found in a competitive market, and have high power generation and distribution costs. Such inefficiencies became apparent as a result of the introduction of competition in Norway and the United Kingdom. The current ESI reform 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, consumer prices do not necessarily increase, and may even fall in some countries.

2.4.1 Taxes and duties below the general rate

Figure 2.3 shows household electricity taxes as a percentage of electricity prices in OECD countries. Several countries, including Italy and the United Kingdom, impose VAT on most consumer goods and services, with a reduced level for certain items,

Figure 2.3: **Household electricity tax as percentage of price in OECD countries in 1994**
(IEA statistics)



including residential electricity. The OECD project scoping study (PHB, 1993) identified reduced VAT or sales tax for residential electricity sales as a subsidy. Some economists would disagree. Governments have often exempted goods from sales tax because those goods were viewed as essential and a sales tax on them would fall disproportionately on low-income households. Examples are food, children's clothes, housing and energy. Recently, the trend in many OECD countries has been to reduce income taxes but increase sales taxes. Within the European Union, tax harmonisation has involved moving towards flat sales taxes for all goods. In this context, especially where alternatives to residential electricity use (notably, energy efficiency investments) are subject to sales tax, exemptions from sales tax can be viewed as support to electricity consumption (tax expenditures). For the purposes of this study, it is not important whether such exemptions are called subsidies.

2.4.2 Support to investment, risk limitation, rate of return controls

Governments have used a wide range of mechanisms to encourage the development of electricity infrastructure and to keep down the prices charged by what is usually a monopoly supplier. Perhaps the most obvious mechanism is provision of equity for ESI investment. Governments also provide loans at below-market interest rates, allow utilities to issue tax-exempt bonds and use a variety of other mechanisms to enable utilities to obtain cheap capital. A range of capital subsidies or support to investment is used throughout the OECD.

An even more common practice is limiting of ESI exposure to the risk that investments may later prove to have been unnecessary or misguided. Risk limitation generally occurs through the existence of monopoly franchises – in most countries, electricity utilities have the sole right to supply consumers in their region or in the country as a whole. What this usually means is that the utilities are able to obtain loans at low interest rates because they are less likely to default than more competitive firms, and thus represent low risks for lenders. Interest rates affect the construction choices of the utilities, as does the low level of risks in itself. In a competitive market, utilities would be compelled to manage their investment to allow for the risks that technology might not function well as expected. In addition, they would have to anticipate that fuel prices might change unexpectedly or that environmental regulations might change.

Rate of return controls have been used in the United States as one of the main measures to regulate monopoly utilities. Utilities are allowed to recover capital expenditure through rate-basing – incorporating a price increment into electricity tariffs on agreement with the state regulator. The increment is generally set so as to limit the real rate of return on utility shareholder equity to around 6-8%. While such a rate of return may be acceptable to equity holders seeking secure investments, it is far below the rates typical for equity investments in competitive private sector industries. It has long been recognised that rate of return controls can provide an incentive to overinvest and favour capital-intensive technology. The demand-side management movement in the United States was partly a response to such distortion, with regulators requiring utilities to consider the demand-side (and supply-side) alternatives to new construction.

Although support to investment, risk limitation and rate of return controls are often aimed at developing efficient electricity systems and reducing electricity costs, such support may actually tend to raise electricity costs. In particular, the limitation of risk through protection of the ESI as a public sector monopoly and the use of rate of return controls lead to inefficiencies, visible partly in high capacity planning margins. Such inefficiencies are apparent in the Norway and U.K. case studies, and have also been recognised in the ESI reform under way in the United States.

2.4.3 Subsidies for remote and rural electrification and price regulation

The case studies on Australia, Italy, Russia and the United States identified support to remote or rural electricity supply. This support can be financial, as in the case of the provision of low-interest loans for rural electrification co-operatives in the United States, or can take the form of regulations, such as the Italian requirement that the state utility ENEL supply electricity to remote areas at the standard tariff. Such subsidies are generally conceived as social measures, with the aim of ensuring that all households have access to electricity. Frequently, however, support for remote electrification results in extensions of grid supply where stand-alone supplies would have been cheaper. In some instances the cheapest option for stand-alone electricity supply would have been based on renewable energy sources and/or co-generation. Meanwhile, social support might be more cost-effectively provided through financial transfers to low-income households than through a general cross-subsidy from urban to rural households.

Price regulation is common in electricity markets because of the monopoly nature of most utilities. However, the level of price regulation generally depends on negotiation and arbitration, which can sometimes lead to regulated price levels that are politically expedient rather than economically efficient. Countries, and regions within countries, vary in the extent to which stakeholders are involved in price negotiations. Thus, in some countries (e.g. Russia), prices are determined by government-appointed committees, while in others (e.g. the United States), they are determined through a public hearing process. Governments or ministers often play a key role in price setting. Consumers may have explicit influence on prices through representation at public hearings, or implicit influence through politicians' need to maintain popularity.

Considerable prior inefficiencies were revealed by the processes of price adjustment in the United Kingdom and Norway following market reforms in those countries. Parts of the ESI that had previously been subject to no competition and little public scrutiny achieved cost reductions as large as 50% following market reforms. However, it is impossible to tell what prices would obtain in a competitive market, if no such market exists.

Where prices are regulated, cross-subsidies are likely to exist among regions, sectors, or consumers using power at different times. In some countries, as for example in many Eastern and central European countries and the CIS, industrial consumers may pay higher prices than residential consumers even though it is more expensive to distribute power to small consumers than to large ones. On the other hand, in some OECD countries the pressure to keep industrial costs low may result in cross-subsidies from households to firms.

2.4.4 Preferential contracts for energy-intensive industry

After the Second World War, it was common in many countries for public sector industries to have access to electricity produced by public sector utilities at below-market prices. Low electricity prices are particularly important for electricity-intensive industries such as aluminium smelters, which thereby obtain an advantage in international competition. As a result of reforms associated with the tendency towards privatisation and trade liberalisation, such subsidies to heavy industry are now relatively rare, but persist in a few cases in OECD countries. One instance was identified in the case study on Australia, where an electricity contract negotiated many years ago between a state power utility and an aluminium smelter could not be re-negotiated by the state government responsible. The provision of subsidised electricity to industry is much more common in countries with economies in transition. The Russia case study estimates that electricity prices to industry in Russia are about a fifth below what their unsubsidised level would be. This represents a much smaller subsidy per unit of electricity than that for residential electricity but, given the large share of the industrial sector in Russian electricity demand, it is one of the largest single energy subsidies in Russia.

2.5 Effects of removing support for electricity

The effects on the environment and the economy of removing consumer subsidies depend on the type of subsidy and how it is removed or reformed. Estimating these effects depends on understanding how consumers are likely to respond to changes in electricity prices or to competitive electricity supply, and how the ESI is likely to behave under altered market conditions. In some instances the size of the support cannot be known until it is removed – this may be the case, for example, with regard to cross-subsidies among consumers resulting from price regulation, which can be empirically assessed only in hindsight once all consumers are supplied by a competitive electricity market.

2.5.1 Environmental effects

The case studies show that removing subsidies, where this results in higher electricity prices, 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 subsectors. Where electricity is the strongly preferred energy form for an end-use, for example in lighting or operating electric appliances such as refrigerators and computers, the effects of electricity price changes on demand are very small.

Reducing electricity demand can be expected to lead to decreased environmental impacts. The decrease can be larger than would be expected just from the average environmental effects per unit of power, because marginal power demand is usually met by fossil-fuel-fired plant of only moderate efficiency and with higher emission factors than baseload plant.

Figure 2.4 shows results from the analysis carried out by Decision Focus Incorporated (DFI, 1993) for the U.S. case study using Gemini. The figure shows the effects of removing U.S. federal energy subsidies on CO_2 emissions over the period to 2035. DFI finds that the two types of subsidy whose removal offers the largest emission reductions are subsidies to utilities: low-interest loans to rural utilities, and the tax-exempt status of municipal utilities. By contrast, they also find that removing consumer energy subsidies to low-income households (the Low Income Home Energy Assistance Program or LIHEAP) has very little effect on CO_2 emissions.

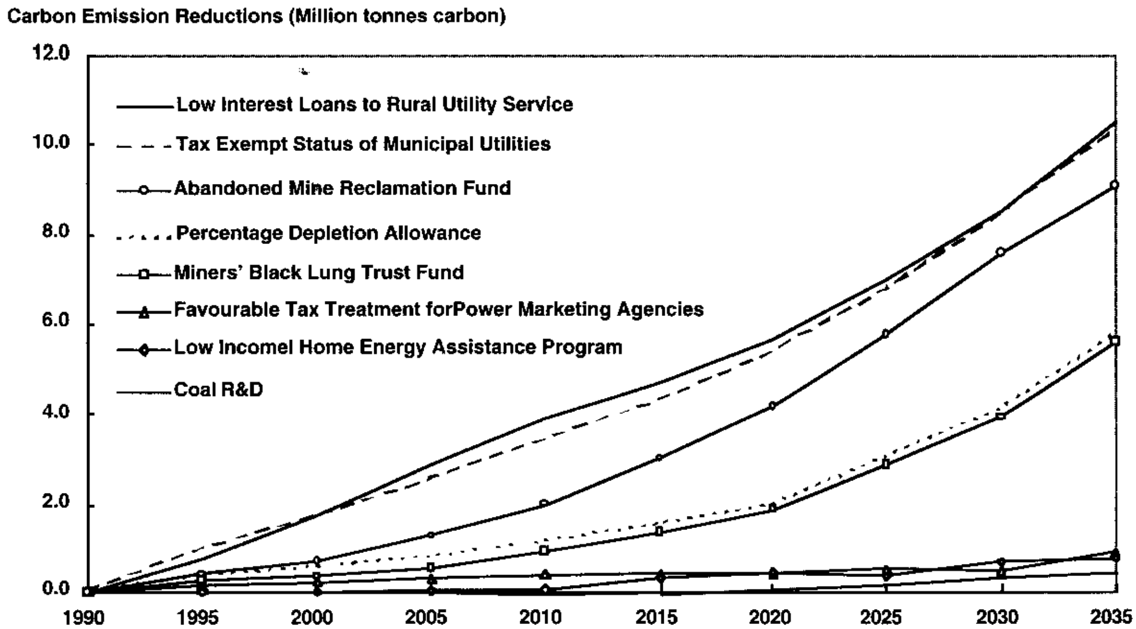
The findings of the U.K. and Italian studies are similar to those of the U.S. study in that they indicate that support to the ESI is likely to have more impact than support to consumers. In both studies, increasing sales tax on residential electricity consumption to the general rate results in only slight decreases in total electricity use, of the order of 1%. Some of the environmental benefits of this are offset by increases in consumption of other fuels. The studies calculate CO_2 emission reductions of a few hundred thousand tonnes. Removing support to producers results in emission reductions of the order of 10 million tonnes, largely because of the effects on fuel choice in the ESI.

The supports to producers with the largest environmental impact are probably those that reduce the rate of return sought from ESI investments. These supports include subsidies to investment as well as the limitation of exposure to risk and liability, and rate of return controls associated with monopoly franchises.

The effect of the ESI discount rate on technology choice is discussed above in the context of support to coal. It was noted that investment in coal-fired plant is likely to be dependent in many countries on the use of below-market discount rates. The same argument applies to nuclear power.

The protection of the ESI from risk can contribute to low discount rates. However, risk protection may also have adverse environmental effects. In the United States, Andrews and Govil (1995) find that the protection of utilities from risk may have led them to pay insufficient attention to the potential for environmental standards to tighten in the future. Utilities have been successively required to reduce their emissions of particulates, SO_2 and NO_x, and

Figure 2.4: **Carbon emission reductions from removing individual U.S. federal subsidies**



Source: DFI, 1993

may in the future need to reduce CO_2 emissions. Technical changes to coal-fired plant have been made to meet each requirement in turn, starting with electrostatic precipitators to reduce particulate emissions, then FGD to reduce SO_2 emissions, and now low-NO_x burners and SCR to reduce NO_x emissions. Each of these changes has been the cheapest at the time, but if a long-term view had been taken and utilities had aimed to minimise costs associated with possible future environmental constraints, they might have adopted different options. Andrews and Govil find that, although FGD is the cheapest option for addressing sulphur emissions alone, the combination of SO_2, NO_x and particulates is more cheaply reduced by switching from coal to gas-fired CCGT. While utilities in a competitive market are not likely to take a longer-term view than monopoly utilities, they are likely to think more carefully about risk when making investments.

The issue of protection from liability has been discussed more in relation to nuclear power than to other forms of power generation. This discussion has arisen largely because of the uninsurable nature of the risk of nuclear accidents, and the uncertainty about permanent disposal of nuclear waste and reactor decommissioning. The development of nuclear power has generally depended on governments' willingness to underwrite liabilities in these two areas. Without this support, there would be very much less development of nuclear power, with less associated pollution in the form of releases of radioactive substances. On the other hand, fossil fuel use and the associated environmental impact would be much higher.

2.5.2 *Economic, employment and trade effects*

Support to electricity sector investment can be viewed as a distortion in capital markets, tending to lead to greater investment in that sector than private, competitive capital markets would have done. Governments often provide such support intentionally, to stimulate employment and maintain activity in the construction and engineering industries. Although reducing this support might lead to job losses and reduced output from those industries, it should in principle provide a stimulus to other sectors of the economy through reduced construction and engineering costs and lower interest rates. It should also allow the economy as a whole, especially electricity-intensive industries but also the construction and engineering sectors, to become more internationally competitive. These various effects, not explored in the OECD case studies, represent an important area for future work, perhaps partly through empirical studies of industries in countries where investment patterns in the ESI have been reformed.

Support for electricity consumption is often introduced with the aim of improving the access of low-income households to electricity, or of reducing industrial costs and improving competitiveness in international trade. 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 a more expensive way to support low-income households than targeted subsidies, such as grants for home insulation for low-income households. Removing this support, and perhaps introducing a subsidy for energy efficiency improvements for low-income households, might achieve the desired benefits for those households while offering economic benefits in a variety of ways:

- budgetary costs might be reduced, a) by focusing on low-income households rather than providing a tax exemption for all households, and b) if quality-of-life improvements for those households are achieved more cost-effectively through energy efficiency investments than through tax exemptions for fuels;

- economic efficiency should be improved by reducing the distortion in energy markets for most households, and because tax levels elsewhere in the economy (e.g. marginal income taxes or the standard rate of sales tax) could be reduced as a result of the increased revenue from residential energy sales;

- there might be benefits for manufacturing industry as a result of an increased incentive to invest in energy-efficient technology, and this could result in increased employment overall, depending on the relative labour intensity of energy supply industries versus manufacturing industries.

The removal of electricity subsidies for energy-intensive industries might also offer a range of economic benefits. Where electricity subsidies are removed and the revenue is recycled through reduced taxes elsewhere in the economy, other industries' production and international competitiveness can be expected to rise. Energy-intensive industries might become less competitive in the short term, but more competitive in the long term as a result of restructuring that may be overdue.

Measures that reduce the output of energy-intensive industries are also likely to reduce employment in those industries. As in the case of coal subsidy reform, one way to address this problem is to transform the electricity subsidy into a regional employment subsidy.

2.6 Externalities of electricity generation

The externalities associated with electricity production and use are highly uncertain, partly because of technical and scientific uncertainties in quantifying the environmental effects of electricity use, and partly because of disagreement regarding the valuation of those effects.

The European Commission's "ExternE" project is one of the most comprehensive attempts to date to quantify electricity sector externalities. However, the project report (EC, 1995) notes that many externalities cannot yet be quantified, even for the specific case studies examined, and that the unquantified externalities may be larger than those that have been quantified. This means that, at present, only a lower bound can be estimated for the total external cost of electricity use.

2.6.1 Coal-fired power station at West Burton

Table 2.6 summarises the EC (1995) estimates of external damage from a coal-fired power station, fitted with FGD and low NO_x burners, at West Burton in the United Kingdom. The total of the short-term damage quantified by the study amounts to 4.78 mECU/kWh[6], although the uncertainty in this figure should be stressed. It should also be noted that no valuation has been carried out for several types of environmental and social impact. The vast majority of the quantified damage is associated with SO_x and NO_x emissions and their effects within the United Kingdom. A similar case study for a coal-fired power station in Germany finds a much larger external cost because air pollution effects are estimated over a wider area.

6. 1 Ecu in 1994 = $1.25

Table 2.6: **Coal fuel cycle damage cost estimates: West Burton**
(mECU/kWh)

Damage Range	Timescale of Damage: Short		Medium †	
Local	Public health (accidents)	0.062	Occupational health (e.g. miners' diseases)	0.107
	Occupational health (e.g. mining accidents)	0.83	Aquatic (direct emissions to water)	NQ
	Noise	0.15		
	Subtotal	**1.04**	**Subtotal**	**0.107**
	Total	**NQ**	**Total**	**NQ**
Regional	Public health (air pollution effects)	3.71	Public health (air pollution effects)	0.029
	Agriculture (air pollution effects)	0.026	Materials (air pollution effects)	1.28
	Liming acidified waters	0.0016	Forests (air pollution effects)	0.004
			Aquatic (air pollution effects on water)	NQ
			Biodiversity NQ	
	Subtotal	**3.74**	**Subtotal**	**1.31**
	Total	**NQ**	**Total**	**NQ**

† Undiscounted values.
NQ=not quantified
Source: EC, 1995

Table 2.7: **Global warming damage associated with coal-fired power generation**

Sources	Valuation estimate (mECU/kWh) at discount rate of: 0%	1%	3%	10%
Cline (1992)	14.9	–	2.2	0.6
Fankhauser (1993)	10.4		1.5	0.4
Tol (1994)	–	18.3	11.7	2.6
Hohmeyer and Gärtner (1992)	5 030	–	770	190

Source: EC, 1994

The study does not estimate costs associated with climate change due to greenhouse gas emissions in the coal fuel cycle. However, it does provide a range of damage figures based on a review of the literature on social costs of climate change, which are shown in Table 2.7. These social cost estimates, which are very uncertain and highly contentious, are based on a variety of approaches to valuation, including assumptions about the type of damage that would occur as a result of climate change, as well as the valuation of the damage. Climate change costs also depend on the actual climate effects of greenhouse gas emissions. The discount rate chosen to evaluate the present value of future damage is a subject of philosophical debate among economists.

Depending on the assumptions made, global warming damage associated with coal-fired power generation could be less than 1 mECU/kWh or more than 5 ECU/kWh. Climate change externalities in the range of \$5-125/tC (Pearce *et al.*, 1996) imply a cost of the order of 1-25 mECU/kWh for coal-fired power generation.

In sum, the total external cost of coal-fired power generation cannot be estimated except with an extremely low level of confidence, but a working value of about 10 mECU/kWh was taken for the purposes of the U.K. case study for a coal-fired power station fitted with FGD and low-NO_x burners. For power stations not fitted with this equipment, air pollution damage, which is mostly associated with acid aerosols, might be up to five times higher, assuming: a) that the value of damage is proportional to the emission level and b) that West Burton would be typical of other power station sites. This would result in total social costs of the order of 25 mECU/kWh for an uncontrolled coal-fired plant.

Given that most of the quantified externalities associated with coal-fired power generation result from air pollution, and that oil-fired generation is expected to have similar emission factors for major pollutants, this report takes the same working value for the external costs of heavy fuel oil use as for coal use.

2.6.2 *Gas-fired power station at West Burton*

Using the same methodology as for the coal fuel cycle, EC (1994) derives damage costs associated with a CCGT power station at West Burton fired with natural gas, as shown in Table 2.8. The total of short-term effects quantified is 0.64 mECU/kWh.

Table 2.9 provides the range of global warming damage estimates associated with a CCGT power station. Not surprisingly, as CCGTs have less than half the CO_2 emissions of coal-fired stations, the estimates are reduced by a factor of just over two. Taking the \$20/tC figure mentioned above, the climate change damage associated with CCGT power generation would come to about 2 mECU/kWh. Thus, an overall working value for the externality associated with generation by CCGT might be put at 2.5 mECU/kWh.

2.6.3 *Nuclear power station in France*

The EC study also evaluates the external costs of nuclear power generation in France, with separate evaluations for the costs associated with routine exposure (occupational and public) to ionising radiation, and the costs associated with rare large accidental releases of radioactivity material. It estimates the routine damage costs at 2.5 mECU/kWh without discounting, and 0.1 or 0.05 mECU/kWh when discount rates of 3% and 10% are used, respectively. The accident-related costs are highly uncertain, and depending on the accident scenario range from 0.002 to 0.1 mECU/kWh.

The study mentions that the range of results in the literature for the nuclear power externality is from 0.1 to 100 mECU/kWh, depending on assumptions and methodology.

The U.K. case study took a working value for the nuclear externality of about 1.25 mECU/kWh. The unwillingness of the private sector to take on the liability for risks associated with nuclear power indicates that insurance companies might adopt a higher valuation.

2.6.4 *Effects of removing externalities*

2.6.4.1 *Externality adders with subsidies*

The U.K. case study briefly considers the effects of introducing externality adders to the costs of electricity generation from the various fuels and technologies, using the working values for externalities discussed in the last section. Externality adders reinforce the effects of some support – notably for nuclear power – but work in opposition to other kinds, notably for coal. The large externality estimate for an existing coal-fired plant without emission controls makes this the most expensive kind of plant for baseload operation. However, it can be competitive for use lower in the merit order (at load factors below 20%), as the capital cost of new plant makes it uneconomic to operate at such low load factors. Retrofitting FGD to existing coal-fired plant is not competitive with other options in most circumstances. Under most of the "with subsidies" scenarios, nuclear power is the cheapest new baseload technology given the externality adders used here, provided load factors exceed about 70%. Even in the low-gas-price scenarios, CCGT may be more expensive for baseload than subsidised nuclear power in the early years of the period examined, 1990-2020. However, CCGT is likely to be the cheapest option for operation at load factors between 20% and 70%.

If ESI subsidies had been maintained in the United Kingdom, the introduction of externality adders based on the working values used here might thus have resulted in a very substantial shift to nuclear power and CCGT, and a reduction in emissions of conventional air pollutants and greenhouse gases. The extent of the reduction has not been quantified in the current study. It should be noted that, as mentioned above, the value used for the nuclear power externality lies below the middle of a range from the literature that spans three orders of magnitude (from a factor of 12 smaller to a

Table 2.8: **CCGT/natural gas damage cost estimates: West Burton**
(mECU/kWh)

Damage Range	Timescale of Damage: Short		Medium †	
Local	Public health (accidents)	0.0066	Occupational health (e.g. miners' diseases)	NQ
	Occupational health (e.g. mining accidents)	0.10	Aquatic (direct emissions to water)	NQ
	Noise	0.027		
	Subtotal	**0.14**	**Subtotal**	**NQ**
	Total	**NQ**	**Total**	**NQ**
Regional	Public health (air pollution effects)	0.504	Public health (air pollution effects)	0.039
	Agriculture (air pollution effects)	NQ	Materials (air pollution effects)	0.12
	Liming acidified waters	NQ	Forests (air pollution effects)	NQ
			Aquatic (air pollution effects on water)	NQ
			Biodiversity NQ	
	Subtotal	**0.50**	**Subtotal**	**0.16**
	Total	**NQ**	**Total**	**NQ**

† Undiscounted values.
NQ=not quantified
Source: EC, 1994

Table 2.9: **Global warming damage associated with CCGT/natural gas power generation**

Sources	Valuation estimate (mECU/kWh) at discount rate of: 0%	1%	3%	10%
Cline (1992)	6.4	–	1.0	0.3
Fankhauser (1993)	4.5		0.7	0.2
Tol (1994)	–	7.9	5.3	1.4
Hohmeyer and Gärtner (1992)	2 160	–	350	105

Source: EC, 1994

factor of 80 larger). A nuclear externality ten times higher than that used here would make nuclear power more costly than CCGT in all scenarios.

2.6.4.2 *Externality adders without subsidies*

The choice among generating options is strongly affected by the rate of return required on investment. In the "with subsidies" scenarios, this is set at 5% per year. The U.K. case study comments that the required rate of return for private investment in the ESI under competitive conditions may be in the region of 10-11%, reflecting risk as well as the private opportunity cost of capital. Even an increase in the required rate of return to 8%, which is the rate currently required of public sector investments in the United Kingdom, has a considerable effect on the relative costs of generating options. The relative positions of CCGT and existing (mostly coal-fired) plant are greatly improved and the relative positions of new coal and nuclear power are worsened. This shift is one of the most significant effects of policy reform in the United Kingdom. The main effect of introducing externality adders in these circumstances is to rule out the use of existing coal or oil-fired plant except at low load factors, and to rule out any construction of coal or oil-fired plant in all the fuel price scenarios considered in the case study. Thus, with subsidies removed, externality adders strongly favour the choice of CCGT for all new construction and to replace existing coal-fired plant for baseload. Existing coal-fired plant is cost-competitive with new CCGT in these circumstances for operation at load factors below about 25%.

2.7 Implementation issues in reforming energy supports

The foregoing sections have already given some indication of the original policy objectives of existing supports – usually related to employment, protection of domestic markets, export promotion and support for low-income or rural households. Removing these supports will inevitably arouse opposition from those whose interests are served by keeping them. On the other hand, there is growing international momentum on the path to policy reform, including removing supports, 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 measures such as providing 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 and using the reduction in expenditure on subsidies as an opportunity to reduce overall taxes so that the economy is more efficient and industry is more competitive.

One 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.

Many OECD Member country governments face an additional difficulty, in that supports are provided in a wide variety of forms by different levels of government. This can make the measurement of support particularly difficult. Federal governments may be committed to reforming support to energy use but have little or no jurisdiction over some policies of states or provinces.

Improved transparency may be an important first step in reforming subsidies. An initial stage might be to ensure public knowledge of the range of measures that can act as support to energy production and consumption. This might mean collecting and making available information on:

- the level of direct financial support to fuel production and supply, electricity generation, transmission, distribution: grants, deviations from the levels of taxation applied to other large companies, special rules for capital depreciation for tax purposes;
- direct financial support to electricity consumers: deviations from the levels of taxation and subsidy applied 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 the generation of electricity and for electricity transmission; also public service obligations, which require the ESI to supply 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.

While much of this information is already available in some form, collecting and collating it would require financial resources and political agreement. Assimilation and interpretation of this information can also be challenging. The OECD case studies provide some indication of what can be achieved in a variety of situations with very limited funds.

A second step 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.

International institutions might be able to play a role in facilitating policy reform where governments have an interest in this area. This might involve collecting information on support to energy production and use, and mediating information exchange and development of methodologies for assessment of policies. The IEA, OECD, FCCC and Energy Charter already collect some relevant information, and their activities could be adapted or expanded to address policy reforms of the type considered here.

While environment policy may have played a partial role in existing reform processes, it has not been the main driver. Thus, in some countries, reforms may lead in the long term to increased environmental damage caused by growing demand for cheaper energy. Avoiding this outcome will depend on co-operation among energy, environment, finance and other concerned ministries to develop strategies that address the full range of economic, social and environmental objectives.

Chapter 3

Transport Subsidy Reform

Three OECD case studies examine the effects of removing road transport subsidies by introducing full-cost pricing for road users in France (Orfeuil, 1997), Japan (Morisugi, 1997) and the United States (DRI, 1997*b*). The three countries represent the three OECD regions (Europe, Asia Pacific, North America) and have very different transport sector characteristics:

1. France has moderate population density, 105/km^2 – low relative to neighbouring European countries and Japan, high relative to North America. French cities are compact, with population density that falls off rapidly in the suburbs, and fairly high levels of public transport provision. Most passenger transport in France is by car, and car travel per person is higher than in other major European countries, but public transport use, especially of rail, is also higher than in most other countries. Freight transport in France is mainly by road, with only moderate use of rail. Both car use and freight volumes in France grew rapidly in the 20 years to 1991, with an 80% increase in car traffic. Road freight has increased while rail freight traffic has decreased.

2. Japan's average population density is 330/km^2, but most of the population is concentrated in a small portion of the land area in the coastal plains. Per capita rail use is higher than in France, while per capita car use is lower. Freight transport in Japan is almost entirely by road or by coastal shipping. Japan saw a very rapid increase in car use over the 20 years to 1991, with car traffic quadrupling. Road freight has increased, partly at the expense of rail freight, by a factor of more than two over the same period.

3. The United States is a large country with relatively low population density (28/km^2), and very high levels per capita of both passenger and freight traffic. The vast majority of surface passenger transport is by car, including in most city centres. A large share of freight in the United States is carried by the railways, although road freight traffic per person is higher than total freight per person in most other countries. Car traffic has increased over the 20 years to 1991, but by a smaller percentage than in France or Japan. Road freight has also increased, but with no decline in rail freight.

In all three countries, the road network is fairly mature. However, construction of motorways continues and is the main area of network expansion.

3.1 Scope of case studies

The studies focus on road transport, partly because most of the environmental impact of transport is caused by road users. While other transport modes are subsidised and do have negative environmental effects, the aim of the project was not to track down all subsidies, nor to identify the environmental impact of all forms of subsidy, but rather to provide an initial investigation of some key areas where the removal of subsidies and other market distortions could have large environmental benefits. Future analysis may address other modes, notably air transport.

3.2 Subsidy evaluation

The transport case studies evaluate various types of support to road use. In particular:

1. All three studies evaluate the balance between, on the one hand, spending on road building, road maintenance and road services by various levels of government, and, on the other, the level of fees and taxes paid by road users to government. The net "subsidy" for motor vehicle users in this case is the difference between the government spending for motorised vehicles and the total revenue from taxes and fees specific to motor vehicle users. The U.S. case study notes that government outlays do not represent the total economic cost of providing the road network: in particular, if the capital invested in roads is priced at its opportunity cost, this could increase the net annual subsidy to road users by up to $60 billion.

2. The French and U.S. case studies also look at some other types of distortion in markets affecting road users, and at cross-subsidies among road users. Cross-subsidies are identified in particular between urban and rural driving, between light- and heavy-duty vehicles, and between diesel and gasoline users.

3. A still wider definition of "support" includes the non-internalisation of social and environmental costs. All the case studies evaluate the level of externalities from car and truck use.

In the following, these three types of support are considered in turn.

All three case studies start by estimating the net balance of government spending versus revenue for road (motor vehicle) users in each country, as defined in point 1 above. This raises many questions about what constitutes a government expenditure to support motor vehicle use, and what constitutes a user payment. The studies are based on a common approach, assessing road-related expenditure at all levels of government and including expenditure by public companies. User payments include all special taxes and fees associated with road use and paid to government and public companies. Taxes that are not peculiar to road use, such as sales tax at the standard rate on vehicles, parts, fuel and services, are excluded. Despite this common approach, there are areas of considerable ambiguity in estimating both government expenditure and user payments. One problem area identified in the Japanese report is the component of government expenditure that supports non-motorised transport – e.g. the provision of sidewalks, paths, benches, lighting, policing and other facilities and services. Expenditure supporting non-motorised transport is rarely distinguished in road budgets from that supporting motorised transport spending. The Japanese report addresses this by considering two extremes: one where all government road-related spending is for motorised vehicle users, the other where all spending from general revenue is considered to be for non-motorised transport.

It is harder to identify cross-subsidies (point 2 above) because the disaggregation of revenue data by user group varies among countries, and it is not currently possible to identify definitively the costs imposed by different groups. The disaggregation of revenues and outlays is further complicated by the administrative structures in the countries studied:

- In France, the revenues and expenses for each category of road involve different levels of government: the nation, regions, "départements" and municipalities.

- In Japan, general road works are managed by central institutions (the Ministry of Construction, through Regional Construction Bureaux) and local institutions (local government). The toll road system is separate, and involves public and private agents (four public corporations, 20 local authorities, 36 local public corporations and a private corporation).

- The U.S. highway system is administered by federal and state agencies, as well as by nearly 39 000 county, township and municipal authorities. Jurisdiction over roads is decentralised, with about 80% of total road mileage administered at the local level.

As a result of these complexities, and despite attempts to reach a common framework, the approaches taken in the three case studies differ. The studies provide breakdowns of user fees and government spending which vary in structure and detail according to the data available.

The evaluation of external costs, which is necessary to consider the effects of the support mentioned in point 3 above, is the most difficult area. It requires many approximations, assumptions and guesses, along with economic and scientific expert judgement. In the current case studies, it has been possible to provide only limited exploration of the effects of variations in critical factors in externality estimation. Without more careful evaluation, policy based on this analysis would be poorly founded. Given the uncertainties, externality estimates used for policy purposes may depend as much on political considerations, and the results of discussion and negotiation, as on "objective" analysis.

The case studies identify government expenditures associated with road transport in 1991, estimate the external costs associated with the sector, and compare these expenditures and costs with user fees and taxes related specifically to the use of road transport. Relying on a variety of approaches, they develop reference scenarios of road traffic, its related social costs and government revenues in 2010. Finally, they investigate the environmental and economic effects of internalising the social costs for users, using a variety of policy instruments.

3.3 Budgetary transport subsidies

Transport policymakers have had to deal with increasingly serious problems, including rising levels of traffic congestion and road damage, noise, vibration and pollution. Some of these issues have traditionally been addressed through technical means. Roads are built and widened to ease congestion, and strengthened to reduce damage by heavy vehicles. Further capacity increases and safety improvements are achieved through traffic management systems and sophisticated road design. Vehicle standards are introduced to reduce pollution and noise and improve safety.

In recent years, transport ministries have been actively seeking ways to manage congestion other than through increasing capacity. In theory, the most economically efficient approach involves road-user charges based on the marginal cost associated with each additional person's use of the roads (EC, 1996*a*; Newbery, 1990). This might be expected to include the cost of road provision as well as other social and environmental costs. Full-cost road pricing and even private road ownership have been seen as potential mechanisms for discouraging driving and reducing the congestion, accidents and environmental damage associated with car and truck use. So far they have rarely been employed, however, because of political and technical difficulties in introducing efficient charging systems. This is one reason that governments try to recover the costs of road provision through relatively crude road user charges on fuel or vehicles.

3.3.1 Measuring transport subsidies

There is little argument over the basic principle that road users should pay for the services they receive, but the appropriate level of payment is often disputed. The example of the opportunity cost of capital invested in U.S. roads was given above – depending how this is counted, the cost of road provision in the United States varies by a factor of almost two. The opportunity cost of the land used for road construction is also uncertain: where governments purchase land by compulsory expropriation, the opportunity cost of the land might sometimes be higher than the price actually paid.

On the other hand, roads do have functions – military and emergency service access, for example – which, arguably, should be paid out of the public purse. Some observers have argued that the transport sector has positive externalities and so should be subsidised by government. However, it can also be argued that most of the positive externalities claimed – such as economic efficiency advantages from the mobility of goods and services, or pedestrian access to homes and services – are internalised through one market or another.

Even if the net cost of road provision can be agreed, it is not at all clear how costs should be divided among private motorists, public transport users, commercial goods vehicle operators, pedestrians and public services. Marginal costs are especially difficult to evaluate and justify in a way that all road users would accept.

Similarly, there is some question over which taxes and fees should be included in an evaluation of road user payments towards government expenditures. For example, sales taxes levied at the normal rate can be viewed as part of general taxation, but lobbyists against increases in fuel and other transport taxes frequently include sales taxes when they argue that road users already pay their full costs. Fuel duties are less obviously part of general taxation – in some countries, including the United States and Japan, they are explicitly levied to provide a road fund. In other countries, especially in Europe, fuel duties originated essentially as a general revenue-raising measure, while special vehicle taxes, registration fees, annual road taxes, etc., might be explicitly intended to raise funds for purposes associated with provision of road and road user services.

Items included in the balances for the three OECD case studies vary among the three countries, but include:

On the revenue side:

- special vehicle purchase taxes, vehicle registration fees and annual licence or other fees;
- fuel taxes;
- driver licence fees;
- charges for the use of public facilities, such as tolls and parking charges.

On the cost side:

- land appropriation, infrastructure construction and maintenance funding;
- spending on policing and emergency services;
- administration of licensing and registration systems;
- exemptions from sales taxes on fuel or vehicles for certain road users.

These balances are used in the case studies as the measure of net aggregate budgetary subsidies to road users. Revenues and spending are also disaggregated to obtain estimates of the net subsidies to different types of user. Disparities exist between: diesel and gasoline users, who pay different levels of tax in many countries; light-duty and heavy-duty vehicles, which impose very different costs in terms of road damage and road construction standards; and urban and rural road users, who impose different costs in terms of road provision.

In calculating the level of user payments to governments, the studies exclude normal levels of sales tax on goods and services. This component of road transport taxes is assumed to be part of general revenue-raising, rather than a fee related to the provision of infrastructure and services.

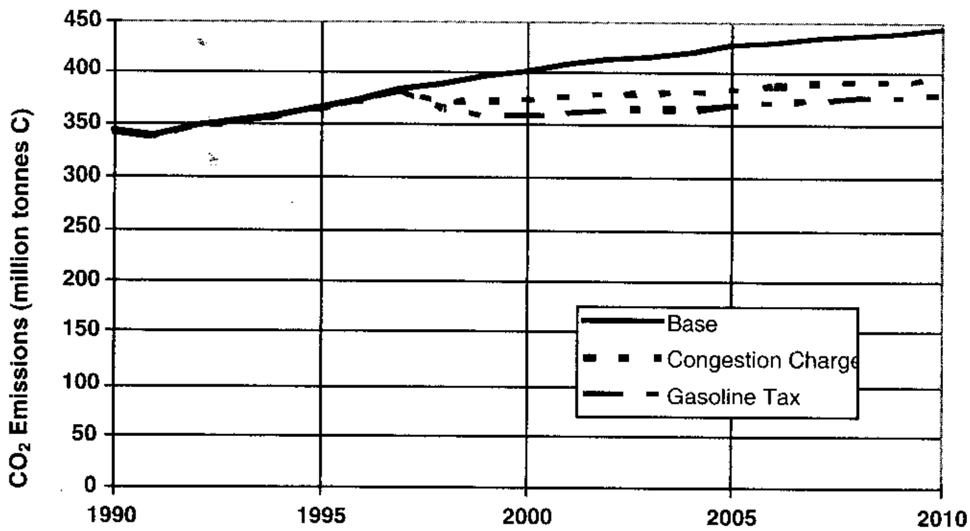
The Japanese case study tests the effects of different allocations of government spending among road users. This is particularly important for Japan, which has much lower levels of car use and higher levels of bus use than France or the United States. The shares of public spending assumed to be allocable to cars and trucks range in the case study from 64% to 100%. The remainder is assumed to be allocated to pedestrian and public transport infrastructure, utilities (electricity, gas, water, sewerage) under roads, the use of the roads by public services, etc. A fair allocation would probably lie between these two points and the figures chosen must be taken as an illustrative range.

As Table 3.1 shows, user fees in 1991 exceeded government outlays in France by about $9 billion; this excess is projected in the case study to fall to $8 bil-

Table 3.1: **Public sector expenditure vs. user fees in the transport sector**
(1991 $)

	Public Sector Expenditure					User Fees	Ratio
	Total (billion $)	% of GDP	Per vehicle ($)	Per unit of traffic ($/vkm)	Per unit of fuel ($/litre)	Total (billion $)	Fees/ public expenditure
France	19	1.6	650	0.044	0.44	29	1.49
Japan (low car/truck allocation)	57	1.6	950	0.14	0.68	72	1.26
Japan (high car/truck allocation)	88	2.5	1460	0.21	1.05	72	0.82
United States	74	1.3	400	0.021	0.16	59	0.79

Figure 3.1: **Effects of road user full-cost pricing, United States**



Source: DRI, 1997*b*

lion in 2010, on the assumption that fuel taxes do not increase (in fact, fuel taxes in France have increased since the study was written). In Japan, the position is less clear. If the definition of government expenditure on behalf of car and truck users includes all aspects of road spending, these road users received a subsidy of $16 billion in 1991, and it is projected to increase to $24 billion in 2010. However, using the lower estimate, where 64% of government road spending is allocated to car and truck users, the study finds that these users paid an excess in taxes of $15 billion in 1991, rising to $18 billion in 2010. Finally, the U.S. study finds a net subsidy to road users of $15.5 billion in 1991, rising to $25.5 billion in 2010[7].

When the costs of road provision and the user fees are disaggregated by type of user, the picture changes somewhat. Diesel vehicles in Japan do not pay their full costs, because the diesel fuel excise duty is lower than that for gasoline. For France, Orfeuil (1997) carries out a very detailed analysis of the net subsidy to different types of road user. Although he finds that most users pay more in tax than they cost the government, gasoline users pay an excess of FF 51 billion (about $10 billion in 1991 dollars), while diesel users pay very little excess. He also finds a very substantial difference between urban and rural road users, with rural users paying a much larger excess (FF 39 billion) than urban users (FF 13 billion). Urban diesel users, especially light vans and heavy trucks, pay less in taxes than they cost in road expenditure.

3.3.2 Environmental effects of user fee road funding

As noted above, French road users already pay the full government costs of road provision. Japanese road users may also do so, subject to the uncertainty about the allocation of the road budget among road users. For the United States, where road user payments fall short of government road spending, the case study investigates two alternative "full user fee funding" scenarios. One of these scenarios is based on an increased gasoline tax from 1998, the other on a mixture of congestion pricing and parking charges for

7. Haltmeier, (DRI, 1997*b*) finds that net subsidies in fact fell to $11 billion in 1993, due to increased taxes and reduced road spending. However, as noted earlier, counting capital at its opportunity cost could increase the annual subsidy by $60 billion.

cars and axle weight charges for trucks to raise revenue. Government spending is reduced in both of these scenarios to an "optimal" level. The second scenario is called the "optimal pricing" scenario, because the fees introduced are designed to reflect the budgetary costs related to different types of road use. Fuel taxes are a second-best solution to user fee funding because fuel use is only indirectly related to the amount of road space required by cars, or the amount of road wear caused by heavy trucks.

The gasoline tax scenario obtains 15% greenhouse gas emission reductions in 2010 relative to the base case scenario, where user fees are unchanged. The optimal pricing scenario obtains 12% greenhouse gas emission reductions (see Figure 3.1). Traffic levels are affected in the two scenarios in different ways. Overall levels are reduced more in the gasoline tax case than in the optimal pricing case, but under optimal pricing, traffic patterns are changed, the largest reductions occuring in commuter traffic.

The study does not give a detailed evaluation of the environmental effects of full-cost pricing other than the reduction in CO_2 emissions, but some effects can be deduced from the changes in traffic levels. While the effects of the new charges on heavy-duty vehicle traffic are very small (at the most a 1% reduction in the gasoline tax case), effects on light-duty vehicle traffic, and especially peak traffic, are larger. In the optimal pricing case, peak light-duty vehicle traffic is reduced by 13%, although off-peak traffic increases by 3%. In the gasoline tax case, peak light-duty traffic is reduced by 10%, and off-peak traffic by 6%. Thus, to the extent that the major externalities of road use (congestion, air pollution, accidents, noise) are associated with peak traffic, the optimal pricing case is the scenario in which these externalities are most effectively reduced.

3.3.3 Economic and other policy issues in full user fee funding

The U.S. case study includes an evaluation of the macroeconomic effects of changes in road user pricing, using DRI's macroeconomic model of the U.S. economy. The road user fees replace existing sources of funding for road and highway construction, including federal and state income taxes, state and local property taxes, and state sales taxes. The net impact of the shift in financing is to decrease income tax but to increase overall consumer prices through the increased cost of driving.

The full user fee funding scenarios show GNP figures 0.3%-0.5% lower in 2010 than in the subsidies-continued scenarios, although these results need to be treated with caution. Alternative choices of tax reductions might have more positive consequences, and could lead to a GNP increase, as indicated by the range of results from DJA (1994) related to energy subsidy reform (Figure 2.2, above). Estimates of the economic effects of changes in taxation are also likely to depend heavily on the model used.

The costs considered in the case studies are total and average costs of road provision. Economically efficient road user charges would be based on long-run marginal costs, which would need to be evaluated with a much more detailed view of the way each kilometre driven by each road user affects the current and future need for government expenditure, at the margin. Such a detailed study has not been carried out here. Efficient charges would need to reflect directly the costs that each road user incurs – thus, they would vary according to type of vehicle, location, traffic conditions and other factors (EC, 1996*a*). It is technically possible to impose such charges and many governments have experimented with, or implemented, road pricing programmes of one kind or another. At their simplest, these involve tolls for restricted access routes such as motorways and bridges. Some cities (notably Bergen, Oslo and Trondheim in Norway) have implemented toll rings (Polak and Meland, 1994; Ramjerdi, 1994). New Zealand imposes charges on trucks for their use of roads on the basis of the distance driven. Several national and local governments have experimented with electronic road pricing. So far, however, no such measure has received wide acceptance.

3.4 Other support for car use

In addition to budgetary expenditure on road transport, the case studies briefly consider other types of explicit and implicit support to road users. The U.S. and French studies identify the provision of parking spaces for employees at work as a major implicit support for car use, and examine the effects of introducing parking charges. The extent to which parking provision can be considered a market distortion in favour of driving depends on the situation: where it is an untaxed benefit to employees, and a similar benefit is not offered to employees using public transport or other modes, there is a distortion in favour of car use.

Tax schedules and employment practices in many countries act as support of one kind or another to car use, and also to the purchase of larger or more powerful cars. These practices include the provision of company cars, tax credits or payment by employers for expenses in travel to work, and many others. Many governments impose lower taxes on company purchases of cars than on private purchases. These purchases can include company purchases for employees and the purchase of hire cars, which together may comprise a large proportion of the national fleet and are usually sold into private use after three to four years.

Planning regulations that require developers to include a minimum number of parking spaces with new office buildings or housing can also act as an implicit support to car use. None of these possible distortions have been assessed in the OECD case studies or the current report.

3.5 Transport externalities

In addition to evaluating budgetary subsidies to road transport, the case studies evaluate road transport externalities. They include assessments of the external costs of traffic congestion, accidents, traffic noise, air pollution and greenhouse gas emissions. Externality definitions and methods for valuation differ more among case studies than do methods for budgetary subsidy definition and valuation, reflecting a general difficulty achieving consensus among experts on what constitutes an externality and how it should be valued.

All three case studies include estimates of the level of transport externalities in 1991. Only the French and Japanese studies evaluate the effects of reducing or internalising externalities along with budgetary subsidies.

3.5.1 Defining and measuring externalities

Many estimates have been made of the external costs of road transport in OECD countries (EC, 1996*a*; ECMT, 1994; Deluchi *et al.*, 1996). The estimates often depend on a chain of variables that have to be estimated or modelled. In the case of air pollutants these include: 1) emission factors which depend on the technology, its location, mode of operation, weather conditions, etc.; 2) pollution dispersion and reactions among pollutants in the atmosphere which are again highly variable according to time, location and weather conditions; 3) pollutant deposition on organisms and property; 4) the physical damage caused (dose-response) and 5) the costs entailed. Techniques for damage estimation are under active development[8], but the studies produce widely differing results [see, for example, EC (1995) and Deluchi (1996) for very detailed accounts of the state of the art].

Existing studies have mainly tended to focus on four types of externality associated with driving:

- costs imposed on other motor vehicle users in the form of delay because of congestion;
- costs imposed on other road users (including pedestrians, cyclists and public transport users) because of accidents or the risk of accidents, to the extent that these are not covered efficiently by insurance;
- costs imposed on the population in general in the form of suffering, damage and loss of visual amenity from air pollution;
- costs imposed on the population in general in the form of reduced amenity and quality of life because of noise.

Other external costs may be attached to climate change, depletion of non-renewable resources, damages resulting from disputes over resources, effects of transport on habitats and biodiversity, social dislocation, effects on urban quality of life and housing value, and other factors. Most of these are very difficult to value, and some may be very large.

The physical damages associated with transport can in principle be measured, although it might not always be possible to attribute the damages to a particular vehicle, driving in a particular place at a given time. However, damage valuation is more subjective. Once the physical damage has been quantified, there are various possible valuation approaches:

- *Direct costing* is possible only where financial costs are incurred and causes can be ascribed. This may be the case, for example,

8. The European Conference of Ministers of Transport (ECMT) has a Task Force on Social Costs, which is discussing and developing methodology for external cost estimation, as well as assembling new cost estimates.

for the repair of monuments damaged by air pollution, or for the installation of insulation to diminish traffic noise.

- *Willingness-to-pay (or to receive)* studies determine, through surveys, the amount of money individuals say they would be ready to pay (or receive) to get rid of (or put up with) a nuisance. A weakness of this method is that it can give a poor approximation of the social cost, especially when the agents are poorly informed. Willingness-to-pay studies often give lower externality values than willingness-to-receive studies.

- *Hedonic pricing* derives the damage costs from the observed market prices of some related goods (for example, by valuing the fall in house values resulting from nearby road development or coal mines). A major difficulty in this approach is distinguishing the effects of different influences on the market in question.

- *Avoidance costing* involves estimating the cost of avoiding an externality in the first place. Avoidance costing is often used because it is relatively easy to obtain the necessary data. Estimates may be based on abatement costs actually incurred as a result of emission regulations. The approach can provide a minimum value for the externality per unit of damage insofar as actions already taken to avoid the damage, even if required by law, are an expression of willingness-to-pay. In practice, however, marginal avoidance costs are unlikely to equal the marginal welfare costs of pollution.

Analysts differ in the type of effects they believe should be included in externalities. For example, the additional time spent travelling because of congestion can certainly be considered an externality at the level of the individual driver and is included in some estimates of the externalities of road use. However, many analysts argue that drivers take congestion into account in their decision to use the roads, and that only the costs of congestion that are external to the road sector should be considered as externalities[9]. These are quite small and hard to evaluate. Evaluation of accident costs, and the component that is not paid by insurance, is particularly difficult. Most studies do not take account of the indirect effects of accident risk on quality of life. These might include extra time and stress for non-motorists in negotiating city streets, or the time cost to parents who feel it is necessary to drive children to school because it is too dangerous for them to walk, along with the additional externalities caused by the resultant extra traffic.

Efficient pricing would in theory mean creating a market in the various forms of damage, so that sufferers from noise, air pollution and so on could seek direct recompense from those who cause it. In the case of road congestion, the most efficient solution would probably be for roads to be managed and operated in competition with one another and with other transport modes, with universal road pricing. Such a solution is unworkable in many circumstances, however, and monopoly management of roads is likely to remain the most common approach.

In practice, externalities exist because of the difficulty in creating efficient markets, but government policies can have some of the effects of markets. The appropriate level for efficient taxes to internalise externalities would be the marginal externality caused by each individual road user. Determining this is, again, almost impossible. Damage from air pollution, for instance, varies according to the location of the pollution source, the time of day, the weather and the extent to which property and ecosystems are exposed. Thus, externality estimates tend to be based on very crude averages, or are extrapolated from a very few precise evaluations for particular circumstances.

The average external cost of an activity is obtained by dividing the total damage caused by the level of activity. The marginal cost is obtained by dividing the cost associated with a small increase in activity by the size of that increase. Marginal cost pricing is often advocated as the most economically efficient approach to managing the use of a common good or service. Pricing below the marginal cost implies a subsidy from society at large to users of the good or service.

Economists usually argue that the revenue from environmental taxes should be used wherever it would achieve the greatest benefit to the economy – reducing taxes elsewhere or increasing public expenditure. Thus, individuals whose welfare is reduced because of environmental damage would not necessarily receive

9. The point here is that queuing is common in many types of market, and is not usually used as an argument for government intervention. Congestion pricing is justified on the grounds of economic efficiency, rather than on the grounds of the existence of an externality.

compensation unless this were seen by the government as a priority in itself. Indeed, governments might choose to return the tax revenues to taxpayers, including to those causing the damage through reductions in other taxes, if this were seen to be the most economically efficient use of the revenue. This approach may make sense if the taxes reflect damages to true public goods. However, many of the externalities associated with transport are in fact associated with damage to private goods for which property rights are well established (e.g. personal health and property). Compensation could normally be sought through normal damage claim procedures, enforced by the legal system. Nevertheless, these externalities persist because of the large transaction costs that would be involved for a very large number of individuals, each seeking small amounts of compensation from a large number of road users. In principle, internalising those externalities would mean ensuring that compensation is paid, although in practice it may often be impossible to distribute compensation payments fairly.

The authors of the OECD case studies found it difficult to identify robust estimates even of the damage costs associated with air pollution and noise. Thus, the French study relied on estimates of control costs rather than damage costs for both air pollution and noise, while the Japanese study adapted air pollution externality estimates per vehicle-kilometre that had been developed for Germany. Governments wishing to introduce road user charges aimed at internalising externalities are likely to have trouble finding externality estimates that are generally accepted.

The case studies consider different ranges of externalities. All three considered externalities associated with accidents, air pollution, noise and climate change. The French study also included congestion, while the Japanese study included habitat loss. The U.S. study drew on literature sources (in particular MacKenzie *et al.*, 1992) covering a very wide range of social and environmental costs.

3.5.2 *Environmental effects of externality charges*

The French and Japanese studies both look at the impacts of measures to reduce or internalise externalities.

3.5.2.1 *Effects of fuel taxes*

Fuel taxation is often discussed as a crude means of reflecting the externalities of road use to drivers, for some of the same reasons (partly convenience, partly because fuel use is related to the amount of road use) that governments frequently collect road funds through fuel taxes. However, externalities do not reflect direct budgetary costs to governments and the argument for increasing taxes to address them is weaker than that for collecting road funds. Some of the externalities discussed above – those associated with climate change, depletion of resources and security of oil supply – can be efficiently internalised through fuel taxes. The others might be more efficiently reduced or internalised through measures such as congestion pricing, increased insurance premiums and standards or charges for air pollution and noise. Effects on habitats and communities might best be addressed through changes in transport system design.

The French case study notes the political difficulty in raising fuel taxes sufficiently to internalise costs, and their ineffectiveness in reducing externalities other than climate change. Orfeuil (1997) roughly estimates that raising fuel taxes to reflect all externalities would increase fuel prices by about 50%, and reduce traffic and most externalities by about 15% (greenhouse gas emissions would be reduced by about 35%). Michaelis (1996), using a simple model of transport volume and energy use, finds about a 10% reduction in car traffic and a 6% reduction in freight traffic resulting from a similar fuel tax increase.

The Japanese case study evaluates the effect of fuel tax increases only, in a partial equilibrium model of the road transport sector (i.e. increasing fuel tax rates results in reduced driving, and hence lower requirements for government expenditure and reduced externalities). The study finds that raising fuel taxes to a level that results in total government revenue equalling government expenditure plus total externalities results in a CO_2 emission reduction in 2010 of 11% or 29 million tonnes. Michaelis (1996), using the same externality estimates, finds a CO_2 emission reduction of about 15% in cars and 20% in trucks. Fuel tax increases in France to reflect the externality estimates by Orfeuil (1997) would result in CO_2 emission reductions of a similar order of magnitude to those in Japan (Michaelis, 1996). In the United States, where fuel prices are much lower than in the other two countries, the CO_2 emission reduction caused by externality adders might be expected to be about double that in France or Japan.

The reduction in CO_2 emissions caused by fuel tax increases derive, in the long term, roughly half from reductions in driving and half from reductions in energy intensity (Michaelis, 1996). Thus, externalities associated with traffic might be reduced by a fuel tax about half as much as the CO_2 emissions. On the other hand, externalities associated mainly with urban traffic (the majority) would be reduced less than this: fuel taxes generally have less effect on urban traffic than on rural traffic, as urban traffic is more constrained by congestion and the availability of parking spaces. For example, NOVEM (1992) finds in the Netherlands that a 30% fuel price increase would reduce urban traffic by 4.8% but overall national traffic by 7.1%.

3.5.3 *Effects of other means of reducing and internalising externalities*

While externality adders in fuel taxes would probably be an effective means of achieving quite large greenhouse gas emission reductions from the transport sector, other measures might be more efficient in reducing the broad range of externalities.

The French case study develops a "synthesis scenario" relying more on a combination of measures targeting the various externalities directly:

- Four new measures generate additional revenue: parking fees in towns, taxation on employer-provided parking, suppression of parking spaces in city centres and reduction of tax exemptions related to travelling to work by car.

- Progressive increases in investment in noise protection result in a one-third reduction in noise exposure.

- Introduction of routine vehicle emission inspections, and an obligation on owners to ensure that their vehicles meet the emission standard under which they were licensed, is assumed to reduce emissions by 15% and fuel consumption by 5% (through improved engine maintenance).

- Withdrawal of the 50% reduction in the annual licence fee for vehicles over five years old, with the increased revenue being used to reduce taxes on low-income households, is assumed to increase the rate of car scrapping, especially for vehicles that cannot meet emission standards and require extensive maintenance work. The result is a further 35% reduction in urban pollution.

- A mix of measures to improve road safety – including restricting use of the most dangerous vehicles to very experienced and safe drivers, increasing road patrols and investing in safety measures – reduces accidents by 24%.

Public income increases by 8% compared to the base case, with most of the increase coming from light vehicles in towns. Overall, these measures reduce urban traffic by 11%. Expenditure requirements decrease relative to the base case because of the urban traffic reduction, but this is offset by an increase in spending on measures to reduce noise and accidents. Overall, public sector outlays decrease marginally (by 0.5%) relative to the base case. The overall effect of these measures on road transport externalities can be seen in Table 3.2.

While these results are largely a matter of expert judgement, the indication is that greenhouse gas emissions might be reduced substantially, although not as much as they might be if fuel taxes were used as the only measure to address externalities. On the other hand, most of the non-climate externalities are

Table 3.2: **External costs (high estimates) of road transport in France, 2010**

	Base Case (billion $)	**Synthesis Case** (billion $)	**Difference** (%)
Noise	3.83	2.58	-33
Pollution	4.54	3.18	-30
Greenhouse gas	5.59	4.94	-12
Accidents	9.77	6.75	-31
Congestion	5.37	4.60	-14
Total	29.10	22.05	-24

Source: Orfeuil, 1997

reduced by substantially more than the 10-15% that might have been obtained through a fuel tax increase to incorporate externality adders.

Most of the policies included in the "synthesis scenario" are designed to reduce, rather than internalise, externalities. While the package of measures does result in an increase in the marginal cost of road use, this is mainly through an elimination of tax expenditures rather than through efficient measures to price externalities. The study suggests that, as the externalities are reduced but not internalised or eliminated through this package of measures, there might still be an argument for introducing a fuel tax increase similar to that investigated in the last section. Such an increase would further reduce total externalities by about 10%.

3.6 Economic impacts and implementation issues

The political feasibility of policy reform is likely to depend largely on whether reforms are consistent with a broad range of policy objectives – in particular objectives related to the economy as a whole, to social equity, to international trade and to the environment.

The role of the transport sector in the economy is poorly understood. It is clear that transport of people and goods plays a key role in the functioning of local, national and international markets for labour, land, raw materials, intermediate goods and products. This role is rarely captured in economic models: transport is usually incorporated as a cost, sometimes as a contributor to personal welfare, but rarely, if ever, as factor of production. The effect of transport efficiency on the cost and availability of the full range of traded goods and services is poorly understood, much less modelled. Similarly, the negative effects of transport on quality of life, communities and the environment are poorly understood and are not incorporated in macroeconomic models. All these gaps in understanding of the sector make it difficult to provide a theoretical evaluation of the economic and social consequences of subsidy reform or of internalising externalities. Democratic processes, informed by theory and also by empirical case studies, may have a stronger role to play in evaluating transport sector policy.

3.6.1 Fuel tax increases

Economic analysis of the direct effects of gasoline taxes frequently indicates a negative impact on consumer surplus and GDP because of their effects on household consumption (e.g. Koopman, 1995; Boyd and Uri, 1994; DRI, 1997*b*). The ability to respond to taxes by changing patterns of vehicle use varies among households, with high-income, multiple-car households having the greatest flexibility (Walls *et al.*, 1993). Opponents of fuel tax increases often argue that they would be regressive (i.e. would increase inequity in wealth distribution). Equity effects are likely to differ among countries. Several studies indicate that gasoline taxes would be regressive in the United States, but progressive in Europe (Fisher *et al.*, 1996). This depends on the distribution of car ownership and car use across income groups as well as the level of access to alternative means of transport.

Any possible economic costs of increased gasoline taxes might be counteracted, at least in part. Regressive effects can be countered by using tax proceeds to increase transfers to low-income households or to improve provision for public and non-motorised transport; broader effects on the economy might be positive for certain uses of the revenue – e.g. to reduce tax rates for low-income households, stimulating employment. However, governments considering increasing fuel taxes clearly need to assess their national situation and consider the effects of different uses of the revenue.

Diesel taxes have long been kept low in many countries because of the potential negative effects of higher taxes on users of diesel – mainly commercial transport operators, especially freight companies, and the industries that depend on them for goods transport. Diesel fuel prices have been found to have an effect on the total volume of goods transport (IEA, 1994*c*), although the effects are small and often unmeasurable. To the extent that increased diesel taxation leads to less goods transport, there is likely to be an effect on patterns of production. A doubling in diesel price could increase the cost of production in the short term by an amount of the order of 1%, affecting national competitiveness where the tax increase is unilateral. In the long term, shifts in transport and location patterns might largely compensate for this. Meanwhile, if diesel users are paying less than their share of road costs and are causing a large proportion of the external costs of road use, introducing charges to address these costs would be expected to have beneficial effects for aggregate welfare.

Where the additional tax revenue is used to reduce general income taxes, the measure may have negative effects on low-income households and industrial output. On the other hand, if the revenue from full cost transport pricing is targeted on these areas, it may be possible to achieve net benefits.

3.6.2 Internalising externalities

Although none of the OECD case studies provides a macroeconomic evaluation of the effects of internalising externalities, some observations can be made, based on what might be expected in theory. Reducing and internalising externalities may lead to reductions in GDP, as consumer expenditure is diverted into emission control technologies, and as car and truck access to city centres is restricted, impeding access to jobs and shops. On the other hand, aggregate welfare should, in principle, increase, although estimating this effect would depend on having a metric for "green" GDP or welfare that incorporates externalities.

It is also possible that GDP could increase as a result of internalising externalities, where the effect is to stimulate certain industries, such as those that produce pollution control equipment, or to stimulate new patterns of urban development and technical change. This seems improbable from a neo-classical economic perspective, which tends to the assumption that the free market is naturally the most efficient state for the economy. But viewed from an evolutionary economics perspective, changes in regulation and other constraints on the market may stimulate innovation and growth.

Although regulations and other measures to reduce externalities are often considered inefficient compared with charges to reflect externalities, governments of OECD countries have often found regulations to be more politically feasible than charges. There are some good reasons for this. First, regulations may be easier to implement than charges related to vehicle emissions and other externalities. Second, environmental regulations may be more costly than charges, but they are usually formulated to encourage firms to invest in clean, up-to-date technology when economic and investment cycles permit, increasing the value of their assets. Environmental charges, conversely, show up as an ongoing increment in variable costs even during downward swings in the economic cycle, and are thus a greater threat to firms' survival. Third, the objective of a regulation is usually fairly obvious, whether to reduce emissions or noise, or to improve safety or the pedestrian environment. Environmental and other charges may serve these same objectives, but they also raise revenue for the government, and this can lead to mistrust on the part of those who have to pay them.

A full understanding of the economic, equity, trade and environmental effects of the range of measures considered here would depend on more careful analysis. This might partly involve detailed modelling of alternative options, including measures more carefully targeted on specific road users and externalities. The effects of this type of measure might be evaluated in a general equilibrium or macroeconomic simulation model with detailed input/output representation of industrial sectors, in particular the motor industry. An additional approach that might be more fruitful in the short term could involve assembling more case study information on countries that have adopted different combinations of policies, or have undertaken changes in transport policy.

3.6.3 The role of local government in internalising externalities

Internalisation policies may sometimes be more feasible for local governments than national governments. This may be partly because local authorities – especially urban authorities – more directly represent the groups that suffer external costs, and partly because the major lobby groups that tend to oppose internalisation policies are more consistently effective at the national than at the local level. The most common measures used by local authorities are charges for parking and tolls for using infrastructure where there are few access points, such as bridges and tunnels. Technical developments make it increasingly feasible for local authorities to consider road pricing where charges are linked to the distance travelled on congested roads, or cordon charges on entering or leaving a particular zone. Cordon charges, the most feasible form of road pricing, have so far been applied in only a very few cities, notably Bergen, Oslo and Trondheim in Norway, as well as in Singapore. Road pricing based on distance travelled (i.e. implying continuous or frequent electronic monitoring and payment) has not been attempted except on an experimental basis.

Road pricing schemes have been considered and abandoned, or at least postponed, in numerous cities, including Cambridge (U.K.), Bonn/Cologne (Germany) and Hong Kong. These cases illustrate the potential barriers to road pricing which include:

- national laws that prevent local governments from charging for road use;
- differences in policy objectives between different parts of government (e.g. road authori-

ties may see road pricing as a means of raising road-building funds, while city councils see it as a means of regulating traffic);

- the technical difficulties and expense involved in installing a reliable and efficient system;
- popular opposition to the charges;
- opposition to accounting systems that keep track of individuals' movements.

The introduction of full cost pricing through user fees is likely to depend on a number of innovations to overcome such barriers, and others, at the local level. These might include developments in:

- *Institutions*: It may be necessary to develop new approaches to negotiation and discussion between local, regional and national government agencies; it may also be necessary to find new ways to involve the public in decision-making;
- *Technology*: While road pricing technologies have been demonstrated, the only technologies that are in commercial use are automatic toll-collection systems. Continuous charging, charging related to vehicle emissions, and charging related to the actual congestion level have been tested but not implemented.
- *Individual/Community Behaviour*: Individuals play an important part in new local policies, through their voting behaviour, responses to consultation, and also through their direct responses to the measures. The success of measures may depend on individuals' accepting that the externalities being addressed are sufficiently important to warrant the charges.

There are so far relatively few examples of national approaches to encourage local internalisation initiatives. The U.S. federal government's programme to implement the Intermodal Surface Transportation Efficiency Act contains many innovative elements but has not yet been in place long enough to have a clear picture of its effectiveness. Nevertheless, ISTEA has already stimulated and funded a large number of local projects including some evaluations of road pricing schemes. The European Commission's Green Paper, *The Citizen's Network*, (EC, 1996*b*) proposes a networking approach to promote innovation and best practice in public transport, also contains many elements that could contribute to the development of local internalisation policies.

Chapter 4

Conclusions

The OECD project on "Environmental Implications of Energy and Transport Subsidies" was initiated with the primary aim of identifying "win-win" opportunities where removing subsidies would offer benefits for both the economy and the environment. The project case studies have identified many "win-win" opportunities, but they have also demonstrated that it is not possible to generalise about the effects of removing any type of subsidy. These effects will depend on local and national circumstances, including the full range of policy reforms that might accompany the removal of a subsidy.

4.1 Environmental effects of policy reform

The case studies have identified substantial opportunities to reduce environmental impact through policy reform. Key areas include:

- Removing coal producer grants and price supports (including market entry barriers and preferential conditions in ESI regulation and financing): such a reform 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. This type of reform is also likely to offer considerable benefits in reduced acid gas emissions and reduced impacts of coal mining.

- Removing sales tax exemptions for electricity (and other energy forms): this option appears to offer a small potential for GHG mitigation, less than a 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 million tonnes of CO_2 per year by 2010 in the countries studied.

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

- Introducing or increasing road user fees to reflect the costs of road construction and maintenance, and road services provision. Such fees could reduce peak traffic and its environmental impact by around 10% in North America.

- Introducing a range of measures to reduce and internalise the externalities of road use. Measures considered in the case studies could reduce many environmental and other effects by 30% or more.

Overall, the case studies find greenhouse gas mitigation opportunities in the region of 400-500 million tonnes of CO_2 in 2010, while SO_2 and NO_x emissions together could be reduced by around 2 million tonnes per year in the countries studied. Reductions in coal consumption by around 100-200 million tonnes per year would mean lower local environmental effects of coal mining. These include damage to ecosystems and disruption of human communities, soil and groundwater pollution with heavy metals and chlorine, and release of radioactive material and particulates. The reduction in environmental damage as a result of reforming subsidies is likely to be larger in the longer term, as removing market distortions leads to changes in investment in energy and transport infrastructure, with increasing effects on patterns of use.

Although the environmental effects of removing some types of support appear large in absolute terms, the proportional reductions are quite small. The CO_2 emission reductions mentioned above represent about 3% of total FCCC Annex I country emissions projected by the IEA for 2010. The SO_x and NO_x emission reductions represent about 5% of power station acid gas emissions in the OECD in 1990. The largest effects come from removing support to polluting activities and from introducing new measures to reduce environmental damage or to internalise its costs. Some of the case studies find that environmental controls and charges are made more cost-effective by removing support to polluting activities.

While some of the policy reforms considered in the case studies may be a step in the direction of environmental sustainability, none of the case studies developed a scenario of policy reform that could be described as achieving environmental sustainability. Reforms in the electricity sector seem likely to favour the use of natural gas in CCGT in the short term in many countries. It is not known how long a greatly expanded role for natural gas could be maintained. Meanwhile, burning natural gas does produce pollution, albeit less than that produced by burning coal. A large-scale transition to renewable energy sources would be unlikely unless the externalities of fossil fuel use were considered to be in the upper range of those identified in the current set of case studies, and addressed through policies to reduce or internalise them. Similarly, a transition to environmentally sustainable transport systems would depend on much stronger policies than those considered in this study. As the French transport case study notes, externality valuations are liable to increase in the future as incomes rise in OECD countries; such an increase in externality valuation might imply that governments would be more able to take action to address the externalities.

4.2 Feasibility of reform

The environmental benefits listed above are linked to the reform of support whose value to its recipients may be of the order of $100 billion. Those who would lose these benefits are likely to oppose reform. Governments introducing policy reform will need to consider stakeholder interests carefully, and may need to provide support during the period of transition. One way of doing this is to convert less obvious support such as tax expenditures and market barriers, to direct subsidies. This can help clarify the benefits at stake and facilitate a more open political discussion of any subsequent reform.

Since any process of policy reform is liable to be opposed by groups that expect detrimental effects for themselves or others, this study places particular emphasis on the need to address the concerns of such groups and to identify approaches to reform that offer social and economic benefits as well as mitigating greenhouse gas emissions. The 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 reform.

Subsidies and support are provided at many different levels of government. In some federal countries, the national government may have little jurisdiction over energy policy in states or provinces. In these circumstances, the main role for national government in policy reform may be to improve the quality of information on state policies and market conditions, and to help states reassess of their policies.

The level of support to road users and the extent of transport externalities vary widely within countries, especially between rural and urban regions. Thus, there is a good argument for placing a strong emphasis on the role of local governments in transport policy reform. In addition to being better able to deal with specific local problems, local governments may be more able than national governments to experiment with new approaches, and to avoid strong political opposition from lobby groups that wish to preserve existing supports.

4.3 Overcoming barriers

The role of international organisations in relation to national governments may be similar to that of federal governments in relation to states. Based on the results from the case studies, the following factors appear important in attempting to understand whether a country's coal- and electricity-related policies are likely to increase greenhouse gas emissions:

- construction and operating costs of different types of generating plant in the country, including the costs of the various forms of energy available;
- the level of direct financial support to coal and electricity production;
- direct financial support to electricity consumers;
- trade policies for fuels or equipment used in electricity generation or for electricity;
- price regulations and support, including controls on procurement of fuels and equipment;
- investment conditions for the ESI.

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

The European Conference of Ministers of Transport is developing and improving on its database of Member country transport policies and financial and other statistics related to the transport sector. The extension of such work to non-ECMT countries might be one way to improve on the quality and availability of information in this sector.

4.4 Methodologies

This project set out with an additional aim of evaluating methodologies that could be used to assess the effects of removing subsidies. Again, it is not possible to provide a strong recommendation for any particular methodology, based on the case studies. However, it is possible to suggest that there is value in using more than one approach to consider any given situation: different models and sets of assumptions may produce different results, helping to identify key elements in the implementation of policy reforms.

4.5 Further work

The case studies have identified some issues that could not be explored in depth in the course of the project, but that might be considered in future work by the OECD and others, and should certainly be considered in any national analysis. These include:

- the economic effects of different approaches to recycling subsidy reductions in the economy;
- employment and equity effects of different approaches to policy reform, including, for example, the effects on employment in other sectors of reducing subsidies for coal mining;
- the significance of some of the less quantifiable environmental effects of policy reform – in particular, effects on land use, habitats and biodiversity of changes in coal production patterns and changes in road funding.

Finally, it is perhaps worth noting that most of the case study results summarised in this report derive from modelling studies of hypothetical situations. The best way to understand the effects of policy reform is likely to be through observation of reform that has actually occurred. This is increasingly a practical undertaking as governments report on policies and their effects to international bodies such as the FCCC and ECMT. It is to be hoped that in future efforts to analyse the effects of policies, analysts will have an increasing wealth of information on which to draw.

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Glossary

AGR	Advanced gas-cooled nuclear reactor.
Annex I Countries/Parties	Countries or Parties listed in Annex I of the FCCC. The countries include all OECD Europe countries, central and eastern European countries, including Russia, Ukraine and Belarus, as well as Canada, the United States, Japan, Australia and New Zealand. The "European Community" is also listed.
CSE	Consumer subsidy equivalent: a measure of the total support provided to consumers of a commodity in the form of government grants, tax expenditures, and price controls.
EJ	Exajoule: 10^{18} joules. A unit of energy equivalent to 1055 quadrillion Btu.
ESI	Electric supply industry: includes generation, transmission, distribution and sales.
FCCC	The UN Framework Convention on Climate Change. The convention aims for the stabilisation of greenhouse gas concentrations in the atmosphere at non-dangerous levels. Parties listed in Annex I of the convention have agreed to introduce policies and measures aimed at returning greenhouse gas emissions and absorption by sinks to 1990 levels by 2000. Annex I Parties have also agreed to find means of strengthening their commitment under the convention by late 1997.
FGD	Flue gas desulphurisation.
GJ	Gigajoule: 10^9 joules. A unit of energy equivalent to 1.055 million Btu.
hhv	Higher heating value. The specific heat of combustion of a fuel including the heat of vaporisation of the water produced on combustion.
lhv	Lower heating value. The specific heat of combustion of a fuel minus the heat of vaporisation of the water produced on combustion.
LNB	Low NO_x burners.
MJ	Megajoule: 10^6 joules. A unit of energy equivalent to 1055 Btu.
Mt	Million tonnes
Mtce	Million tce
Mtoe	Million toe
PM	Particulate matter.

(...)

PSE	Producer subsidy equivalent: a measure of the total support provided to the producers of a commodity in the form of government grants, tax expenditures, and price support whether imposed directly or through market protection.
PWR	Pressurised water-cooled nuclear reactor.
SCR	Selective catalytic reduction (a NO_x emission control technology).
tce	Tonne of coal equivalent. 1 tce = 29.5 GJ.
toe	Tonne of oil equivalent. 1 toe = 41.868 GJ.
VAT	Value added tax

Part Two

Case Studies

Chapter 5

Climate Change Implications of Eliminating U.S. Energy Subsidies

Michael Shelby, Robert Shackleton, Malcolm Shealy and Alexander Cristofaro[1]

5.1 Introduction

In recent years, concern over energy-related environmental problems has prompted a reassessment of U.S. governmental policies that, one way or another, encourage overconsumption and overproduction of energy. The energy sector contributes to a variety of environmental problems, including local air and water pollution and solid waste contamination, but recent concern has focused most heavily on the potential influence of energy use on the global climate. Fossil fuel energy use is responsible for at least 60% of the anthropogenic greenhouse gas (GHG) emissions that trap solar radiation in the earth's atmosphere and could lead to significant climate change[2]. Reducing energy use should therefore be a vital component of any strategy designed to reduce the likelihood of climate change and promote sustainable environmental objectives.

In the past, assessments of subsidies have focused mainly on the narrow trade-off between the goals of economic efficiency and equity concerns. From an economist's point of view, energy subsidies tend to distort the allocation of resources by reducing energy prices below market levels, thus encouraging overuse of energy. In assessing whether subsidies are desirable, efficiency losses need to be balanced against social objectives such as distributional impacts or public goods considerations. As climate change mitigation and sustainable development become increasingly important goals, policy makers will have to factor these emerging environmental problems more prominently into public policy decision making.

It may be attractive to reduce or eliminate energy subsidies, for a variety of reasons, e.g. to yield environmental benefits, improve the budgetary position of the government, and possibly improve overall eco-

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2. Since the onset of the industrial revolution, fossil fuel combustion and land use changes have increased atmospheric CO_2 concentrations by about 25%. Half of the increase has occurred since 1970, as developed countries continue their heavy reliance upon fossil fuels and the developing countries – particularly China and India – undergo rapid industrialisation. Even with accelerated improvements in energy efficiency, continued fossil fuel use could lead to a doubling of atmospheric carbon by the second half of the next century. Although scientists have not established a firm, direct link between increased atmospheric CO_2 and higher temperatures in this century, considerable research suggests that a doubling could raise global average temperatures by 1.5° to 4° C, with potentially widespread ecological and economic consequences.

nomic welfare. Furthermore, eliminating energy subsidies may help achieve two of the publicly announced goals of the Clinton Administration: stabilising GHG emissions at 1990 levels by 2000 and paring down the Federal government's budget deficit.

In this paper, we focus on the GHG reductions that would result from eliminating Federal energy subsidies, while also estimating the economic implications of such a policy shift. To help policymakers factor emerging environmental considerations into existing efficiency and equity calculations, we attempt to rank subsidies in terms of their associated emissions per dollar of subsidy. This allows for explicit acknowledgement of the multiple trade-offs in achieving various environmental and alternative social goals. We do not attempt to quantify the long run economic benefits of mitigating climate change nor to evaluate the full multimedia environmental impacts of policy options.

5.2 What is an energy subsidy?

Studies in the existing literature arrive at startlingly divergent measures of the extent to which the energy sector is subsidised in the USA, from as little as \$5 billion economy-wide to as much as \$174 billion in the transportation sector alone. The divergences stem mainly from differences in definition.

The textbook definition of a subsidy is relatively straightforward: "a transfer of economic resources by the government to the buyer or seller of a good or service that has the effect of reducing the price paid, increasing the price received, or reducing the cost of production of the good or service". Nevertheless in practice it is quite complicated to enumerate and measure the extent of subsidies that affect the market for any particular commodity. A thorough taxonomy of subsidies would include:

- policies that transfer resources through market prices (e.g. price regulations, government procurement policies, import tariffs, non-tariff trade barriers);
- direct transfers (e.g. direct grants or payments to consumers or producers, or the provision of inputs at below-market prices);
- tax policies (e.g. tax credits, exemptions, deferrals, exclusions and deductions, investment expensing, accelerated depreciation, or other preferential tax treatment);
- policies that reduce input costs (e.g. preferential loans, loan or liability guarantees, indirect expenditures such as research and development); and
- provision of infrastructure and subsidies to so-called "complementary goods".

These classes can overlap, as two simple examples show. First, investment tax credits or deductions can serve to reduce capital input costs in the power sector. Second, provision of infrastructure can be thought of as reducing input costs (e.g. having a Coast Guard reduces the risk – and thus the cost – of shipping petroleum products) or as a subsidy to a complementary good (e.g. construction of highways makes road transportation less expensive).

The last type of subsidy presents particularly thorny analytic problems in attempts to measure the size of subsidies that affect the energy market. Energy is used in conjunction with many other goods and services. These complementary goods may also be subsidised, and such indirect subsidies (those outside of the energy sector) can boost the demand for energy just as surely as do energy-specific subsidies.

In the transportation sector, for example, currently only about 75% of highway construction and maintenance costs are covered through user fees (for example, fuel taxes, vehicle excise taxes, license and registration fees, tolls). The remainder is paid for out of general revenues raised by processes unrelated to driving. These arrangements amount to a large subsidy for road users, who in response drive more and consume more fuel than they otherwise would.

In addition to energy-specific and indirect subsidies, some observers contend that subsidies also "exist whenever the Government fails to implement programs that internalise uncontrolled environmental costs in energy markets". That is, if the consumption [or production] of a good imposes environmental damages that affect a third party, the failure of the government to impose fines or taxes that require the consumer [producer] to internalise the costs imposed on others constitutes a form of subsidy to the consumer [producer].

Fossil fuels contribute to many different kinds of pollution throughout their extraction, refinement, transportation, combustion and disposal. It is extremely difficult to evaluate and quantify all their environmental effects. Even when the nature and extent of these damages can be accurately determined, they can be very hard to place a dollar value on. Hence a failure to price a fuel at its full social cost is very difficult to quantify.

While we recognise that incorporating all environmental externalities into energy prices may well have profound implications for the energy sector, our goal in this paper is to develop estimates only of the climate change impacts of eliminating a reasonably well-defined set of conventional subsidies to the energy sector and a few of the largest indirect subsidies, namely in the transportation and housing sectors.

5.3 Existing studies of energy subsidies

Two major recent studies, one by the U.S. Department of Energy and one by the Alliance to Save Energy, have sought to quantify the extent to which the United States energy sector is subsidised at the federal level[3]. The studies are difficult to compare for several reasons. First of all, they examine different years (1989 versus 1992), during which somewhat different policies were in place. Second, each presents a range of estimates on the extent of subsidies, which makes dissecting the full set of individual subsidies difficult. Third, they call attention to somewhat different sets of subsidies, and reasonable arguments can be made against the inclusion or exclusion of some of the items on each list.

The Department of Energy (DOE) study estimates that total federal subsidies to the energy industry in 1992 amounted to between \$4.9 billion and \$14.1 billion – 1% to 3% of the \$475 billion worth of energy consumed that year. The low end limits the definition of an energy subsidy to direct Federal expenditures in the energy sector that actually show up in the Federal budget (e.g. grants, tax credits, loan guarantees, research and development expenditures). The high estimate is the sum of all energy-specific subsidies referred to in the study, including many that only indirectly affect the budget. This number is not actually cited anywhere in the report, but can be derived from a careful reading of the text. (See Box 5.1 at the end of this chapter for a catalogue and reconciliation of the energy subsidies listed in these studies.)

5.3.1 Direct tax expenditures

The largest direct expenditure cited by the Department of Energy study is the Low Income Home Energy Assistance Program (LIHEAP), which spends \$1.1 billion annually to help poor households purchase fuels for heating and cooling. DOE also counts some \$2.1 billion in tax deferrals, credits, deductions, exclusions and exemptions; the largest, the percentage depletion allowance, provides a more favourable alternative to standard cost depreciation in expensing properties containing energy resources. This provision of the tax code was initially enacted during World War I to encourage development of petroleum for the war effort[4]. Also counted is the Alternative Fuel Production Credit, which subsidises the production of gasohol (\$670 million annually).

5.3.2 Direct taxes

The government levies significant excise taxes on energy sources to support a variety of trust funds for various responsibilities that are conventionally considered public. The largest, the Transportation Trust Fund, funded mainly through an excise tax on motor vehicle fuels, is used principally to construct and maintain highways. Of \$23 billion in total revenues in 1992, about \$3 billion was siphoned off to general revenues rather than being directed to highway construction or maintenance. In the Department of Energy estimates, this \$3 billion is deducted from the total subsidy figure.

5.3.3 Research and development

Federal research and development (R&D) spending can be considered a subsidy since it may help

3. To our knowledge, no one has quantified energy subsidies at the state and local level, although the Alliance recently published a study of this issue. One obvious example is energy conservation activities subsidised by "demand-side management" programs adopted by State Public Utility Commissions, which the DOE predicts will account for \$4 billion in annual expenditures by 1997.

4. It is often noted that once a subsidy is incorporated into the tax code it is almost impossible to eliminate due to lobbying by interest groups that receive the benefits. While this observation may be generally true, there are cases where energy subsidies have been phased out or eliminated. For example, despite intense pressure from the oil and gas industry, the percentage depletion allowance has been scaled back from \$4 billion in 1983 to about \$1 billion today.

lower industry production costs eventually by leading to technological advances. For example, government-funded research on technologies to convert coal into petroleum or synthetic gas could lower the cost of such technologies and lead to the development of a viable synthetic fuels industry in the USA.

Energy-related R&D expenditures in 1992 totalled roughly $2.5 billion. R&D expenditures for particular energy types included $0.9 billion for nuclear power development, $0.5 billion for coal and less than $0.5 billion each for oil, gas, shale oil, renewables and conservation. The net impact of all these expenditures on GHG emissions is unclear. Those for coal, oil and shale are likely to reduce the quantity of fuel needed to deliver a given quantity of useful energy, but are also likely to increase the demand for the fuel, leading to an overall ambiguous effect on GHG emissions. Natural gas combustion produces GHG emissions, but substitution of natural gas for coal or oil reduces emissions. Nuclear power, conservation and renewables R&D promotes the development of low-emission energy sources.

5.3.4 *Subsidies not directly related to federal budget*

The subsidies listed above constitute the "low-end" DOE estimate. In addition, a wide variety of other subsidies can be included in a "high-end" DOE estimate. The largest ones are those that the Federal government provides to the public power sector by maintaining a legal, financial and tax environment that lowers electricity prices to consumers. According to DOE, these subsidies total about $5.1 billion a year.

Government agencies or co-operatives provide roughly 24% of all electricity sold in the USA. The best known of these are the Power Marketing Agencies (PMAs), such as the Tennessee Valley Authority and the Bonneville Power Administration. The PMAs borrow money from the Treasury Department at low, long-term Treasury interest rates. They can amortise their loans over many years, thus keeping low-interest loans on their books[5]. The total value of subsidies to PMAs is estimated by DOE at $2.2 billion[6].

The Rural Electrification Administration, recently renamed the Rural Utility Service (RUS), was created in the Depression to raise the productivity and standard of living in rural states; it provides loans at a 2% interest rate. The value of this provision is roughly $1.2 billion. Publicly owned utilities receive low-interest funding through access to tax-exempt municipal bonds, a provision worth $1.7 billion.

The Price-Anderson Act (1959) reduces nuclear power production costs by lowering insurance premiums. It placed a limit of $560 million on the liability of an individual nuclear power plant for damages due to one accident. Congress raised the limit to $7 billion in 1988. A study by Durbin and Rothwell has calculated the total value of the subsidy at $3 billion annually even with the 1988 amendments.

In the Alliance study, the estimates of energy subsidies are $7 billion to $21 billion larger than DOE's, ranging from $21 billion to $36 billion. The main reason the Alliance calculations are so much larger is that the definition of subsidies is broader. In some cases, the Alliance enumerates subsidies that seem rather clearly to be energy subsidies but are not discussed in the DOE report; in other cases, it lists subsidies that are only tenuously related to the energy sector or that have been eliminated.

The Alliance enumerates $2.2 billion to $2.5 billion more than DOE in Federal government expenditures for the provision of infrastructure that benefits the energy sector, including almost $800 million for surface mine reclamation, nearly $500 million in export subsidies by the Export-Import Bank and some expenditures by government agencies that only tangentially affect the energy industry, such as the Coast Guard, which presumably oversees waterborne fuel shipments ($484 million). The Alliance also lists $1 to $3 billion more in tax exemptions and exclusions than DOE. Some of

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5. For example, the Bonneville Power Administration depreciates generation assets over 85 years and transmission assets over 45 years.

6. The are three methods of estimating the extent of public power subsidies: budget cost, market price and historical cost. The simplest is the budget cost method, which compares Federal revenues and outlays in a current fiscal year. This may give misleading results since it makes no allowance for recovery of past capital outlays. The market cost method compares the price of government sales of electricity to the price in market; the extent of the subsidy is the difference. In some cases a comparable market price does not exist, necessitating the use of the historical cost method, which calculates the price that would fully cover the costs of production. The figure given in the text is based upon the market cost method.

these, such as tax exemptions for seaports, are perhaps somewhat questionable.

The Alliance study enumerates some $400 to $700 million in general Federal tax revenues directed to energy-specific trust funds, such as those for nuclear waste disposal or oil spill liabilities. The Black Lung Disability Fund is designed to compensate miners who retired before 1970, or in cases where no mine operation can be assigned responsibility. Although coal producers have contributed to the fund through excise taxes, their contributions have fallen short of program payments. The difference between outlays and excise taxes collected represents a subsidy to the industry. The Alliance study does not include the roughly $3 billion from energy excise taxes that goes to general revenues and thus constitutes a negative subsidy. In addition, the Alliance apparently attempts to measure the cost of government-provided uranium enrichment services, estimating it on a historical cost basis, at $0.5 billion to $1.2 billion.

Two of the largest subsidies listed by the Alliance are $2.8 to $9.8 billion in accelerated cost recovery of energy-related capital stock and $800 million to $1.2 billion in general investment tax credits. Since the energy sector is so capital-intensive, roughly one-fourth of all the credits were applied to energy-related capital. Both provisions were greatly reduced by the Tax Reform Act of 1986. Due to the transitional (though long-lived) nature of these benefits, these tax provisions still had a large impact on energy markets in 1989, the year of the Alliance assessment. Yet inclusion of these two items in the summary of subsidies may be misleading, overstating the size of subsidies that are subject to policy manipulation or reform, since they have already been eliminated from the tax code.

The DOE study does not count the $2.1 billion Strategic Petroleum Reserve (SPR) as a subsidy to the energy industry, while the Alliance does. Filling the SPR increases petroleum demand and probably increases domestic petroleum prices and boosts domestic producer sales as a consequence. On the other hand, it could be argued that the SPR has a broader societal benefit of helping to insure against a sudden disruption in international petroleum markets, thus keeping prices somewhat lower in the long run than they would be otherwise. The same arguments could be applied to the Naval Oil Shale Reserves Program, but its net economic and emissions impacts are even more difficult to calculate than those of the SPR.

5.4 Environmental impacts of subsidy removal

To quantify GHG emissions impacts from the removal of energy-specific subsidies, EPA commissioned two studies employing different modelling tools: Gemini, a model developed by Decision Focus Inc. (DFI) for EPA and the Jorgenson-Wilcoxen-Slesnick (J-W-S) model, developed by Dale Jorgenson Associates (DJA). Gemini attempts to simulate perturbations to the energy sector, while J-W-S examines the impacts of a policy change economy-wide, as well as in the energy sector[7].

DFI found several interesting results. First, only 13 of the 46 energy subsidies identified raise GHG emissions; the rest focus upon nuclear energy, renewables and energy conservation, all of which decrease emissions. Nevertheless, as a general rule the largest subsidies are those that increase GHG emissions.

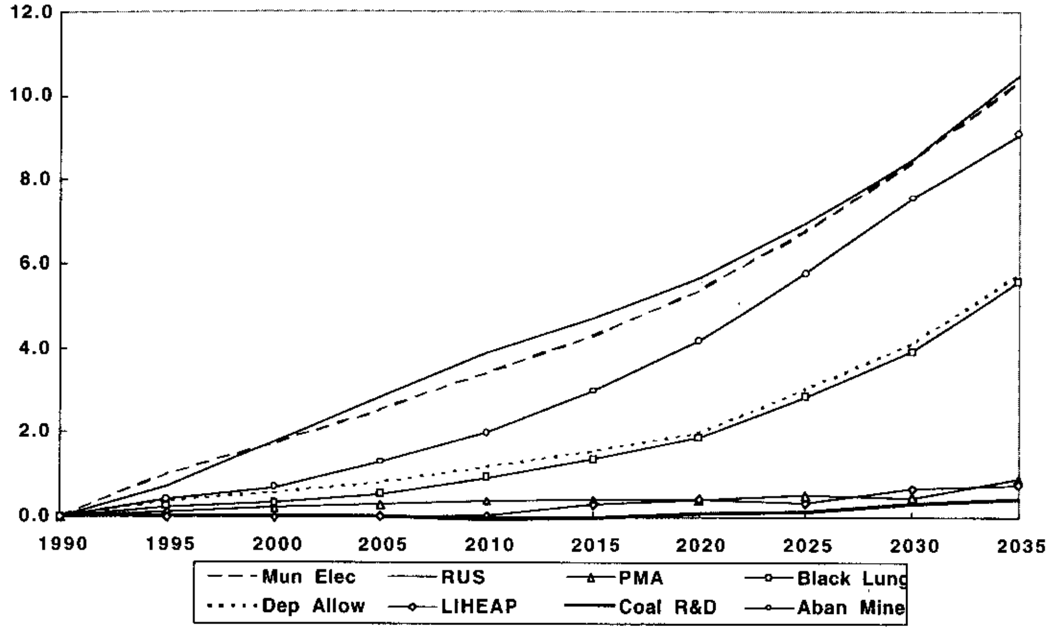
Figure 5.1 shows the potential impact of eliminating eight of the subsidies that one might expect to have the largest influence on carbon emissions. The DFI analysis shows that the largest impact on emissions comes from: eliminating low interest loans to the RUS; withdrawing the tax exempt status of municipal utilities (Mun Elec); requiring existing coal firms to fully support the Abandoned Mine Reclamation Fund (Abandon Mines); removing the percentage depletion allowance (Dep Allow); and requiring existing coal firms to fully support the Black Lung Trust Fund (Black Lung).

The other subsidies seem to be of little importance from a carbon point of view. Even though the

---

7. There are many different economic models used to simulate the impacts on GHG emissions of alternative policy options. Energy sector models, of which Gemini is one, use process or econometric analysis to model conversion technologies in great detail, and focus upon equating supply and demand in a large number of specific energy markets. These models capture extensive detail on available technologies and the dynamics of adjustment and the turnover of long-lived assets; producer and consumer behavior are constrained from optimal response strategies (i.e. expectations are adaptive). The J-W-S model falls into the class called computable general equilibrium (CGE) models. It is a disaggregated, econometrically estimated, intertemporal assessment of the whole U.S. economy, with an embedded energy sector. Expectations are formed based upon perfect foresight. CGEs tend to be predictive of the long-run response to a policy change.

Figure 5.1: **Emissions reductions from individual subsidy removal**



favourable financial treatment of PMAs is the largest public power subsidy, eliminating it has very little impact on carbon emissions: much of the power generated by the PMAs comes from hydro and nuclear sources. (In contrast, the RUS is heavily coal-dominated. Elimination of LIHEAP also has a negligible emissions impact, as does elimination of DOE's coal conversion R&D program ($50 million), which helps foster technologies to convert coal into petroleum or synthetic gas, and its oil R&D programs.

Figure 5.2 presents the consequences of eliminating the $9.4 billion in energy subsidies that increase GHG emissions[8]. DFI concludes that "after 2015, the elimination of subsidies prevents the growth in total carbon emissions. The overall impact on methane emissions is similar." These results suggest that while the impact of subsidy removal is modest in the near term, implementing this policy could play a significant and growing role in climate change mitigation in the longer run, after 2010. DFI concludes that "the reduction of GHG emissions is a small percentage of total emissions...total U.S. carbon emissions are reduced by only two percent in the year 2035. Nevertheless, the absolute reductions are still significant: roughly 12 million metric tonnes (MMT) in 2010 and 46 MMT in 2035."

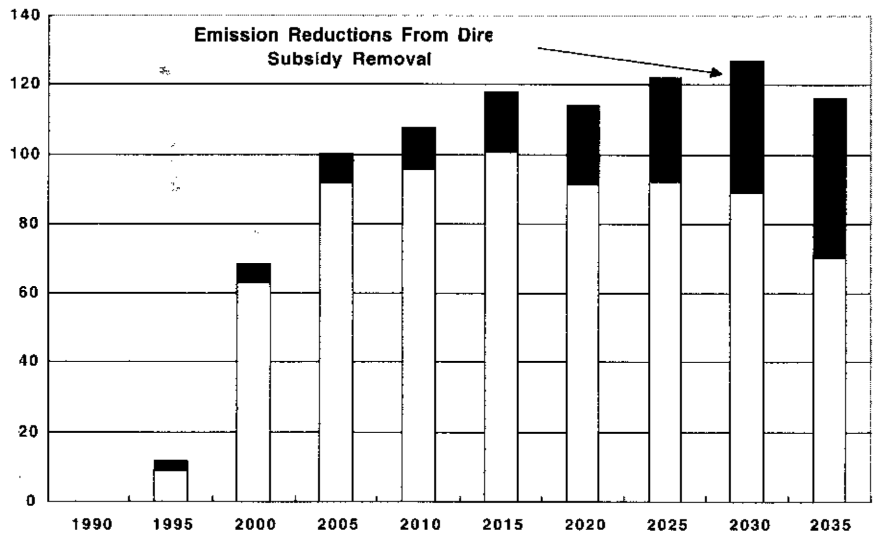
By way of comparison, D. W. Jorgensen Associates estimates that total subsidies to the energy sector are $15.4 billion (including subsidies to non-carbon energy sources)[9]. The elimination of these subsidies results in reductions in carbon emissions that average between 4.0% and 4.4% annually from 1990 to 2050. This translates into emission reductions of 64 MMT in 2010. In the J-W-S model, carbon emissions ultimately stabilise on their own by 2050 without policy intervention, growing by 14% in the process. The removal of subsidies contributes an estimated 30% of the total reduction required to achieve stabilisation.

One interesting and surely controversial result from DJA is the consequence of eliminating subsidies

8. LIHEAP, subsidies to synthetic fuels, the percentage depletion allowance, subsidies to the Black Lung Trust Fund and the Abandoned Mine Reclamation Fund, the coal conversion R&D program, and public power subsidies. See Box 5.1 for details.

9. The major difference between the DFI estimate of energy subsidies that cause GHG emissions and the DJA estimate of total U.S. energy subsidies is the inclusion of the Price Anderson Act ($3.0 billion) and the DOE R&D budget ($2.5 billion).

Figure 5.2: **Carbon reductions from direct subsidy removal**



to carbon-reducing energy activities (conservation, renewables and nuclear power). The result is a small but beneficial effect upon carbon emissions, because eliminating these subsidies has two effects – a scale and a substitution effect – which work in opposite directions on carbon emissions. The scale effect causes energy prices in general to rise, which lowers energy consumption and reduces carbon emissions. There is also substitution within the energy sector towards more carbon-intensive fuels, which increases emissions. The J-W-S model estimates the scale effect to be greater than the substitution effect.

The J-W-S model also permits estimation of the economy-wide implications of a policy change. The choice of how to redirect revenues is an important determinant of the economic consequences of subsidy removal. Economic performance as measured by GNP is enhanced when the additional government revenues are applied to reducing taxes on capital income. This option favours capital formation at the expense of consumption, thereby boosting output. GNP and real income are 0.2% higher as a consequence[10] (see Figure 5.3).

The economy also benefits if revenues are used to reduce the marginal rate on labour income. The change in the tax system raises the opportunity cost of consuming leisure, thereby inducing workers to supply more labour and produce more output. The fact that workers spend the increased income mainly on consumer goods (rather than saving it) dampens the effect on growth compared to the case in which capital taxes are reduced. GNP is only 0.1% higher as a consequence.

The economy suffers if energy subsidy elimination is offset by a cut in average income tax rates. Households spend their higher income on consumption, while the supply of labour is left unchanged. Output falls by roughly 0.3% relative to the base case.

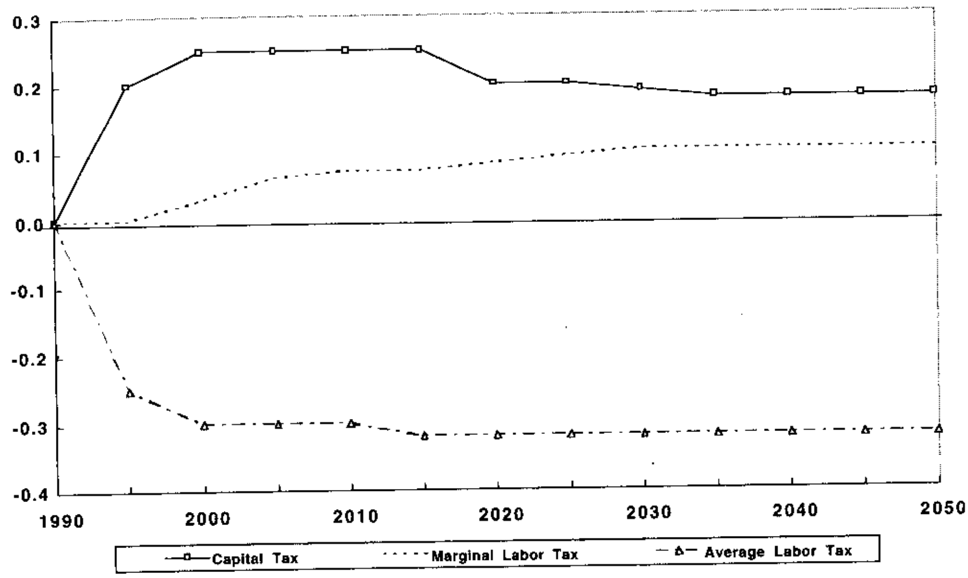
5.5 Phasing out indirect energy subsidies

5.5.1 Transportation

Indirect subsidies outside the energy sector – particularly in the transportation sector – also spur carbon emissions and energy use. The transportation sector represents roughly 30% of U.S. energy demand and 35% of U.S. GHG emissions. Transportation is the fastest growing source of GHG emissions in the USA and perhaps the most difficult source to control from a political standpoint.

10. As currently structured, the J-W-S model assumes that all policy actions are undertaken in a revenue-neutral fashion. Thus, it cannot estimate the impact of policy changes upon the Federal government's budget deficit.

Figure 5.3: **Impacts on GNP from subsidy removal with different revenue recycling mechanisms**



Initiatives in this sector account for only 7% of the reductions outlined in the President's Climate Change Action Plan announced in October 1993.

Road transportation, which accounts for 80% of transportation sector energy use, is subsidised from construction to end-use. The Federal Highway Administration (FHWA) annually publishes figures on roadway receipts and disbursements from all levels of government. In 1991, total receipts for highway expenditures (net of bond proceeds and reserve funds) were $78.3 billion. While most Americans believe their roads are fully financed through gas taxes and tolls, these sources accounted for only $59.1 billion (75%) of the total. The remaining $19.2 billion (25%) was raised from revenue sources unrelated to transportation (FHWA, 1993). Internalising this subsidy to drivers through a gasoline tax could reduce carbon emissions by roughly 20 MMT in 2000 and 33 MMT in 2010. The average gasoline tax required to achieve this goal over this period is roughly $0.15 per gallon. Less driving would also reduce the costs of road construction and maintenance over time.

Subsidisation of transportation is also provided for in the Federal government's tax code. Section 132(f) of the Internal Revenue Code defines "qualified transportation fringes", or employee transportation benefits exempt from all forms of income tax. Employer-provided parking benefits are tax-exempt up to $155 per month per employee (the limit affects almost no parking)[11]. By some calculations, American business spends about $52 billion per year on employee parking. Recent surveys confirm that nearly all employers who offer parking do not charge employees for its use. In all, perhaps 75 to 85 million Americans receive free parking at work. These practices are encouraged by local zoning laws that typically require the provision of excess parking at employment sites. The direct tax subsidy associated with these expenditures is about $19 billion per year, *probably larger than total direct energy subsidies in the USA*[12].

The section 132(f) subsidies are even more powerful than the tax numbers would suggest. The tax code stipulates that these exemptions apply only if the benefits are provided by the employer (as opposed to

11. Section 132(f) also exempts employer-provided transit or van-pool subsidies up to $60 per month per employee, but these exemptions are new and not yet heavily utilised.

12. Calculated by multiplying total employer expenditures on employer-provided parking, assuming zero receipts from employees, by an average marginal effective tax rate on income of 36.5%.

purchased in the market by employees) and only if the benefits are not provided in lieu of any salary or other compensation option. With these restrictions, the code in effect subsidises parking and other transportation benefits only where no other option is offered.

Given the magnitude of these subsidies (particularly the parking exemption), it is surprising how few authors have written on the topic. Donald Shoup (1992 and forthcoming) describes the parking exemption and its impact, as does the National Academy of Sciences report "Curbing Gridlock" (1994). According to Shoup, for the city of Los Angeles, the parking subsidy is equivalent to 11 cents per mile travelled (assuming an average round trip to work of 36 miles, and an average parking subsidy of $3.87/day). By way of comparison, the cost of gasoline for the same trip would amount to 5 cents per vehicle mile.

One innovative option for eliminating parking subsidies proposed by Shoup is called parking cash out. This would transform a tax subsidy narrowly targeted at employer-paid parking into a powerful reward for commuters to ride transit, carpool, or find other means of commuting. Employees given free parking at work could retain the parking space or accept the cash allowance equal to the market cost of the parking space. The cash reward is considered taxable income, so cashing out would generate tax revenues, which can be used to help reduce the government's budget deficit. We estimate that if businesses offered employees the option of a cash payment of equal value to the parking subsidies, U.S. carbon emissions would decline by 14 MMT in 2000 and by 17 MMT in 2010. Eliminating the subsidy entirely would reduce carbon emissions by 22 MMT in 2000 and by 27 MMT in 2010[13].

Parts of the budgets of two Federal agencies, the Coast Guard and the Army Corps of Engineers, subsidise particular transportation modes, thus acting as indirect subsidies to the energy sector. According to the Alliance, a variety of Coast Guard operations, such as aid to navigation, ice operations and marine safety operations, reduce the costs of waterborne shipments of energy, principally coal and oil. This total subsidy is estimated at $485 million annually. Similarly, the Army Corps of Engineers builds and maintains ports, harbours and the inland water transportation system. Much of this spending primarily benefits oil and coal producers, who are bulk users of waterborne transport. The Alliance estimates the total value of Army Corps of Engineers services that support the energy sector at roughly $617 million annually. Financing these programs with user fees would raise the costs of transporting oil and coal, increasing the prices for these fuels and lowering carbon emissions. DFI estimates that eliminating both these subsidies would reduce carbon emissions by 2.5 MMT in 2010 and 6.3 million MMT in 2035.

Many authors have applied a more expansive definition of subsidy to the transportation sector. Mackenzie *et al.* have attempted to value the "full social cost" of driving in "The Going Rate: What It Really Costs To Drive". This study defines two kinds of social costs: market costs reflected in economic transactions; and external costs, which are not reflected in the marketplace. Subsidies in the market cost category include not only government-inspired transfers to drivers, but also private sector subsidies. In addition to the government tax breaks and construction subsidies described above, several other types of transportation expenditures could be considered subsidies because users do not pay for them directly: validated parking at shopping malls, company cars, and the full value of employee parking.

Somewhat farther afield are the external costs of transportation-related energy use. Damages from conventional air pollution (such as smog) from driving are estimated at $10 billion annually (French, 1988). Using a cost of control methodology[14], climate change impacts are estimated at $27 billion annually. Noise pollution from driving is estimated to inflict $9 billion in lost property values to non-drivers every year.

Since half of the oil imported to the USA from the Persian Gulf is used in road transportation, Mackenzie *et al.* allocate half of U.S. military expen-

13. In these estimates, we assume that the total cost of driving is $0.09/mile, the value of the employer-provided parking per month is $50, the average commute round-trip is 22 miles (as opposed to 37 miles in Los Angeles) and the elasticity of vehicle miles travelled with respect to price is -0.15.

14. Mackenzie *et al.* took estimates from the literature of the carbon tax necessary to reduce GHG emissions by 20% from their 1990 levels. The cost estimates cited here are the likely impact such a tax would have in the transportation sector. Mackenzie *et al.* (1992), *The Going Rate: What It Really Costs To Drive*, World Resource Institute.

ditures in the Gulf – roughly $50 billion annually – to drivers. Deaths and injuries of pedestrians and bicyclists from automobile accidents are valued at $39 billion. In 1988, 14.8 million motor vehicle accidents led to 47 000 deaths and five million injuries. Pedestrians and bicyclists accounted for 17% of motor vehicle fatalities. External costs catalogued in "The Going Rate" totalling $135 billion are described as subsidies to driving, and indirectly to energy, resulting from government's failure to enact programs to ensure the internalisation of costs.

While most authors agree that transportation is subsidised, they differ on the net impact of subsidisation on energy consumption. "The Replacement of Transportation Subsides with Optimal Highway Pricing and Investment", prepared by DRI/McGraw-Hill, compares the current practice of highway finance with an economists' optimal scheme in which highway costs to users are equal to the marginal costs of building and operating the roads.

Highway costs are basically determined by road width and road thickness. Road width is a function of demand, and is best paid for by peak-period charges. Road thickness and damage costs are a function of the damaging power of each vehicle, and are best financed through a tax on axle-loadings for trucks. (The pavement damage caused by cars is trivial.) Thus, an optimal scheme would replace most current financing, *including gasoline tax financing*, with a combination of congestion and axle-load fees. The net energy impacts of such a change have not been well studied. The DRI paper makes the important point that, because road costs do not correlate to gasoline consumption, gasoline taxes are not necessarily an efficient solution to transportation subsidies.

5.5.2 Housing

The residential sector accounts for roughly 10% of all energy use in the USA. Compared to other countries and adjusted for climate, U.S. residents use more energy per household but roughly the same amount of energy per square foot of space. Many individuals have hypothesised that favourable tax treatment of housing in the USA increases the demand for residential energy. For instance, Gentry writes that "the link between the housing stock and energy demand is direct: housing services are produced by combining houses and residential energy. With over 50% of the U.S. capital stock devoted to housing, even a small interaction between tax treatment of housing and energy demand could induce large changes in energy use".

Housing receives favourable tax treatment in three major ways: 1) for homeowners, imputed rents are not taxed and mortgage interest and property taxes can be deducted from income; 2) for rental property, landlords benefit from accelerated depreciation; and 3) the corporate income tax induces investment in non-corporate assets, such as housing, rather than corporate assets. The total value of these subsidies is estimated at roughly $95 billion in 1994.

Gentry estimates that elimination of all forms of preferable treatment for housing would increase the average price of housing by roughly 23%. This figure represents the difference between the tax treatment of residential housing and corporate assets. Most of the tax advantage is due to corporate tax policy. If only the deductibility of mortgage interest and property tax from personal income were to be eliminated, the amount of the subsidy would fall to 7.4%.

There are two effects from a change in the price of housing. First, less housing is purchased, causing energy demand to decrease. Second, less energy capital is used such as energy-efficient design, which increases energy use. The first effect dominates the second so that total energy use (i.e. for heating and cooling) in the residential sector is decreased.

According to Gentry, counting all forms of preferential tax treatment of housing results in a 6.8% reduction in energy use. Eliminating the deductibility of mortgage interest and property taxes, which amounts to only a fraction of the favourable tax treatment of housing, reduces residential energy by 2.1%.

Gentry's figures are based upon the total energy reduction when all the housing stock has been replaced. But any policy shift would affect only newly constructed or future housing stock. Taking into account the rate of turnover in the housing stock, elimination of all housing subsidies would reduce residential energy demand in 2010 by only 1.5%, causing carbon emissions to fall by 5 MMT. Eliminating the deductibility of mortgage interest and property taxes would cause energy use in the residential sector in 2010 to fall by only 0.5%, resulting in a less than 1 MMT reduction in carbon emissions. Thus, the current pattern of housing subsides, large as they may be, does not appear to have significant impacts on energy usage patterns or U.S. greenhouse gas trends.

Table 5.1: **Carbon reductions per value of subsidy and carbon reductions in 2010**

	Tons of Carbon Reduced /$000 of Subsidy Removed	Carbon Reductions in 2010 (MMT)
Energy-Specific		
Limit low interest loans to RUS	3.3	3.9
Withdraw tax-exempt status of municipal utilities	1.5	2.5
Remove percentage depletion allowance	1.1	1.1
Eliminate favourable tax treatment of PMAs	0.2	0.4
Require existing coal firms to pay for black lung	0.8	0.9
User fees for abandoned mine reclamation	2.3	2.0
Non-Energy-Specific		
Eliminate parking subsidies	1.4	27.0
Eliminate housing subsidies	negligible	5.0
Full funding of highways	1.7	33.0
Charge Coast Guard/Army Corps users full cost	2.3	2.5

5.6 Conclusion

For a variety of reasons, many of the energy subsidies examined in this paper have been in place for years or even decades. Many subsidies have been established to achieve a perceived common good; others have been promoted by groups that benefit from their existence. Once in place, subsidies become very difficult to remove if they continue to provide benefits to anyone. The adage that "an old tax is a good tax" applies just as well to subsidies. For example, nuclear power was going to be "too cheap to meter" in the late 1950s and early 1960s, and it was thought that government had a role to play in its commercialisation, both through R&D expenditures and through restricting liability from accidents. The Black Lung fund was established to provide health benefits to disabled miners whose former employers could not be held liable for job-related disabilities. Building the interstate highway system was thought to be a way increase mobility, bind the USA together and promote nationhood, even though it would increase the use of energy.

Nevertheless, energy subsidies need to be re-examined in light of the increasing need to recognise and accommodate environmental constraints such as the potential for climate change. Taken together, the studies discussed in this paper clearly show that phasing out or eliminating energy subsidies can play a significant role in achieving the climate change goal of reducing GHG emissions (see Table 5.1). A key advantage of a policy shift that causes energy subsidies to be reduced is that it also holds the promise of improving economic performance as measured by conventional output measures such as GNP. If the revenues freed by the elimination of subsidies were channelled toward policies that encourage capital formation or labour supply, the economy would grow both faster and in a more environmentally sustainable fashion than it would otherwise.

Reducing subsidies outside the energy sector, particularly in the transportation sector, appears to have the largest potential for emission reductions. Requiring drivers who use parking and highways to pay the full cost of these services could significantly cut the growth in carbon emissions in the transportation sector over time.

Somewhat surprisingly, limiting the favourable treatment of housing does not appear to have a significant GHG benefit from the standpoint of energy used for home heating and cooling. Largely this is because this subsidy can only influence the stock of new housing, which turns over slowly. What remains unknown is whether a more dispersed pattern of land use is encouraged by the favourable tax treatment of housing, and whether this pattern in turn causes more energy use and GHG emissions from vehicular travel.

Another way to look at the equity-environment trade-off is to evaluate which subsidies, when removed, will achieve the highest emissions benefits *per dollar of subsidy removed.* Table 5.1 attempts to rank the subsidies whose elimination would lead to the largest GHG reduction. As can be seen, some of the electricity subsidies have the largest associated GHG benefits per dollar of subsidy removed, followed by the indirect transportation subsidies. Full funding of highways and elimination of parking subsidies yield relatively high emission reductions per dollar and large total emissions reductions overall.

Box 5.1: **Reconciliation of Estimates of Federal Energy Subsidies**

The following table shows the various estimates of Federal energy subsidies referred to in the text, reclassified using the taxonomy from Putnam, Hayes and Bartlett also referred to in the text. The first column, "DOE/EIA 'Direct'", shows the official estimate presented in the first chapter of EIA's *Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets.* This estimate involves all energy subsidies in the energy sector that can be traced to the Federal budget. The second column, "DOE/EIA 'High'", is a compilation of all of the subsidies enumerated in the text of the DOE/EIA report. The third and fourth columns, "Alliance High" and "Alliance Low", show the subsidy estimates presented by the Alliance to Save Energy in *Federal Energy Subsidies: Energy, Environmental and Fiscal Impacts.* The fifth, "DJA", lists the subsidies included in the Jorgenson Associates study; the sixth, "DFI", lists those included in the DFI study. Both the DJA and DFI studies draw closely from the DOE/EIA report; the DFI study examined only those subsidies that raise GHG emissions.

Federal Energy Subsidies: Reconciliation of Estimates
(Millions of 1992 $)

	DOE/EIA "Direct"	DOE/EIA "High"	Alliance Low	Alliance High	Jorgenson	DFI
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**
Percentage 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	-

Chapter 6

Greenhouse Gas Impacts of Russian Energy Subsidies

E. Gurvich, A. Golub, A. Mukhin, M. Uzyakov, M. Ksenofontov.[1]

6.1 Energy subsidies evaluation

This report summarises the results of an analysis of energy subsidies in Russia and an evaluation of their impact on emissions of greenhouse gases (GHG) and other pollutants[2]. Since Russia is in the midst of major economic reforms that have brought about important shifts in the types and extent of energy subsidies in the economy, the analysis examined the issue from the pre-reform period through the present.

During the era of central planning, the Soviet economy was generally characterised by a pattern of resource-intensive development and a policy of setting relatively low prices for raw materials and energy. The largest explicit energy subsidies were budget subsidies to the coal industry, amounting to roughly 6 billion roubles in 1990, or 0.9% of GDP. Even more important, however, were the implicit subsidies resulting from price controls designed to keep domestic energy prices lower than international prices. In the case of pre-reform Russia, comparison of domestic and international prices is complicated by the fact that the nominal rouble/dollar exchange rate was set at an arbitrarily low level and did not reflect real purchasing power parity (PPP). We suppose that comparisons based on PPP exchange rates are more revealing, as they show fuel prices relative to those of other goods.

The figures presented in Table 6.1 indicate that in 1990, domestic fuel prices in Russia were 2.5 to 3 times lower than in the USA, and 3 to 3.5 times lower than in OECD countries. Ignoring gasoline, the gap between Russian and international household energy prices was even larger than the gap between industrial prices (see Table 6.2).

Low energy prices contributed to the resource-intensive pattern of economic development in the former USSR, but were not the only or even the most important factor. Low energy prices and low energy efficiency were only one aspect of an economic system that was wasteful of all resources. The biases of central planning led to a failure to maintain rates of technological development comparable to the developed market economies, and a tendency to maintain obsolete equipment past its economic lifetime. Both of these tendencies contributed to high levels of industrial pollution. The magnitude of the gap between the central planning and market systems can be appreciated by comparing energy use and pollution levels. Estimates made for this study show that production of the same final product in Russia uses 90 per cent more energy than in the U.K., and 2.5 times more than in the USA. This situation is aggravated by obsolete equipment that does not meet pollution standards. If equipment comparable to standard U.S. or U.K. technology was adopted, the joint impact of

1. Other contributors to the study include: G. Hughes, K. Lvovsky, A. Gorman (World Bank), R. Shackleton (US EPA), and N. Korobova (Market Problems Institute).

2. The complete study has been published as "Greenhouse Gas Impacts of Russian Energy Subsidies", in vol. 1 of "Environmental Implications of Energy and Transport Subsidies", OECD/GD(97)154, OECD, Paris.

Table 6.1: **1990 energy prices for industry in Russia, OECD countries and the USA**
(1990 dollars)

	Russia (PPP exch. rate)	**OECD**	**USA**
Steam coal (t.)	18	61	37
Gas ($1000m^3$)	35	115	99
Crude oil[3] (t.)	40	128.7	127.6
Gasoline (l.)	0.20	0.50	0.31
Electricity (100 kWh)	2.3	7.1	4.8

Source: Estimates based on RF Ministry of Energy reports and IEA Statistics ("Energy Prices and Taxes").

Table 6.2: **1990 household energy prices in Russia, OECD countries and the USA**
(1990 dollars)

	Russia (PPP exch. rate[4])	**OECD**	**USA**
Gasoline (l.)	0.31	0.50	0.31
Gas ($1000m^3$)	43	295	208
Electricity (100 kWh)	2.3	10.2	7.9

Source: Estimates based on RF Ministry of Energy reports and IEA Statistics ("Energy Prices and Taxes").

increased production efficiency and compliance with tighter emission standards could cut total CO_2 emissions by half, and emissions of other compounds by two-thirds to four-fifths.

Since the initiation of economic reforms in 1992, government energy policy has been changing continuously. Both prices and trade are gradually being liberalised, though some regulations are still in effect. Prices for crude oil, petroleum products and coal were liberalised in several stages during 1992-1993. Power prices are still controlled, but the regulation authority has been partly decentralised and delegated to special regional boards that include representatives of producers, consumers and local authorities. Gas prices formally remain under the control of the central government, but the monopoly producer "Gazprom" exercises significant independent control. Oil exports were constrained by quotas until 1995, when they were abolished. However, throughout the period, oil exports have been subject to export duties imposed to cover the gap between domestic and world market fuel prices (particularly large in 1992-1993). These export duties amounted to 20 ECU/tonne for oil in mid-1995. The development of real fuel prices is presented in Figure 6.1.

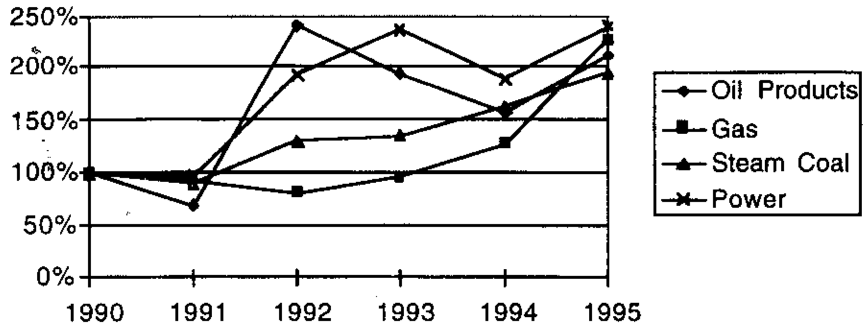
Taken together, these results suggest that market reforms are leading to a gradual decrease in energy subsidies. By 1995, the lion's share of subsidies to industrial users had been eliminated. However, efforts to remove subsidies have been far from straightforward, and there is little assurance that the energy prices attained through these efforts will be sustained. For this reason, 1994 relative energy prices were used as a benchmark for the estimations in the analysis presented here. There still remain substantial subsidies in parts of the energy sector, notably in the coal industry and in the household sector. All household energy prices have dropped significantly in real terms since 1990. In particular, natural gas prices for households fell by a remarkable 94%.

More specifically, there were four main types of energy subsidy in Russia in 1990-1995:

- large direct budget subsidies for coal;

3. Average import prices for the first half of the year.
4. PPP for consumer markets

Figure 6.1: **Real fuel prices in Russia**
(1990=100%)



- reduced energy prices for households, financed in part from local government budgets, and in part by other users through cross-subsidies;

- restraints on domestic oil prices in the form of export quotas and duties, which helped maintain low relative energy prices for domestic users compared to the world market; and,

- use of oil and gas export revenues to cross-subsidise heavily undervalued domestic oil and gas supplies.

Defining unsubsidised price levels required a different approach for each fuel. The subsidy-free price levels for exported goods such as oil and gas were estimated on the basis of net-back prices. It was assumed that converting border prices from dollars to roubles using the purchasing power parity (PPP) level rather than the current nominal exchange rate would produce more accurate estimates. This approach uses relative world market prices as a baseline, and assumes that the exchange rate converges with the PPP level in the long run. According to our estimates, the 1994 PPP exchange rate was 2.23 times higher than the nominal level, and 1.61 times higher in 1995.

The unsubsidised prices for refinery products were estimated by comparing the cost of unsubsidised crude oil supplies with the prices of imported oil products. Projected prices for coal were derived from their assumed proportions to gas prices, since gas is a close substitute for coal. For electric power, subsidy-free prices were defined on the basis of production costs for thermal stations with unsubsidised fuel inputs.

Subsidy-free prices for households were calculated by summing energy prices for industrial users, distribution costs, and value added tax. Tables 6.3 and 6.4 summarise our estimates of unsubsidised price levels for all fuels.

The analysis described here focused primarily on the subsidies enjoyed by energy consumers. To get a general idea of the scale of these subsidies in Russia, we compared the costs of fuels supplied to domestic end-users at the actual rouble prices effective in 1994, with the subsidy-free prices estimated above. Similar estimates were made for 1990 (the same approach was used to define unsubsidised energy prices). The volumes of energy demand assumed in the calculation of these estimates referred to the corresponding years. It was found that the average ratio of unsubsidised to actual prices, weighted by final use of various fuels, was 215% in 1990 and dropped to 179% in 1994. This fact, together with the decline in energy demand resulted in a significant reduction (roughly 30%) of total energy subsidies in constant prices, as evidenced by the figures in the third and the last columns of Table 6.5.

As shown in Table 6.5, the analysis of implicit and explicit subsidies in energy prices revealed that energy subsidies for end-users in the Russian Federation totaled 8.4% of GDP, both in 1990 *and* in 1994 (GDP decreased by 29 per cent in PPP terms over the same period). However, the *structure* of energy subsidies changed to an important degree during this period. The share of energy subsidies allocated to the residential

Table 6.3: **Estimated unsubsidised energy price levels for industry**
(1990=100%)

	1994 (actual)	**1995**	**2000**	**2005**	**2010**
Crude oil	187%	247%	279%	299%	327%
Petroleum products	156%	196%	185%	175%	168%
Natural gas	128%	196%	212%	236%	263%
Coal	161%	246%	246%	246%	275%
Power	188%	238%	250%	258%	272%

Table 6.4: **Estimated unsubsidised household energy prices**
(1990=100%)

	1995	**2000**	**2005**	**2010**
Gasoline	112%	105%	100%	96%
Natural gas	244%	264%	295%	328%
Steam coal	330%	330%	330%	369%
Electricity	412%	414%	419%	428%
Heat	3 625%	3 645%	3 687%	3 764%
Power	488%	491%	496%	507%

sector grew dramatically, as household energy prices dropped (in real terms), and those for industry rose. The residential sector received only 27% of energy subsidies in 1990; by 1994 it enjoyed as much as 65% of overall energy subsidies. Once converted to dollars using the nominal exchange rate and adjusted for Russia's share of overall energy use in the former USSR, the resulting total subsidy value is roughly consistent with the USSR estimates made by B. Larsen and A. Shah[5].

6.2 Long-term projection model and scenarios

This analysis of the long-term impacts of eliminating energy subsidies and implementing various environmental policies was undertaken using an economic simulation model developed by Gordon Hughes of the World Bank's Environment Department. The model allows for the gradual substitution of outdated technologies by more efficient modern technologies as industry responds to market reforms and increased competition. Production using the more efficient technologies is characterised by lower resource intensity and lower emissions. During the adjustment period, 'old' and 'new' equipment operate in parallel (it is assumed that 'new' capacities are used first, while residual output is provided from the 'old' equipment). Performance of the 'old' technologies is characterised by the input-output matrix constructed for the 1990 Russian economy. The 'new' technologies are characterised by the corresponding matrices for the USA, the U.K., Western Europe or Spain.

The following types of economic responses to these interventions are incorporated into the model:

1. Production using the 'old' plant or equipment adjusts to changing prices.

2. Increases in effective energy prices lead to accelerated investment in new technology and plant or equipment renovation.

5. LARSEN, B. and A. SHAH (1992), "World Fossil Fuel Subsidies and Global Carbon Emissions", Working papers WPS 1002, World Bank.

3. Higher energy prices for households cause a decrease in consumption, represented by demand elasticities.

4. Enterprises may respond to pollution fees by reducing emissions through decreased energy use and/or by investing in scrubbing or other abatement equipment.

The model makes long-term projections for output by sector, energy use, emissions of major pollutants, emissions by sector, enterprise type and fuel use, and revenue from pollution fees. It also incorporates assumptions concerning four principal components of economic activity: macroeconomic growth, power sector development, energy prices and environmental regulation. The principal assumptions can be stated as follows:

- GDP growth resumes in 1996;

- annual growth rate attains 5% by 2000 and remains at this level through 2010;

- GDP regains its 1990 volume in 2006, and is 20% higher in 2010.

The model considered three separate sets of energy price assumptions for industrial users:

- 1990 price levels, referred to as *high subsidies*;

- the real prices actually observed in 1994, referred to as *reduced subsidies*; and,

- the *unsubsidised levels* presented above in the previous section.

In addition to subsidies elimination, the possible environmental effects of two environmental policy tools – pollution fees and taxes on carbon dioxide emissions – were evaluated by the model. Pollution charges were adopted by Russia in 1990 and brought into force in 1991. A salient feature of the system of pollution fees in the Russian Federation is the application of two different charge rates, one for discharges within the applicable emission standard, and another, five times higher, for emissions above the standard. The pollution charges were introduced as the main environmental protection policy in Russia. They were, however, significantly depreciated once economic reforms began due to extremely high inflation. Although charges were indexed several times, their real level in 1994 was only about 4.5% of the initial value adopted in 1990. As for the CO_2 tax, the possibility of its introduction in Russia has been discussed but has not yet been put into practice.

The scenarios explored by the model differ with respect to these policy tools. The following options were considered:

1. *Charges for emissions* of SO_2, NO_x, TSP and other substances.

   1.1 *Low level* (corresponding to actual rates of 1994).

   1.2 *High level – 70 times greater than the Low level* (3 times greater in real terms than the initial rates of 1990). The "High level" approximately corresponds to the overall level of pollution fees in Poland.

2. *CO_2 tax.*

   2.1 CO_2 tax is *not introduced.*

   2.2 CO_2 tax *is introduced* at the level of about $10 per metric tonne.

Table 6.5: **Estimated energy subsidies in 1990 and 1994**

	1990			**1994**		
	trillion roubles	$ billion (nominal exch. rate)	$ billion (PPP exch. rate)	trillion roubles	$ billion (nominal exch. rate)	$ billion (PPP exch. rate)
Total energy subsidy	54.4	93.7	73.2	51.3	22.5	51.8
GDP	644.2	1110.7	867.0	611.0	268.0	617.2
Energy subsidy as percentage of GDP		8.4%			8.4%	

Table 6.6: **Projected levels of energy use and emissions for 2010**
(in percentage of 1990 level)

	Primary energy use	TSP emissions	CO_2 emissions	NO_x emissions	CO_2 emissions
High subsidies	102.8	50.4	63.1	89.6	100.2
Reduced subsidies	99.5	46.5	59.0	85.6	96.7
Subsidies eliminated	89.4	34.0	47.5	75.8	86.2
Reduced subsidies + pollution fees	98.1	37.0	51.8	83.7	95.0
Reduced subsidies + CO_2 tax	97.7	36.3	51.2	83.5	94.4

Figure 6.2: **Projected TSP emissions**

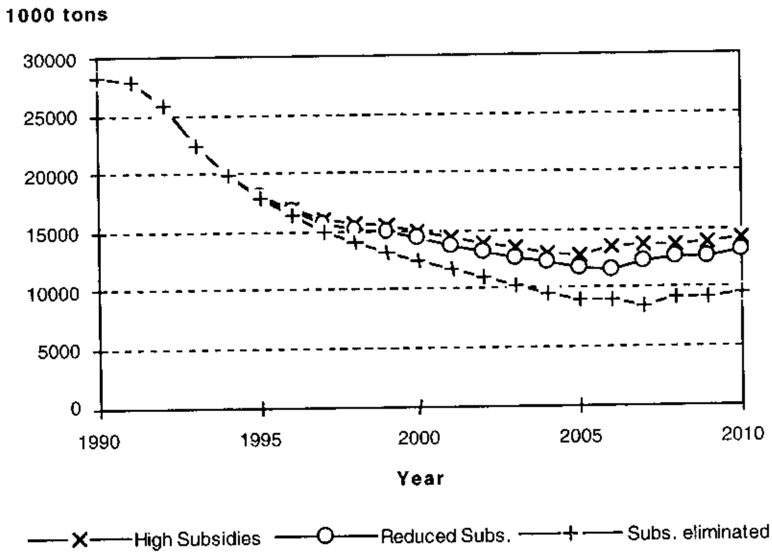
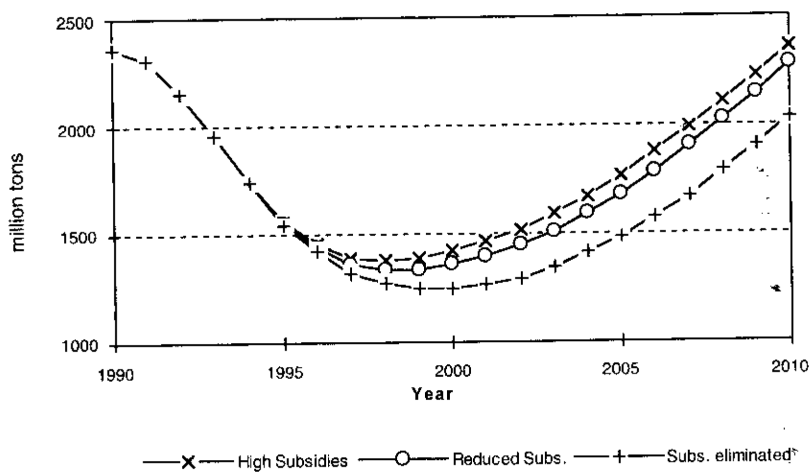


Figure 6.3: **Projected CO_2 emissions**



6.3 Evaluation of subsidies elimination: long-term effect

The impact of eliminating subsidies was evaluated by comparing the projected patterns of energy use and emissions for different scenarios. Some projections for the year 2010 are presented in Table 6.6. These figures show that both energy use and greenhouse gas emissions could decrease by approximately 14%-16% as a result of removing all pre-reform (1990) energy subsidies. Maintaining subsidies at their 1994 levels would yield emissions reductions only about one-fourth as large. Given Russia's present circumstances, eliminating subsidies will be a far more important step in controlling greenhouse gases than the introduction of pollution fees or CO_2 taxes. Introducing fees or taxes, even at the maximum level politically feasible, would not have as large an effect on emissions as would simply eliminating energy subsidies.

However, full, immediate elimination of energy subsidies in the Russian Federation is unlikely to occur. Under current economic conditions, enterprises currently have a very limited capacity to adjust to higher energy prices. Dramatic reductions of the direct or indirect subsidies to household energy use are also improbable in the immediate future, principally due to the limited financial resources of households and the strong political opposition that such measures are likely to meet. Rapid adaptation is ultimately hampered by the fact that decades of inefficient industrial, investment and technology policies have left the Russian economy with an infrastructure based on low relative prices for energy, mineral resources and transportation. Energy price increases should, in theory, allow for the most rapid adaptation possible, but appropriate structural and technological shifts can occur only if their scale does not exceed the economy's ability to adapt.

Accordingly, an approach incorporating both subsidies reduction and other measures, such as tighter standards, pollution charges or the introduction of environmental taxes, appears more feasible. Generally speaking, the potential of combinations of subsidy reduction and other measures to reduce emissions approaches that of complete subsidy elimination. In this case, however, the complementary measures are truly effective only if they are deployed once a substantial part of subsidies have been eliminated.

Projected emissions of CO_2 and TSP under the three principal sets of subsidy assumptions are presented in Figures 6.2 and 6.3. Emissions are affected primarily by two factors, changing energy use patterns and the introduction of new technologies with lower emission rates. The relative importance of these factors differs by pollutant – the former dominates for NO_x and CO_2, while the latter is of greater significance for SO_2 and TSP emissions. This distinction accounts for the difference in the respective emissions dynamics. CO_2 and SO_2 emissions grow rapidly after 2000 with energy use growth, while NOx and TSP emissions decrease through 2005, and then demonstrate insignificant growth if subsidies are maintained, or remain constant otherwise.

One can see that even under high initial subsidies, projected emission growth is more moderate than the assumed GDP growth. Two factors are responsible for this 'background' decline of specific emissions. First, it was assumed that consumption patterns are changing as a result of carrying out market reforms and making the economy more open (for example, the service sector, where energy use is low, is expanding). Second, some renovation will take place in the economy regardless of the presence of subsidies, resulting in reduced specific demand for energy and materials, and in reduced emission rates.

Estimates of the impact of each factor taken alone are presented in Table 6.7. These figures show that a considerable 'background' drop can be expected for TSP and SO_2 emissions, with the lower emission rates of the new equipment being the principal contributing factor. 'Background' reductions of CO_2 and NO_x emissions are more moderate and have as their leading cause increased economic efficiency. Shifts in consumption patterns are of minor importance in all cases, though they do account for one-third of the 'background' decrease in CO_2 emissions.

It is noteworthy that the impact of scaling down or removing subsidies does not differ much by pollutant (in contrast to the 'background' effect). Total subsidy elimination reduces emissions by roughly 14%-16% of 1990 levels, while maintaining reduced subsidies yields a 3.5%-4% emissions decrease. The result is that the ratio of two effects – subsidy elimination compared to the 'background' emissions decline – varies over a wide range (from 24% for TSP to 72% for CO_2, i.e. threefold).

The introduction of pollution fees or CO_2 taxes was considered in combination with reduced subsidies. These scenarios are compared to the subsidy elimination scenario and to the scenario in which reduced subsidies are maintained without any other

Table 6.7: **Estimated contribution of various factors to emissions reduction in 2010**
(in percentage of 1990 level)

FACTORS:	TSP	SO_2	NO_x	CO_2
Total 'natural' decline including:	69.3	56.6	30.1	19.5
– shifts in consumption patterns	11.8	11.9	4.3	7.0
– efficiency enhancement	21.4	23.1	15.3	12.5
– use of new technologies with lower emissions rates	36.1	21.5	10.5	0.0
Subsidies elimination*	16.4	15.6	13.9	14.0
Subsidies reduction*	3.9	4.2	4.0	3.5
Pollution fees	9.5	7.2	1.9	1.7
CO_2 tax	10.2	7.7	2.1	2.3

* Compared to keeping high initial subsidies.

measures, and these scenarios are used as baselines. These figures reveal that the impact of pollution fees varies significantly by pollutant. For TSP and SO_2, the introduction of pollution fees yields effects almost as substantial as subsidy elimination, while for NO_x and CO_2 the impact is only moderate.

6.4 Regional analysis

Russia is a very large country with widely varying regional patterns. A national-level analysis is likely to miss substantial regional variations that may be important from a policy perspective. Accordingly, a regional sub-model was developed to undertake regional analyses of the energy subsidies and GHG emissions scenarios. Four major parts of the Russian Federation were singled out for specific analysis: European Russia, the Urals, Siberia and the Far East. Energy price dynamics, subsidy values, emission shares and the long-term impact of subsidy elimination and other environmental policy measures were estimated separately for each of these regions.

In addition to explicit and implicit subsidies to the energy sector, inter-regional energy subsidies existed under central planning. These subsidies resulted from the application of flat prices for the major fuels (both for industry and for the households). Flat prices took into account neither significant variations in production costs nor transportation costs (which constituted the greater part of the gas delivery prices). Thus, the application of flat prices created inter-regional subsidies – consumers in European Russia paid the same price for gas transportation from West Siberia as enterprises in the adjacent areas.

Another source of inter-regional subsidies were household energy prices. Natural gas and gasoline prices were uniform, as were electricity and heat prices, with the exception that both power production costs and prices for industrial users differed by region.

In late 1992, prices for oil and refinery products were more or less liberalised. This resulted in significant regional price differentiation. Price controls for power were decentralised, and this also led to increased variation in prices. Household electricity and heat prices are no longer equalised across the country. Power prices (both for industry and for households) vary in the extreme from region to region, and differences of the order of 1:20 can be observed. Thus, this type of interregional subsidy has presently been all but eliminated. Gas delivery prices, however, remain uniform across the country, and can be considered as a surviving form of interregional subsidy.

One may draw the following conclusions from a comparison of the projected emissions levels under the various scenarios explored in the regional analysis:

- Emissions of all pollutants in European Russia and Far East fall as subsidies are reduced.

- Emissions in Siberia increase under partial subsidies, but drop in the scenario of complete subsidy elimination. The explanation is that partial subsidy cutting produces sufficient price differences between regions to cause production shifts, but price growth is not important enough to compensate it by stimulating the introduction of new technologies and adjustment of the old technologies. Complete subsidy abolition brings emissions in Siberia down.

- Emissions in the Urals are only slightly affected by the degree of energy subsidy in place, and emissions trends of some pollutants tend towards opposite directions. Any reductions in emissions here are balanced by the impact of production relocation.

The main factors influencing emission levels for the entire country were assessed above. Similar evaluations were made at the regional level.

Subsidies elimination affects emissions in a particular region in several ways:

- by changing total production volume;
- by changing the structure of production through sector shifts; and
- by changing emissions per unit of output (due to replacement of old capacities by new ones with lower energy intensities and lower emission rates, adjustment of old capacities to shifts in relative prices, and so on).

An effort was made to estimate the relative contribution of various factors to the overall impact of subsidies abolition. The effect of each factor was defined as emissions change attributable to the observed variation of this factor. All effects were expressed as percentages of the initial baseline emission volume. The estimates presented in Tables 6.8 and 6.9 suggest that from the standpoint of environmental pollution, shifts in the production structure are unfavourable in the Urals and Siberia. This fact is a consequence of moving energy intensive activities to these regions.

Thus one can observe that although subsidies elimination reduces emissions rates everywhere, this effect is countered in the Urals and Siberia by growing production volumes and unfavourable structure shifts. On the other hand, relatively large reductions of emission rates are taking place in these regions. Paradoxically, the reason is the same: cheap fuels attract production to these regions, so more investment is placed here, and new capacities have much

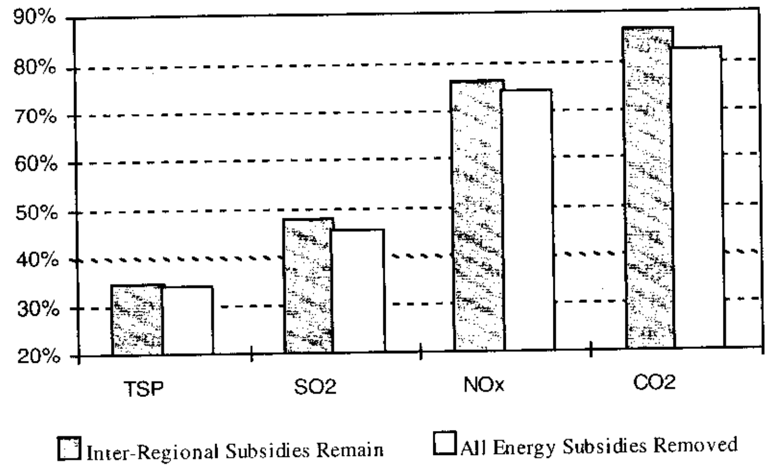
Table 6.8: **Contribution of major factors to the development of TSP emissions**
(in percentage of initial emissions)

Factors:	**European Russia**	**Urals**	**Siberia**	**Far East**
Production volume	-2.6%	5.1%	5.1%	-5.2%
Production structure	-4.9%	-0.3%	3.1%	-4.9%
Emission rates	-15.7%	-7.8%	-24.0%	-8.0%
TOTAL	-23.3%	-3.0%	-15.8%	-18.1%

Table 6.9: **Contribution of major factors to the development of CO_2 emissions**
(in percentage of initial emissions)

Factors:	**European Russia**	**Urals**	**Siberia**	**Far East**
Production volume	-4.8%	10.5%	9.9%	-8.1%
Production structure	-6.0%	5.0%	5.8%	-7.4%
Emission rates	-15.6%	-15.4%	-25.5%	-11.8%
TOTAL	-26.5%	0.1%	-9.7%	-27.2%

Figure 6.4: **Russian emissions indices in 2010**
(1990=100%)



better emissions parameters. Taking into account the unfavourable environmental conditions in the Urals, we may conclude that additional interventions are required in this region.

To estimate the effects of inter-regional energy subsidies, we compared the projections obtained from the regional model with those from the national model (see Figure 6.4). The former assumed elimination of all energy subsidies, while the latter assumed only subsidy-free general price levels with remaining inter-regional subsidies. The lower levels projected in the regional model can thus be attributed to the impact of inter-regional subsidies. The projections presented above demonstrate that the impact is greatest on CO_2 emissions, for which the elimination of inter-regional subsidies provides an additional emissions decline of 4.3% of the initial level. This effect exceeds the impact of partial emissions elimination.

Chapter 7

Effects of Phasing Out Coal Subsidies in OECD Countries[1]

DRI, Paris

7.1 Coal subsidies in OECD countries as measured by the PSE indicator

Support to the coal industry takes many different forms. It is usual to distinguish the following three broad categories of support:

- direct financial aid to current production: grants for capital investment, deficit grants, interest payment grants, payments to employed miners;

- price support that indirectly results from limitation on coal imports or agreements between coal producers and some coal users;

- assistance not benefiting current production, such as payments to redundant miners and inherited liabilities.

Because of the complexity of the support system, it is difficult to estimate the value of the protection provided to the coal industry by the various support systems and barriers to imports. The IEA has nevertheless adopted an indicator called the producer subsidy equipment (PSE), which provides a single measure of the financial support given to the coal industry. The coal PSE is defined as the sum of the net budgetary payments to producers and of the value of indirect measures that support domestic production. It does not include aid not benefiting current production. In other words, it is equivalent to the payment that would keep domestic production competitive with imports, at current levels of production and import prices.

7.2 Approach of this study: comparing energy supply and demand under two scenarios

This study evaluates the energy, environmental and economic effects of phasing out coal subsidies as defined by the PSE. The study focused on six countries where the coal industry benefits from significant government support (Germany, France, Spain, U.K., Japan, Turkey). The other major OECD coal-producing countries are the USA and Canada. In the USA, no coal subsidy was found that falls under the definition of the PSE. In Canada, recent productivity improvements have eliminated the need for subsidies in the future.

The 1993 levels of the PSE are given in Table 7.1, together with the amount of subsidised coal production.

The study investigated, for each case study country, the effect of coal subsidy removal on fuel prices and on supply/demand balances. Changes in the fuel mix and in import requirements can have an effect on world coal markets and this was analysed as well. This was done by defining two scenarios, one where subsidies are maintained at current levels

1. The study summarised here has been published as "The Energy, Environment and Economics Effects of Phasing Out Coal Subsidies in OECD Countries", in "Supports to the Coal Industry and the Electricity Sector", vol 2, "Environmental implications of Energy and Transport Subsidies", OECD/GD(97)155, OECD, Paris.

Table 7.1: **1993 levels of the producer subsidy equivalent (PSE)**

	PSE		*Subsidised Production*
	[$/t]	*[M$]*	*[Mtce]*
Canada	12	48	4.0
France	43	428	10.0
Germany	109	6688	61.5
Japan	161	1034	6.4
Turkey	143	416	2.9
Spain	84	856	10.2
U.K.	15	873	57.4
USA	0	0	0.0

(although subsidy reductions already announced are assumed to be implemented) and one where they are removed as rapidly as practically possible. Energy supply and demand for each country were then compared in the two scenarios. The level of coal production in the six case study countries falls much more rapidly in the No-Subsidy scenario than in the Subsidy scenario (see Figure 7.1).

In the OECD countries covered, coal subsidies, as defined by the PSE, take the form of direct financial aid to the domestic coal industry or price support through special contracting agreements between coal producers and some coal users; such subsidies have the effect of maintaining domestic coal prices at a higher level than imported coal prices. Therefore, phasing out coal subsidies (as defined by the PSE) mostly results in a replacement of domestic coal by imported coal.

The two sectors where special contracting agreements are often encountered are power generation and the iron and steel sector. In OECD countries, 80% of coal burned is consumed in these two sectors and the proportion is expected to increase as other sectors increasingly switch to more convenient fuels.

In the iron and steel sector, the elimination of contractual agreements, or other type of subsidies, will result in the replacement of domestic coking coal by imported coking coal, with nearly a one-to-one volume effect as the effect on consumer coal prices is very small.

In the power generation sector, the coal subsidy removal will have two effects: 1) lower coal prices to power plants and 2) increased flexibility in the choice of fuels for power generation. The first effect implies lower electricity prices and therefore increased electricity demand; however, the effect on electricity demand is small because of the low price elasticity of electricity demand. The result of the first effect, if anything, is to increase fuel use, and in particular coal use, by power plants. The implications of the second effect for the fuel mix depend on the economics of fuel use for power generation and technical constraints for fuel switching. Fuel use economics favours the use of coal in existing plants in the short term (vs the use of gas in new plants) and the use of coal in both existing and new plants in the long term. The long life of power plants results in considerable inertia in the composition of the capital stock and limits fuel switching capabilities in the power generating sector. It is only for new plants that coal's attractiveness could be modified by subsidy removal; there is not much need for new capacity until 2000 and coal is the cheapest option for new plants after 2000. Therefore, the role of coal in the power generating sector is unlikely to be affected much by the removal of subsidies, but the coal will be imported.

Figure 7.3 shows the change between scenarios of production and import levels for the six countries where subsidy phase-out engenders significant changes to the market. The net dominant effect of the elimination of coal subsidies is to replace domestic coal with

Figure 7.1: **Coal production in two scenarios**

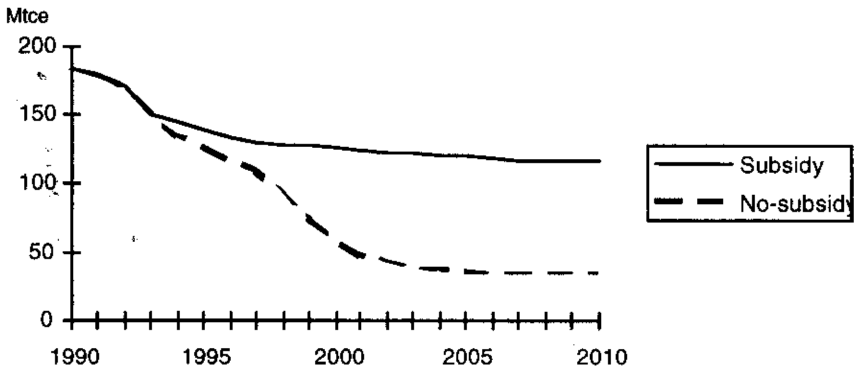
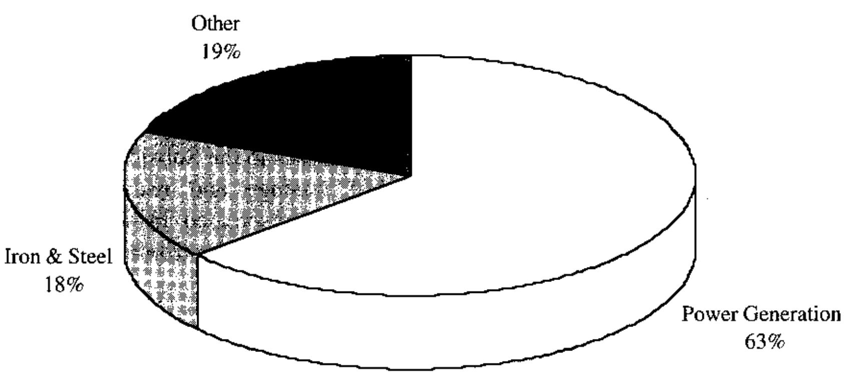


Figure 7.2: **Breakdown of OECD coal demand by sector in 1990**

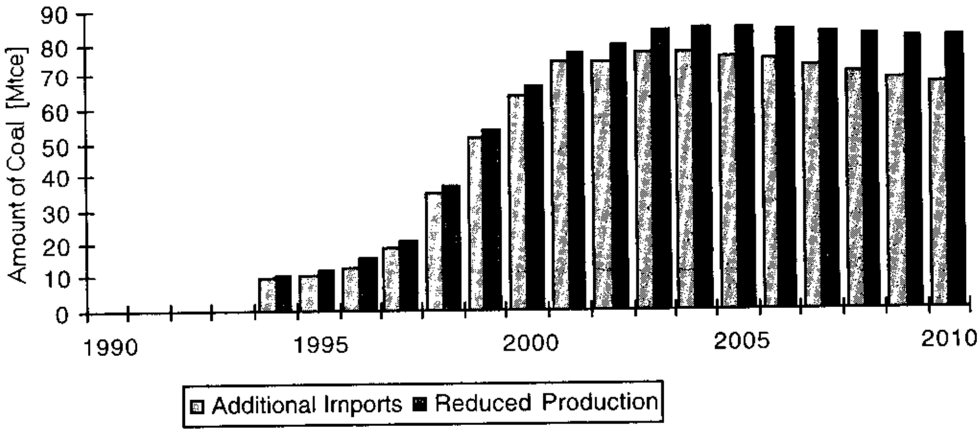


imported coal. Because of the small increase in electricity demand between the Subsidy and No-Subsidy scenarios, there is more use of gas in power plants than there would be if coal subsidies were maintained, but the increase is small. Thus, overall, removing subsidies has little impact on total primary energy demand, on the fuel mix, or on the level of energy prices.

7.3 Effect on world coal trade and prices

If PSEs were reduced to zero in OECD countries, coal imports in the countries covered by the study, and hence world coal trade, would be 80 million tonnes higher than in the Subsidy scenario; this represents a 15% increase in world coal trade. However, the increase would not likely result in significant upward pressure on world prices, because of ample spare production capacity. While in the Subsidy case, coal prices are expected to remain virtually flat in real terms, they are expected to increase by slightly more than 1.3% p.a. in real terms between 1997 and 2010 in the No-Subsidy scenario. By 2010, the price of internationally traded coal is 15% higher with coal subsidy phase-out than in the Subsidy scenario; however, this difference does not alter the competitive advantage of coal for power generation.

Figure 7.3: **Coal production and imports (six countries): Difference between scenarios**



7.4 Environmental and economic effects

As the removal of existing OECD subsidy regimes does not lead to substantial modifications in energy markets, imported coal largely taking up the markets abandoned by domestically produced coal, few environmental benefits would be realised. CO_2 emissions would be reduced slightly compared to a situation where subsidies are maintained, because of a very limited amount of substitution of gas for coal. Benefits would be more substantial in terms of SO_2 emission reduction, as both British and Spanish coal have a higher sulphur content than most imported coal [there would not be much difference in Germany because of widespread use of flue-gas desulphurisation (FGD)]. Impacts from increased coal transport would have to be assessed.

Given the low energy price and demand impact of removing coal subsidies, and the small contribution made by this sector in overall economic output, the macroeconomic impact of subsidy removal is very limited. The countries covered would save up to $10 billion per year by 2005 by phasing out subsidies to the coal sector. However, this represents only 0.05% of GDP and 10% of government expenditure for the six countries.

There will be a negative impact on jobs directly associated with coal mining activities. However, as coal industries are no longer large employers in any of the countries studied, the effect will be small, though there may be important regional implications. The total impact on employment is estimated at 174 000 jobs lost as an immediate result of mine closures in the No-Subsidy scenario relative to the 1992 level of coal mining employment, with around 70 000 job losses in the Subsidy scenario resulting from natural wastage and resource exhaustion. Some jobs would be created in activities associated with coal importing and distribution.

7.5 Effects of including other forms of coal subsidies

The PSE methodology used in this study focuses on aid to current production, and has the advantage of being a widely accepted approach which can be applied consistently across countries using easily available data. It can be argued, however, that the approach is too narrow.

For OECD countries, one way to extend the definition of subsidies is to attempt to measure the subsidy implied in market restrictions resulting from monopolistic structures in consuming industries, and to include direct consumer subsidies (such as government sponsored RD&D and grants for coal burning installations).

The PSE does not take into account environmental externalities, and the failure to include external costs in the pricing of coal can be considered as an implicit subsidy. The practical difficulties of defining an approach to include external costs are formidable, in terms of arriving at a commonly acceptable definition of which externalities to include, assessing their cost in different economic contexts, and gathering consistent and reliable data to support a meaningful analysis of the subsidy impact of externalities. The methodological framework for assessing the cost and impact of environmental externalities is an area which could justify a further research programme.

It is also likely that a far different result would arise from the removal of subsidies to coal in non-OECD countries. The reason is that subsidies are used in some countries to reduce the price paid by consumers, and their removal would have the effect of a large price increase. This would be likely to induce energy conservation investment and fuel-switching away from coal, and hence lead to a reduction in emissions.

Chapter 8

Modelling "Supports" to the Electricity Sector in Australia

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ABARE

8.1 Introduction

This is a summary of the key elements of a more detailed report on "supports" to the electricity supply sector in Australia[1]. The notion of "supports" is interpreted broadly to include not only explicit and implicit subsidies of inputs into electricity supply but also market distortions in the sector more generally. The distortions themselves can be instances of either market failure or intervention failure.

The focus in this case study is the extent to which any such distortions might increase emissions of CO_2 from the energy sector. CO_2 accounted for 92% – on a CO_2 equivalent basis – of the greenhouse gases (other than fluorocarbons) emitted in 1990 by the Australian energy sector. The supports and market distortions considered are those that were provided in Haurie's initial "Framework" report on the conceptualisation of the project. Distortions that could only be analysed qualitatively are first considered, followed by least cost modelling of selected cases in the remaining categories.

Many of the identified market distortions are being addressed through microeconomic reforms in the electricity supply sector and, because of its potential importance as an electricity input, the natural gas sector. These reforms are described in the first section of the full report. This is followed by a presentation of the modelling method. As in the analysis of the Italian electricity sector elsewhere in this study, the approach involves using the MARKAL optimisation model of the energy sector. The Australian variant of this model is known as MENSA.

8.2 The electricity supply industry in Australia

8.2.1 Industry overview

Australia in 1994 had an installed electricity generating capacity of 37.25 GW, producing around 167 TWh a year, an increase from 91 TWh a year in 1979. Final consumption in 1994 was 140 TWh or 7 865 kWh per person. Coal-fired power stations provided 80% of generation, with peak and intermediate load mainly supplied from hydroelectric and gas-fired stations. Nuclear power is not used for electricity generation in Australia.

At present only New South Wales, Victoria, South Australia and the Australian Capital Territory are interconnected to form an interstate grid network. However, interstate electricity trade represents less than 3% of total electricity consumed within the states.

Aluminium smelting is a significant industrial consumer of electricity, benefiting from efficient, inexpensive coal-based electricity in Australia's eastern states, New South Wales, Victoria and Queensland. In 1994 it accounted for most of the 20% of national electricity consumption stemming from

1. The study summarised here has been published as "Supports to the Energy Sector in Australia", in "Supports to the Coal Industry and the Electricity Sector", vol. 2 of "Environmental Implications of Energy and Transport Subsidies", OECD/GD(97)155, OECD, Paris.

Table 8.1: **Primary energy use and CO_2 emissions, Australia, 1990**[a]

Primary energy use	direct allocation[b] '000 PJ	end use basis[c] '000 PJ	CO_2 EMISSIONS direct allocation[d] Mt	share %
End use sector				
Residential	160	297	6.6	2.3
Industrial	643	878	31.9	11.2
Commercial	47	141	2.6	0.9
Transport	1157	1163	79.1	27.8
Other end uses	164	164	0.0	0.0
TOTAL END USE	2171	2642	120.2	42.3
Processes etc.	305	303	29.5	10.4
Energy for electricity	1566	1529	131.1	46.3
TOTAL	4043	4003	280.8	100.0

a. Data derived from MENSA simulation results.
b. Petajoule electricity not allocated to end uses.
c. Electricity generation attributed to the end–uses to which electricity is an input.
d. CO_2 emissions from electricity generation attributed to that sector rather than to end–uses to which electricity is an input.

non-ferrous metals production, this proportion having increased from 6% in 1980.

As shown in Table 8.1, in 1990, electricity generation accounted for 46% of CO_2 emissions from the energy sector compared with 28% from transport fuels.

8.2.2 *Competitive market reforms and their implications for greenhouse gas emissions*

Reforms in the electricity supply industry are designed to promote competition among generators and at the retail level. State-owned transmission grids are regulated to ensure that pricing is transparent and reflects costs, and to provide non-discriminatory access.

While the primary objective of reform is not specifically to reduce greenhouse gas emissions, it is possible to identify effects of reform that could reduce such emissions. These effects include:

- the adoption of pricing structures for electricity that are more cost reflective;
- the removal of implicit support to interest on loan capital;
- an increased role for private generation, including co-generation.

Some aspects of microeconomic reform have ambiguous effects on emissions. These aspects include removal of cross-subsidisation among categories of consumers; some impacts of increased gas and electricity trade; and productivity improvements that may encourage electricity use through an income effect.

8.3 Supports and market distortions not modelled

The "Framework" report identified support for research and development, tax policies and subsidies (including cross-subsidies) to users as some of the areas in which implicit supports might have impacts on costs and emissions. Modelling difficulties precluded quantification of these impacts. However, the full report provides some qualitative discussion.

For example, most state governments have taken initiatives over the past few years to reduce cross-subsidies to residential customers, in most cases by holding domestic tariffs constant and reducing business tariffs. There is some evidence that commercial and industrial electricity use is more responsive to prices than consumption in the residential sector. Commercial and industrial consumption accounts for an average of around 60% of total electricity consumption across states. The effect of the removal of such cross-subsidies on prices will influence CO_2 emissions, but the net effect is not clear.

Interregional cross-subsidies have involved uniform tariff pricing policies throughout most states, in terms of both the initial costs of connection to the grid and the ongoing costs of supply. In some cases, extending the grid to rural areas is economically unviable and the adoption of cost reflective pricing could involve substantial increases in the price of grid connection and electricity supply to remote users. By increasing the price of grid connection, reform can be expected to promote a greater use of remote area power systems (RAPS) at the expense of fossil fuelled, grid-based electricity. RAPS may involve stand-alone diesel generators. However, where RAPS can also make efficient use of renewable sources, saving diesel fuel (and associated costs), then some cost-effective reduction of CO_2 emissions may be possible.

8.4 Supports and market distortions modelled using MENSA

MENSA – *M*ultiple *E*nergy *S*ystems of *A*ustralia – is the Australian version of MARKAL, an intertemporal, optimising, linear programming model of national energy systems developed under the auspices of the International Energy Agency (IEA). The basic structure of MENSA is shown in Figure 8.1. The model involves not only the electricity sector, but also the main associated markets for its inputs and outputs, and other energy submarkets such as transport. MENSA incorporates a regional structure because Australia's energy system involves dispersed nodes of supply and consumption corresponding to the six states of the federal system. Each state possesses characteristic regional features in terms of energy resources and markets. Patterns of electricity generation and uses – and natural gas sources and uses – can differ widely among the states.

ABARE's initial use of MENSA to indicate costs and consequences to the energy system of meeting upper limits to greenhouse gas emissions from the Australian energy sector is documented in Jones, Peng and Naughten (1994)[1]. The model framework has also been used in several analyses of intervention failure and market failure in the energy sector, some of which are noted below. The model is therefore well suited to case studies of a range of market distortions associated with the Australian electricity sector.

The model results indicate for each case study or "test simulation", the difference in emissions and in total discounted cost, energy systemwide, compared with the base case and another benchmark simulation involving a constraint on CO_2 emissions. These cost differences, measured in 1990 Australian dollars, apply to the energy system as a whole for the full projection period (1990-2020) and are discounted to 1990 at an 8% real rate.

In the two benchmark cases, the various market distortions are assumed to be absent, whereas the test simulations indicate the cost to the system of each distortion examined. In the first benchmark case, a least cost simulation (the base case), no upper limit is placed on energy sectorwide CO_2 emissions. In the case of the "1990 stabilisation target" benchmark, these emissions are constrained to return to 1990 levels by 2000 and to remain at that level. In this latter case, the MENSA results indicate that, where none of the listed market distortions are present, the cost to the energy system of meeting this emissions target is A$ 5.7 billion (in 1990 Australian dollars) or 0.11% of discounted GDP projected over the forecast period.

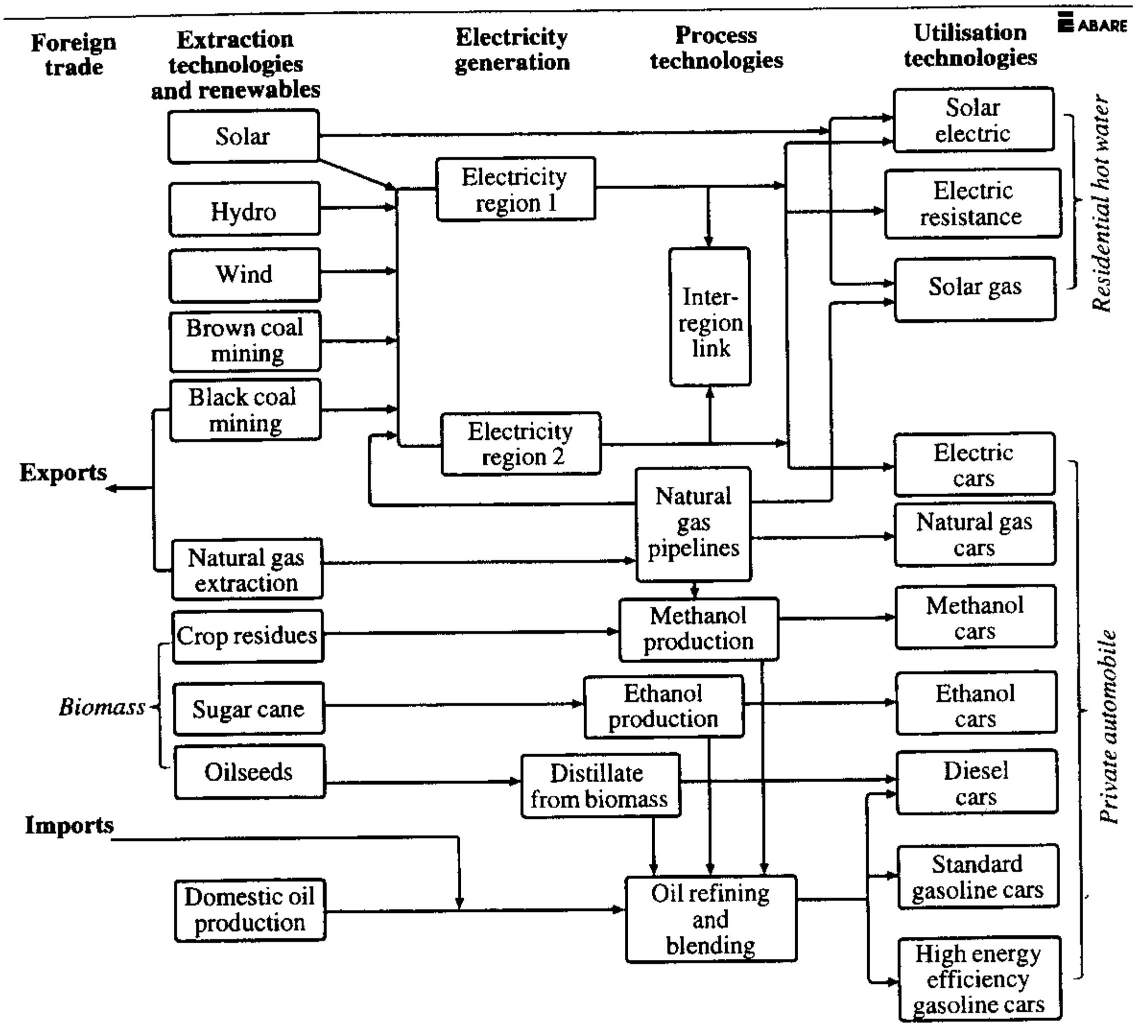
It should be noted that these "energy system costs" do not account for possible impacts on non-energy sectors or international trade-related effects associated with the international adoption of emissions abatement targets. When such effects are accounted for, the increase in estimated cost can be substantial. With recent estimates of GDP loss using the MEGABARE global general equilibrium model, it is possible to determine the economywide cost in Australia associated with applying the 1990 stabilisation target in all OECD countries. This cost (1990 dollars and discounted to 1990 at 8%) was $A 14.3 billion. The case studies are described in the following sections.

8.5 Removal of indirect support to a fossil fuel

It has been argued that an implicit subsidy is being provided to the coal industry by the state gov-

1. See the complete study (referenced in note 1) for references mentioned in the text and for sources for the figures cited.

Figure 8.1: **Part of a typical energy system in MENSA**[a]



a In this schematic representation only two out of the many end uses represented in *MENSA* (residential hot water systems; private automobiles) are included as examples. In the former case there are separate specifications for each state, whereas for automobiles (and other transport) there is just one set of specifications nationwide.

ernment in Western Australia through the construction of the Collie coal-fired power station and consequent displacement of a more cost effective combined cycle gas turbine (CCGT) power station.

The total additional discounted cost of enforcing construction and use of a new 300 MW coal-fired power station to come into service in 2000, rather than the CCGT option, was indicated by an unconstrained least cost simulation of the model. With a 1990 stabilisation target in place, the MENSA modelling indicated that it is almost twice as costly to enforce this option rather than allowing construction and use of a less carbon-intensive, gas-fired station. This increase occurs because, with the requirement that Collie be installed, keeping systemwide CO_2 levels at or below 1990 levels will require higher cost measures throughout the rest of the energy system.

However, it is important to keep this case in perspective: the capacity of this Collie station is equivalent to 0.8% of the total Australian generating capacity of

37.2 GW (1994). Furthermore, implicit support to a carbon-intensive primary fuel input is not typical of the Australian electricity supply sector as a whole.

8.6 Trade policies: new interState connections for gas and electricity

The major existing interstate electricity and gas interconnections are indicated in Figures 8.2a and 8.2b. For modelling purposes, only the effect of new interstate gas pipelines was investigated in this study. Of the types of benefit that can be readily captured in the MENSA framework, these estimated gains are significantly greater than those from new interstate electricity connections.

Measured against the base case with no imposed upper limit on CO_2 emissions, blocking the extension of interstate gas pipelines results in increased energy system costs of A$ 960 million or 0.018% of discounted GDP.

The role of interstate gas pipelines in reducing the cost of meeting upper limits on CO_2 emissions is illustrated by the 1990 stabilisation target case. MENSA least cost analysis indicates that, in the absence of new interstate gas pipelines, the cost of achieving this target would be increased by A$ 4.4 billion to A$ 10.1 billion (an increase of 0.082 percentage points to 0.192% of discounted GDP when the cost of meeting that constraint on emissions is included). This increase would stem in part from significantly reduced substitution of gas for coal in electricity generation.

8.7 Removal of implicit capital subsidies and expanded cogeneration

Prior to microeconomic reform, capital subsidies to the electricity supply sector were typically granted through loan guarantees and the provision of government loans at interest rates that did not fully compensate for the market cost of funds including some allowance for risk of default.

The impact of implicit subsidies on loan capital used in the electricity supply sector, and hence on CO_2 emissions, depends on the technologies and fuels available and their cost structures. A comparison of direct relevance to the Australian experience is that between coal-fired thermal capacity and natural gas CCGT. The former is significantly more capital-intensive and also happens to be more carbon intensive. Hence, if implicit subsidies to capital were removed, a consequent switch from investment in new coal-fired capacity, with its higher capital intensity and longer lead times, to investment in CCGT will tend to reduce CO_2 emissions cost effectively.

To put this comparison in the form of an arithmetic example, consider the case of a discount rate of 8% as representative of rates used by a vertically integrated public utility, and a higher risk inclusive rate that might be required, for example, by a private generator – say 15%. The relative economic position of CCGT significantly improves relative to coal-fired stations when the required return is increased from 8% to 15% real rates. For example, on the basis of technology and fuel costs cited in the full report, the ratio of the discounted cost of the coal-fired option to that of the CCGT option (at their commissioning dates) increases from 0.95 at an 8% discount rate to 1.29 at a 15% discount rate.

An increasing preference for more modular technologies such as CCGT reflects a growing perception of the risk associated with longer lead time and more capital-intensive technologies. In Australia this perception was reinforced by the experience of the 1980s investment boom in electricity capacity. A surplus of coal-fired capacity emerged when this growth was not matched by consumption growth. The advantages of more modular technologies, even after taking account of the economies of scale of conventional coal-fired capacity, have been reviewed by Australia's Industry Commission.

8.7.1 Industrial co-generation

Another important example of a less capital-intensive, more modular technology is industrial co-generation. It involves the joint production of electricity and process heat, usually in or for privately-owned industrial plants. Again, the removal of any implicit subsidies to capital, or any increase in the required rate of return, is likely to improve the economics of industrial co-generation.

Two other microeconomic reform mechanisms may also encourage industrial co-generation. Gas is a preferred fuel for a decentralised technology such as industrial cogeneration. The deregulation of interstate trade in natural gas will further encourage industrial cogeneration from this source by making gas cheaper and more readily available. The other mechanism that

Figure 8.2a: **Australia's high voltage electricity transmission networks (schematic)**

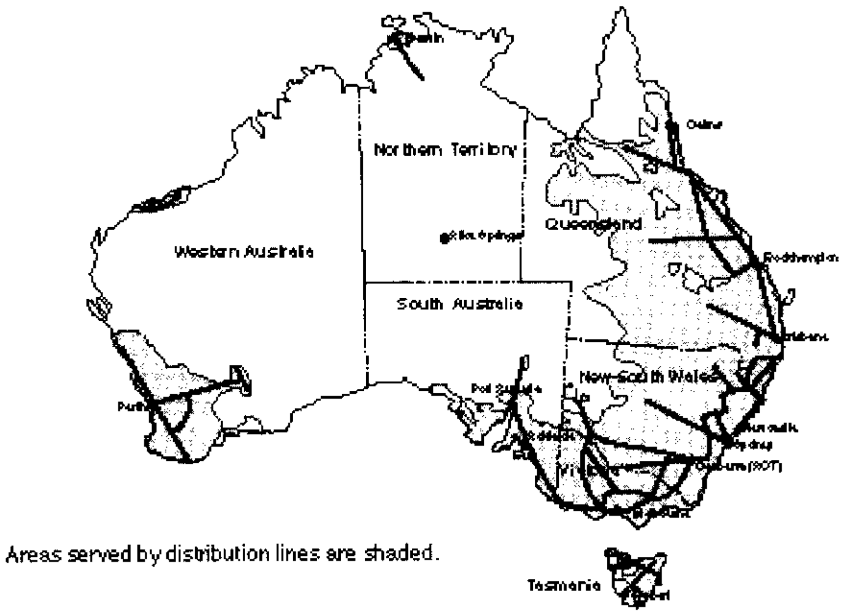
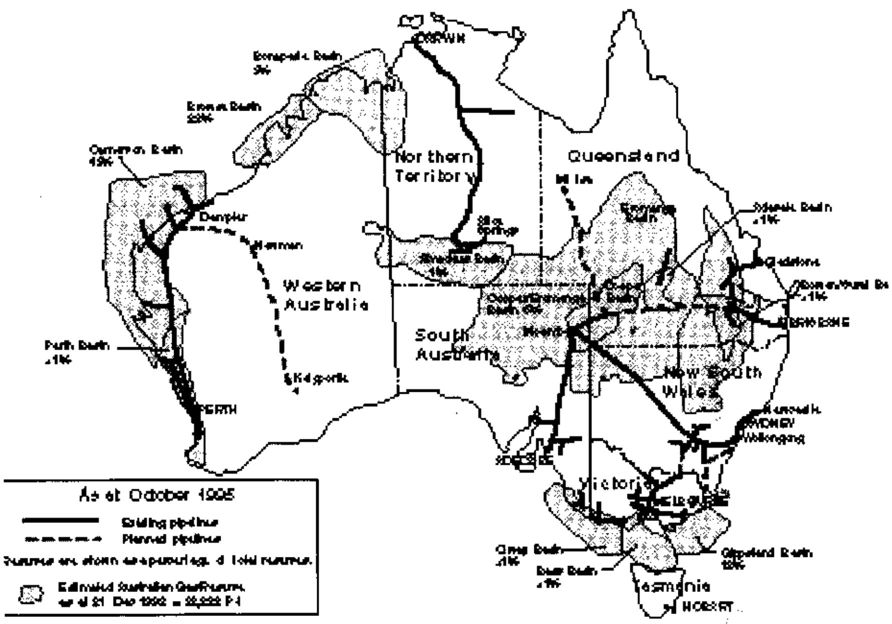


Figure 8.2b: **Location of natural gas transmission pipelines, Australia, 1995**



Source: ESAA, 1995

could encourage cogeneration is the establishment of non-discriminatory terms of access for the sale of private generators' surplus electricity to a nationally interconnected grid. Such access is to be implemented under a proposed national Code of Conduct. Non-discriminatory access provides greater investor confidence that surplus electricity can be sold to the grid and hence promotes investment in technically more efficient technologies such as high pressure boilers that allow improved conversion efficiencies in electricity generation along with process steam. A modelled technology specification reflecting these improvements is referred to as the "new cogeneration".

The modelling results indicate that an increasing role could be played by the "new cogeneration" in reducing greenhouse gas emissions. A "business as usual" case was defined, based on the levels of cogeneration with conventional co-generation technology. This was compared with the benchmark scenario, which incorporated the new technology. In the case incorporating the "old cogeneration" there was an increase in systemwide discounted cost of A$ 650 million, or 0.012% of discounted GDP, in the absence of a CO_2 constraint. With a 1990 stabilisation target, the estimated cost increased from 0.110% of GDP to 0.154%. The cost savings available with "new cogeneration" come from the displacement of higher cost technologies and fuels in both the generation of electricity and the production of process heat for use in industry. With the target in place the greater cost reduction reflects displacement of more carbon intensive coal-fired electricity and direct use of coal in industrial boilers.

8.8 Conclusion

The full report describes a range of market distortions associated with the Australian electricity supply sector but notes that many of these are being vigorously addressed in a programme of microeconomic reform in the sector. Costs associated with some of these distortions have been assessed using the Australian version of the MARKAL model. Among the modelling results were that removing restrictions on new natural gas pipelines between the states could significantly lower the cost of reducing CO_2 emissions. Through several mechanisms, microeconomic reform would tend to encourage increased cogeneration, in turn offering significant opportunities to cost-effectively reduce CO_2 emissions.

Chapter 9

Environmental Implications of Supports to the Electricity Sector in Italy

Giancarlo Tosato, ENEL

9.1 Introduction

As a whole, the Italian energy supply sector is not neutral to taxes and subsidies. The oil sector is heavily taxed and is generally a net donor to the rest of the economy. On the other hand, the Electricity Supply Industry (ESI) in Italy is nearly neutral to Government imposition, since under the form of different net subsidies, it receives public funds nearly equivalent to the amount it pays to the government in taxes or other impositions. Cross subsidies between different producers and consumers are also distorting the electricity market.

Broadly speaking, a subsidy is any intervention or failure to intervene that results in price distortions or variations in production and consumption volumes relative to the situation that could be expected to obtain in a fully competitive market with all social and environmental costs internalised. For practical reasons, the scope of the study presented here has been limited to financial subsidies; other economic subsidies have not been analysed due to the difficulties involved in quantifying their amount and impact[1].

Regardless of the particular subsector or field of application in question, one can make a distinction between two basic types of subsidy. For the purposes of the analysis summarised here, a *net subsidy* is defined as a financial transfer from the economy as a whole to electricity producers and consumers, while a *cross subsidy* is a financial transfer from one subsector of the electricity market to another. Both types of subsidy distort the market and make actual prices different from long-term marginal prices. Net subsidies in particular, reduce the relative price of electric energy and power compared to the price of other commodities, and increase consumption levels above the equilibrium point. Cross subsidies modify the relative shape of electricity supply and demand curves, that is, they alter the equilibrium price of electricity and the volume and structure of electricity production and consumption.

In recent years, as various governments have explored reducing the negative environmental impacts of energy systems through fiscal instruments, the issue of energy subsidies has received international attention. In principle, eliminating existing subsidies to the energy sector and charging for energy services at their long-term marginal cost could result in significant environmental benefits. For this reason, the OECD Environment Directorate initiated a multi-year project on the environmental implications of energy and transport subsidies and undertook a series of case studies exploring the potential environmental effects of subsidy removal in different countries.

The present summary reports the main findings of the Italian case study, which focused on the Italian electricity sector. The first section briefly describes the financial subsidies of the Italian electricity market

1. The study summarised here has been published as "Supports to the Electricity Sector in Italy", in "Supports to the Coal Industry and the Electricity Sector", vol 2, "Environmental implications of Energy and Transport Subsidies", OECD/GD(97)155, OECD, Paris.

Table 9.1: **Subsidies to the Italian electricity sector**[a, b]
(million $)

SUBSIDY	TYPE	1990	1991	1992	1993	1994
1. Spending programmes		**33**	**41**	**158**	**127**	**83**
1.1 RDD&D	net	0	0	0	0	0
1.2 Direct aid	net	33	41	158	127	83
2. Indirect aid		**794**	**367**	**843**	**1080**	**1063**
2.1 Procurement preferences	net	0	0	0	0	0
2.2 Other indirect subsidies	net	794	367	843	1080	1063
3. Capital subsidies		**1738**	**1154**	**1767**	**1338**	**708**
3.1 Equity participation	net	712	707	844	978	504
	cross	46	47	48	42	0
3.2 Loans at preferential rates	net	749	432	611	-293	-32
3.3 Loan guarantees	net	0	0	0	0	0
3.4 Debt forgiveness	net	278	14	313	654	236
4. Tax policies		**1732**	**2418**	**2034**	**2035**	**1719**
4.1 Preferential treatment	net	483	570	610	630	719
4.2 Exemption from excise tax		1163	1506	1037	1046	1000
suppliers	net	960	1211	719	714	688
consumers	net	203	295	318	333	313
4.3 Tax credits		86	342	388	359	0
4.4 Local rates/franchise fees	net	0	0	0	0	0
5. Trade policies		**872**	**1262**	**1119**	**1641**	**0**
5.1 Import-export taxes-supports	cross	872	1262	1119	1641	0
5.2 Non tariff trade barriers	net	0	0	0	0	0
6. Energy and related policies		**3621**	**4159**	**3614**	**3968**	**971**
6.1 Managed non com. contracts		749	793	828	714	971
selfproducers	cross	124	168	203	89	346
consumers (estimate)	net	625	625	625	625	625
6.2 Energy planning	cross	28	46	43	59	0
6.3 Price regulation	cross	36	37	40	38	0
6.4 Production subsidies	cross	2809	3283	2704	3157	0
7. Subsidies to complements & customers	net	**54**	**70**	**77**	**81**	**93**
8. Implicit environmental subsidies	net	**0**	**0**	**0**	**0**	**0**
TOTAL	**NET**	**4050**	**3919**	**4226**	**3806**	**3229**
TOTAL	**CROSS**	**4794**	**5552**	**5388**	**6464**	**0**
Total value of ENEL production		16750	18610	20398	21305	23431
Total taxes on the electricity sector		na	na	3388	na	na

a. positive values indicate subsidies; to convert to billion lire multiply values by 1.6.
b. zero or blank cells indicate that data are not yet available.

in the early 1990s. An attempt has been made to draw up a comprehensive list of net subsidies and cross subsidies associated with electricity production and use. Using a specially developed modelling exercise, the second section evaluates the environmental impacts likely to result from a full or near-total elimination of these subsidies. While in most cases, eliminating electricity subsidies can have a positive effect on the environment, it should be recalled that subsidy removal can have other important effects, including negative social impacts on low income classes, occupational and competitiveness drawbacks on electricity-intensive sectors, and organisational and management changes in the energy supply industry. These consequences must be taken into consideration by policymakers before a final conclusion on subsidy removal can be reached. Such factors, however, are outside the scope of the present study and must be evaluated using different methodologies.

9.2 Scale of financial subsidies to the Italian electricity sector

Although the subject is relevant to the analysis of the energy market, evaluations of electricity subsidies are less frequent in the literature than analyses of electricity fees and taxes. Accordingly, it was necessary to undertake a sort of "field survey" for the study summarised here. Identifying and evaluating the subsidies (summarised in Table 9.1) was a daunting task, involving research into electricity industry accounts, a comprehensive review of national taxation policies affecting the electricity industry, the industry's inputs, and the energy forms with which it competes. These difficulties may partly explain the gap in the literature. The relative scarcity of information on the subject might also be explained by the reluctance of electricity producers to disclose information that might threaten the enormous subsidies they currently receive. In addition, the regulation of the electricity market has been complicated by the fact that many of the regulations enforced in the last few decades contradict or interfere with one another. Enforcement of the regulations is sometimes not carried out in a transparent manner, and the information supplied in the financial reports of the actors enforcing the regulations is not always sufficient to permit a clear understanding of the problems involved.

The main finding of our analysis of subsidies to the electricity sector in Italy is that in the early 1990s, distortions from existing regulation affected about 40% of the electricity market, excluding non-financial interventions. The net public support of the economy to the electricity market has been in the range of 15-20% of the value of electricity production; cross subsidies among different consumers and producers amount to 20-25% of the market.

9.2.1 Net subsidies

Taking into account net subsidies only, during the early 1990s, an average of approximately $3-4 billion was transferred annually from the economy to the electricity sector. This value represented 24% of the value of the energy produced by the state-owned electricity company ENEL in 1990, but fell to 18% in 1993. The amount of taxes transferred from the electricity sector to the economy is slightly lower.

The most significant net subsidies are described below (Table 9.1):

- the fossil fuels used for thermoelectric production are not taxed (or only slightly taxed), while the same fuels are heavily taxed when they are used for other industrial purposes; this exemption from excise taxes amounts to an yearly value of around $1 billion during the years 1992-94;

- electricity suppliers are permitted to operate with an economic margin lower than most companies; this capital subsidy takes the form of equity participation, loans at preferential rates, loan guarantees and debt forgiveness; it amounted to $1.7 billion/y in the years 1990 and 1992, but has been reduced to $0.7 billion/y in 1994;

- private consumers of electricity receive a total of $0.6 billion of support from the rest of the economy, since the Value Added Tax on electricity is only 9%, while the general value is 19%;

- selected industrial producers (such as some steel makers and all non-ferrous metal producers) and service operators (such as railways) benefit from an overall discount of about $0.6 billion/y.

The observed values, regardless of the uncertainty of some figures, show a decreasing trend during 1990-1994, mainly because capital subsidies were halved during this period. By comparing this trend with the ESI privatisation process and its development over time, a correlation between the two phenomena becomes apparent. However, the trend followed by the other principal net subsidies is not affected by the ESI privatisation process; reducing these subsidies will require a broader intervention.

9.2.2 *Cross subsidies*

The financial transfers among different electricity subsectors are increasing, and have grown from less than \$5 billion in 1990 to \$7 billion in 1994. The total amount of cross subsidies is not far from the total value of the Equalisation Fund. The two major components of this value are:

- compensation to thermoelectric producers in order to bring their marginal production costs down to a level nearer to the average; this cross subsidy ranged from \$2.7 to \$3.5 billion in the early 1990s;
- support to electricity imports which compensates ENEL for the loss of revenue incurred by shutting down obsolete and inefficient thermoelectric plants; the amount of support increased from \$0.9 billion in 1990 to \$1.7 billion in 1994.

The total amount of cross subsidies has increased by more than 50% in five years; their weight relative the value of ENEL production increased slightly from 28% to 31%, even though imported oil prices decreased slightly across the same period. This was perhaps due to the increased share of cleaner fuels (natural gas and low sulphur diesel fuel), which provoked an increase in the prices of thermoelectric fuels beyond the increase of the general index of industrial production prices (+3.4% in the same period).

The present increasing trend of cross subsidies demonstrates that no measures have been taken to reduce their importance. Reducing the magnitude of cross subsidies and simplifying their regulatory structure will be among the principal tasks of the newly-appointed Authority for the Regulation of Electricity and Gas Markets.

9.2.3 *International comparison*

Subsidies to the energy sector, and mainly to electricity, exist in most countries; the difference between internal energy prices and the international prices, multiplied by the amount of energy consumed amounted to \$215-235 billion in 1993.

The most significant single subsidy is the support to the coal industry, which is in the last analysis a support to thermoelectric production; it amounts to about \$11 billion in the OECD countries (\$6.7 billion in Germany alone). Other relevant subsidies have been quantified for countries including the USA (federal subsidies for the production of electricity are of the order of \$10-20 billion/y), Russia (nearly \$10 billion/y) and the U.K. (nearly \$4 billion/y). In other important countries (e.g. France) the value of energy subsidies has not yet been quantified and is not available.

A comparison of these international figures with the Italian subsidies quantified by the present study seems to indicate that Italian energy subsidies are far more important than those in other countries. Actually, the sectoral studies undertaken in other countries are usually limited to the analysis of a single subsidy, while the present study covers all electricity subsectors and all types of subsidy.

9.3 Implications of the subsidies

While the financial value of the various subsidies examined here is a measurable quantity, and can be compiled from economic balance sheets, laws and regulations or from statistical yearbooks, an evaluation of the economic, industrial or environmental impacts of the subsidies cannot be based on such observations. When the amount of a subsidy is changed, the effects are usually not significant enough to be distinguished from the effects of other changes; the price elasticity of the market, on the other hand, is partially determinable. On the basis of this kind of information, the evaluation of other effects must be carried out by means of a theoretical exercise. In the case of the present study, the tool used to carry out this exercise was a linear programming model designed to make technical, economic, energy and environmental estimations across several different time periods. The model was constructed with the MARKAL software (see the Note on Methodology further along).

The implications of the subsidies for the electricity market, environmental control costs and social costs were assessed by comparing the differences between the projections of future development in 1) an ideal situation without subsidies (referred to as the benchmark scenario) and 2) a distorted one, where some or all subsidies have been retained. The model also sought to explore the likely effects of environmental management policies. For this reason, in addition to the elimination of subsidies, the benchmark scenario also assumed the implementation of a vigourous emissions control policy. In addition to the control of acid precursors (SO_2 and NO_x) agreed under the international protocols of which Italy is a signatory, a carbon tax with a marginal cost of $50/t$CO_2$ was assumed in the benchmark scenario. For the sake of comparison, the potential effects of subsidy elimination and of keeping subsidies are also evaluated in the absence of the CO_2 tax.

Due to the method used, the projected effects of subsidy removal and environmental control programmes involve a number of uncertainties and require further demonstration. The assessment of the financial value of the subsidies presented in the previous section, on the other hand, is subject to considerably fewer uncertainties.

9.3.1 *Implications for the electricity system*

The marginal price of electricity in the model changes according to the hour of the day, i.e. it depends on the point in the load duration curve. During peak hours, electricity has a marginal price of about $0.17/kWh in the year 2000, when CO_2 control policies are adopted and subsidies to the electricity system are removed (i.e. in the benchmark scenario), but less than half that during off-peak hours. The prices change according to scenario: the marginal price in the year 2000, averaged over different hours, is about $0.115/kWh in the benchmark scenario but about $0.080/kWh if the subsidies are maintained. Since the marginal production technologies are thermoelectric power plants, and change fuels or cycles according to the peak demand level, the marginal price reduction is mainly due to the effects of the public support to thermoelectric production from fossil fuels – heavy oil first, coal and natural gas by a reduced amount – both in the form of cross-subsidies from the Equalisation Fund and due to exemption from excises.

If the market is subsidised, electricity demand increases by about 4 TWh/y as an effect of lower prices. This value is negligible compared to the total net electricity demand projected for the year 2000 (275 TWh/y). However, when the restricted end-use markets for electric power (price dependent in the present ideal experiment) and the long lifetime of existing devices are taken into consideration, the increase in demand becomes much more significant. No changes are detected in the model for electricity demand in the industrial sectors, where all of the most efficient devices are "no-regret", i.e. they are always introduced in a cost-optimised system, independently from CO_2 control or from subsidies. When subsidies are active and marginal prices decrease, electricity demand in the residential sector increases by about 5% for a total projected demand of 66 TWh/y in the year 2000. This rise is due partly to an increase in the useful energy demand, particularly in the forced electricity-use sectors, and partly to a shift from natural gas or light oil in warm water and space heating uses, which is presently estimated at about 11 TWh/y. It is worth noting that the electricity subsidy has a direct effect of increasing electricity use and an indirect effect of increasing the diffusion of district heating produced by co-generation plants. The increase in consumption is mainly due to VAT reductions for residential uses of electricity and to the cross-subsidy from the Equalisation Fund.

Two other observations can be made concerning the differences between the subsidy and no-subsidy projections. First, as one might expect, the magnitude of the existing subsidies to traditional thermoelectric production is such that their presence or absence has direct consequences on the share of electricity produced by plants using renewable feedstocks. If existing subsidies are maintained, the share of electricity produced from renewables falls an average of 2 to 4 percentage points compared to the no-subsidy case. The first situation, more or less predictable, is the direct consequence of the very substantial scale of present subsidies to the traditional thermoelectric production. The second observation, less obvious, shows that the share of independent producers over the total ESI is changing as well: in an ideal situation without subsidies, the share of the independent producers grows from the present 18% to nearly 30% in 2005, while with subsidies their share reaches 25%. This indirect effect is due to certain technical aspects of independent production, which uses combined heat and power plants. These plants are more efficient and permit independent producers to further reduce their electricity production costs by using or selling the heat. This technical advantage is enhanced in the absence of subsidies, which tend to reduce the production cost of traditional thermoelectric production regardless of plant efficiency. It should be noted, however, that these two observations are supported by less evidence than most of the others reported here, and are subject to independent confirmation.

9.3.2 *Implications for the cost of environmental control policies*

The control of acid deposition precursors (SO_2 and NO_x) in the medium term has been agreed by most European countries under different protocols negotiated or under negotiation in the framework of UNECE. Under these agreements, Italy must reduce SO_2 emissions from about 2.0 Mt in 1990 to about 0.7 in 2010; NO_x emissions will probably be reduced from about 1.9 in 1990 to about 1.5 in 2010. According to the model evaluation, the marginal cost of acid deposition or precursor reduction ranges from \$1/kg to \$5/kg, depending on the type of emission (sulphur oxides have the lowest values), the sector (nitrogen oxides from the transportation sector have the highest value) and the time frame of the emission reduction targets. The marginal cost of SO_2 and NO_x emission reduction does not vary significantly with the presence or absence of subsidies to the electricity sector.

The control of greenhouse gas emissions is more complex. As mentioned earlier, when rational decision-making criteria are assumed, "no regret" high efficiency equipment is adopted under all conditions, and its contribution to reducing CO_2 emissions is significant. However, the potential contribution of "no regret" options to reducing greenhouse gas emissions depends on a number of factors. Under conditions of strong, sustained economic growth, a rapidly growing demand for energy services will most likely make it impossible to realise a 50% reduction in greenhouse emissions across the next few decades (as recommended in the IPCC's recent Second Assessment Report) though "no regret" options alone. Accordingly, the assumptions for the benchmark scenario analysed in the present study include tight controls for greenhouse gas emissions, with a marginal cost of 50\$/tCO_2. If this "carbon tax" were implemented in Italy, carbon dioxide emissions from the Italian energy system could drop by 10% compared to the no regret case in the first decades of the next century and could contribute very significantly to stabilizing CO_2 emissions after 2000, even with strong economic growth. Emissions of carbon dioxide fall by about 40 MtCO_2 (compared to a total of about 420 MtCO_2 in 1990) with reference to the no regret case, for a yearly cost of about \$5 to \$8 billion/year.

If subsidies to the electricity system are removed, in both cases CO_2 emissions are lower: by 15 Mt CO_2/y if CO_2 control policies are not implemented, and by a further 10 Mt/y if CO_2 is controlled. This amount becomes more significant when compared with the CO_2 emissions of the ESI, about 120 Mt CO_2/y in 1990, a figure that could easily rise to 150 Mt CO_2/y in the year 2000.

When the situation modelled by the benchmark scenario – no subsidies and a CO_2 control policy – is distorted by altering the marginal prices of electricity through various subsidies, the total discounted cost of the system increases by about 0.1%. Removing all subsidies reduces the total discounted system cost by the same amount, regardless of the level of CO_2 emission control. However, when CO_2 is controlled, more than 50% of the cost improvement can be obtained through removal of capital subsidies, while the removal of cross-subsidies on fossil fuels for thermoelectric production yields an improvement of only 10%. In the free (untaxed) CO_2 emissions case, the capital subsidy accounts for 40% of the difference, while fossil fuel cross-subsidies account for more than 20%.

Investment accounts for about 25% of the total discounted system cost in the benchmark scenario and changes according to the level of CO_2 control and the presence of subsidies. If CO_2 emissions are not controlled, investments drop yearly by about \$600 million/y. The removal of electricity subsidies increases investment by about \$500 million/y. Of course, the capital subsidy has an opposite effect: the removal of capital subsidies reduces investment by about \$300 million/y.

Global CO_2 emissions are reduced by an amount ranging from one-third to one-half of what is required for stabilisation when all subsidies are removed. But not all public supports have the same impact: global CO_2 emissions may increase when only certain subsidies, such as import or capital subsidies are removed. It is clear that more CO_2 is emitted when electricity imports are not supported and are replaced by domestic thermoelectric production from fossil fuels. Less evidently, higher capital costs sometimes have the effect of delaying replacement of obsolete, less efficient thermoelectric power plants and slowing the introduction of new, highly-efficient and capital-intensive thermoelectric technologies.

9.3.3 *An approximate evaluation of the effects on social benefit*

In this context, the overall social benefit of the energy system, including primary energy supply, energy technologies and demand devices, environmental emissions and their control technologies, is approximated by the sum of the total discounted system cost plus the total discounted revenues from the CO_2 tax used to reach an acceptable level of emissions (in the present case, a $50/t$CO_2$ tax is sufficient to attain a near-stabilisation of emissions). In the terms of the present analysis, maximum social benefit is reached in the benchmark scenario, where CO_2 emissions are controlled and all subsidies to the electricity sector are removed.

The presence of subsidies to the electricity sector is currently associated with a social cost of $2.7 billion in annuity equivalent terms, a figure that rises to almost $5 billion in 2010. This cost is mainly due to net subsidies (which account for $1.3 billion annually) and of these, capital subsidies account for the most significant share ($1 billion). The social cost connected to cross subsidies is an estimated $0.7 billion annually, and is mainly due to the cross subsidy to fossil thermoelectric (see Table 9.2).

80 per cent of this social cost is due to losses in the economic efficiency of the energy system entailed by the subsidies, while the rest is due to the poor environmental efficiency of the subsidised system. In other words, from the perspective of environmental management, eliminating the electricity subsidies would yield a double dividend.

9.3.4 *Implications of subsidy removal in the absence of CO_2 controls*

When CO_2 emissions are uncontrolled, the emission-reducing potential of subsidy elimination becomes more significant. The removal of electricity subsidies is likely to increase the marginal cost of electricity by $0.035/kWh, and this increase has a higher relative weight when the carbon tax is not implemented. Another likely effect of subsidy removal under these assumptions is a 10% increase in the use of renewable energy sources.

The impact of subsidy removal on total system cost, CO_2 emissions and social benefit is affected by the degree of CO_2 emission control in different ways. First of all, the effect of subsidy removal on total system cost remains the same whether or not CO_2 con-

Table 9.2: **Incremental costs and CO_2 emissions resulting from electricity subsidies in Italy**
(values indicate increments over the benchmark, i.e. the case without subsidies and with a carbon tax of 50$/t$CO_2$)

Indicator: *annuity equivalent of:*	**Avg. annual sys costs (M$/y)**		**CO_2 emissions (Mt CO_2/y)**		**Social Cost (M$/y)**	
Avg. value in benchmark case:	$194.15 billion;		385.4 Mt			
Value for ESI in 1990:	$16.75 billion		122 Mt		$327.35 billion	
	$50/t CO_2 tax		$50/t CO_2 tax		$50/t CO_2 tax	
Subsidies in place	relative to base with tax	relative to no. subsidies	relative to base with tax	relative to no. subsidies	relative to base with tax	relative to no. subsidies
None	(base) 0	-147.4	(base) 0	40.1	(base) 0	1589
Cross subsidies:						
- to imported electricity	201.9	-26.1	-3.2	35.2	78	1474
- non-fossil to fossil fuel gen.	283.0	465.0	7.2	49.3	533	2540
- consumer cross-subsidies	15.3	-146.9	-0.6	40.1	1	1590
TOTAL CROSS SUBSIDIES	**624.5**	**461.5**	**0.9**	**46.8**	**633**	**2462**
Net subsidies:						
- 9% VAT on resid. sales (19%=norm)	117.1	-133.4	0.6	40.7	146	1623
- subsidies to capital invest. in ESI	1150.1	741.7	-5.3	43.4	1032	2644
- no excise tax on fossil fuel use	-49.3	13.1	3.0	46.0	68	1985
TOTAL NET SUBSIDIES	**1160.0**	**878.5**	**4.2**	**51.1**	**1286**	**2998**
TOTAL SUBSIDIES	**2184.9**	**2068.1**	**13.8**	**59.3**	**2689**	**4537**

trol policies are adopted. Without CO_2 control policies, the removal of subsidies causes an increase in average social benefit equivalent to $2.95 billion annually. This figure declines somewhat in the presence of controls, falling to $2.7 billion, because subsidy removal in the absence of controls results in a greater improvement of the economic efficiency of the energy system. (Note that this does not mean that overall benefits are lower when both CO_2 controls and subsidy removal is assumed, but only that the amount of social benefit directly related to subsidy removal is reduced.) Finally, subsidy removal alone is responsible for an average emission reduction of 19 $MtCO_2$ annually, while in the presence of CO_2 controls, the share of emissions reductions directly caused by removing subsidies (i.e. not counting the additional reductions due to the controls) drops to 14 $MtCO_2$ annually. Since this value (i.e. 19 Mt CO_2) is nearly half of the emission reduction likely to result from a $50/$tCO_2$ carbon tax, in addition to its other effects, eliminating subsidies to the electricity sector can be thought of as a partial surrogate to emission control policies.

9.3.5 Conclusions and implications

If subsidies are removed from the electricity sector, the likely effects include:

- a reduction of CO_2 emissions by a few percentage points;
- a slight drop in the cost of control of NO_x emissions from stationary sources;
- an increase in the average efficiency of electricity production;
- an increase in the market share of independent producers.

The quantitative scale of the effects is less than originally expected, considering the amount of the subsidies; this could be a result of the following factors:

- electricity demand in Italy is not very sensitive to changes in price;
- there are few substitution options for the Italian electricity supply industry.

The effects of removing subsidies are more pronounced in the long term because while they are important enough to alter competition between new plants, they are not significant enough to compel the replacement or shutdown of existing plants and end-use devices. Therefore, it is important to begin removing subsidies as soon as possible. Since the replacement process is slow, the longer subsidies remain in place, the longer it will take for the benefits of an eventual removal of subsidies to manifest.

Furthermore, the model used in the study shows that the effects of carbon dioxide emission control policies and subsidy removal are synergistic: when these measures are adopted simultaneously, the overall improvement is greater than the combined effect of each measure used independently. The removal of electricity subsidies continues to be effective in the long term, when the enforcement of carbon dioxide emission reduction policies is more likely; however, subsidy removal is even more effective, in both absolute and relative terms, in the intermediate period before quantified emission reduction and limitation objectives for a specified time frame have been agreed.

9.4 Note on methodology

The above evaluation of the environmental impacts of Italian energy subsidies was carried out using the MARKAL model generator developed by the IEA's Energy Technologies Systems Analysis Group in 1978-80 and continuously updated since then. A linear programming model of the Italian energy system was set up using this simulation tool. The model explores several time periods and can be solved on the basis of any of a number of objective functions. The costs of reducing CO_2 emissions were evaluated with the first version of the model database.

The MARKAL matrix generator and report writer was updated to suit the purposes of the present study. An updated version of the Italian database was also prepared and a new framework for scenario construction was adopted.

The original version of MARKAL has often been defined as a shadow price generator. Initially, the demand for private goods such as useful energy and public goods such as environmental emission levels are defined. The model then calculates the shadow prices in each year for each good from the supply curve of very detailed technological chains from the primary supply to the end-use demand, choosing the optimal mix among hundreds of processes, plants and devices, user-defined and evolving with time. Prior to the changes made to most recent version of

MARKAL, shadow prices were calculated from the cost of the various technologies, the cost of import, the cost of abatement, and so forth.

Among the MARKAL updates of recent years, two are relevant for the present analysis. First, the fixed time profile of specific demand for energy goods has been replaced by price dependent demand profiles, and the Pareto optimum is now calculated as the equilibrium point of both useful energy supply and demand curves. In the present exercise, the so-called "elastic MARKAL" approach has been used, instead of the MARKAL-MACRO or MARKAL-MICRO versions, which required more database changes. Second, it is now possible to increase or decrease the shadow prices of the resource and of the private/public goods by amounts equal to taxes and subsidies. In other words, it is now possible to construct separate scenarios with shadow prices similar to the present and projected internal prices, and which depart from the marginal production costs and include taxes and subsidies.

Another feature of the present analysis that is somewhat different from previous MARKAL evaluations involves the extensive use of cumulative values such as total discounted system cost and CO_2 emission values to draw conclusions. The use of cumulative values has the effect of averaging the yearly values, which sometimes shift randomly from one year to another due more to slight changes in the level of subsidies than to the optimal technological mix. Since all the effects analysed are time-dependent – negligible in the base statistical year and maximum in the last year – the averages calculated from cumulative values apply to the central year of the model (the year 2000), and may be estimated to be twice as large for the final year of the model time horizon.

Chapter 10

The Market Reforms in the Norwegian Electricity Sector[1]

With almost 100% of its electricity production based on hydropower, Norway is in a unique position when it comes to disposal and emissions from the power supply system. As a renewable resource, water power does not produce any waste or emissions to air. Compared to many of the other OECD countries, in which coal-fired power and nuclear power are the main sources of electricity production, Norway's power production has a modest impact on the environment. This is particularly evident where emissions of greenhouse gases are concerned.

The starting point for the discussion of the environmental consequences of the Norwegian Energy Act was the argument that a more effective utilisation of resources would also contribute to a better environmental situation in general. In the years preceding the reorganisation, the power market was characterised by excess capacity and overinvestment, by price variation throughout the country, and in some cases by the fact that expensive power plants were built before inexpensive plants. This indicated a situation where resources were not optimally utilised. There was a potential for both economic and environmental gains with a more efficient organisation of the market.

Prior to the reorganisation of the electricity sector, the Norwegian power market was characterised by an excessive production capacity. Nevertheless, investments in new capacity continued. This tendency towards over-expansion in generation capacity was partly a result of the pre-deregulation requirement that regional utilities meet all demand in their area.

However, high levels of production in the years prior to the Energy Act were also a consequence of the comparatively high level of precipitation during these years. Energy production has in the past varied significantly according to water inflow to the rivers and the reservoirs connected to the hydropower plants; this factor can affect annual production by as much as ±20 TWh.

The large power surplus in Norway before the reorganisation of the market resulted in low prices in the old Power Pool (restricted to large power producers). In addition, power was exported at very low prices.

The Energy Act came into force on 1 January 1991 and laid down the general terms and the legal framework for a more efficient utilisation of energy resources. Since the reforms were implemented fairly recently, it remains difficult at present to draw any definite conclusions on the impacts of the law. Some of the elements of the market reforms have been gradually introduced and others are still being prepared for implementation. This also makes drawing final conclusions difficult, but the basic assumption is that the reform had a positive impact on the environment.

During the same period, there were also changes in a number of other factors influencing development

1. The study summarised here has been published as "The Market Reforms in the Norwegian Electricity Sector", in "Supports to the Coal Industry and the Electricity Sector", vol 2, "Environmental implications of Energy and Transport Subsidies", OECD/GD(97)155, OECD, Paris.

in the sector. The most important factor is linked to the annual and seasonal climatic variations in temperatures which affect demand, together with variations in the amount of rainfall, which affect the inflow to the hydro system and thereby spot prices, conjunctural changes in the economy, and the relationship between the price of oil and the marginal cost of electricity. Due to the fact that collecting and revising relevant data are very time-consuming activities, the 1993-1994 statistical data necessary to analyse these phenomena have until now been limited. It is, however, already possible to observe important changes in some areas.

Energy prices are important carriers of information in a market-based electricity sector. One important function of a transparent electricity price is transmitting information on the costs of energy use to the consumer. At the same time, power prices provide information on the future return of investments in power transmission and production. Environmental taxes added to energy prices would provide incentives for more environmentally-benign production and consumption. At present, the environmental taxes levied on the Norwegian energy sector are among the highest in the world.

The general objective of the Energy Act was to develop prices that to a larger extent reflected supply and demand conditions, reducing the unnecessary variations in prices between different users and regions, after due consideration of environmental concerns.

Prices in the wholesale market fell considerably following the introduction of the Energy Act. Further, wholesale electricity prices have become more closely linked to medium-term expectations in the spot market. This represents a change of conditions before the implementation of The Energy Act, when substantial differences existed between wholesale energy prices and the average price level in the spot market.

Changes in wholesale prices have also to a larger extent reached the end user. Several larger and medium-sized industrial and commercial customers have renegotiated their contracts and obtained substantial price reductions. Household electricity prices, which had increased each year before the Energy Act came into force, stabilised following the introduction of the Act.

During the years after the implementation of the Energy Act, there was a gradual trend towards more even prices between different users and regions. The degree of price variation in contracts for the wholesale market has decreased. In 1995, 85 per cent of the household prices were within a variation area of only ± 2 øre/kWh, compared to 54 per cent of the prices the year before. There are strong indications that price variations between industrial customers have also decreased. This is particularly the case among the actors now participating in the market. The equalisation of prices will help ensure that both energy conservation efforts and environmental considerations are evaluated under equal conditions, regardless of the region of the country concerned.

The influence of the market price can also be illustrated by looking at the increased turnover in the organised markets. Both the spot market and the weekly market have been gaining in importance during the last few years. A total of 41 TWh was traded in the organised market in 1995, compared to 28 TWh in 1994.

The existence of an electricity market with a larger degree of market-based price formation has led producers to think and trade in a more commercial manner. Since trading or capacity investment decisions are now to a greater degree subject to cost considerations, the actors involved have incentives to avoid the waste of resources. During the years from 1990 to 1994, power consumption at constant supply increased by 10 TWh, while the capacity during the same period only increased by 2-3 TWh. In spite of this, there has been no dramatic increase in price. To put it more succinctly, a substantial drop in wholesale prices has not led to an increased demand. This indicates a more efficient use of resources than has earlier been the case, and is beneficial for the environment.

The effects of the Act on investments have been obvious. Before the Energy Act was introduced, distribution companies had the obligation and exclusive rights to supply the customers in their own area, and were not at risk when building and investing in new capacity. Local projects with high costs and less profitability could be given priority before projects in other areas with less cost and higher profitability. The implementation of a competitive market, in which consumers are free to choose their supplier, has made it difficult for producers to raise consumer prices in order to cover costs. After the Energy Act, producers have been forced to carefully evaluate the potential return on their investments, with respect to their estimates of power sales and the market price on power. Investment in and expansion of the power system has clearly declined since the 1970s and 1980s. The direct environmental impacts of hydropower are associated with the construction of power stations and storage reservoirs and with the construction of transmission lines for transport. These factors have an effect on the natural environment. Together, the decline in investment and more effective production have led to a decrease in encroachment upon the remaining untouched watercourses and surrounding nature.

Since the high voltage transmission system is considered a natural monopoly, one important step in reorganising the power sector was to regulate the services related to the high voltage transmission system, conduct monopoly control to ensure the best utilisation of resources and secure non-discriminatory behaviour by the system operator. Today, a larger degree of rationality seems to dominate in this sector. The introduction of point fees and regulated third party access to the grid has made it more difficult for the system operator to pass on the costs of uneconomical investments to the consumer. The preparation of monopoly control and effectiveness is, however, under continuous development. This makes it difficult to verify any measurable effects so far, but there is some evidence that there has been a small reduction in the transport costs during the last three years.

The stricter ranking of priorities for new projects following the reorganisation of the electricity supply sector represents the most important gain for energy efficiency and the environment resulting from the Energy Act and the introduction of competition. Environmental considerations relating to the exploitation of water resources still play an important role in the concession system for new production capacity. This aspect of the decision-making process was not affected by the Energy Act.

The general development of electricity demand also depends on factors outside the power market. Changes that have taken place after the implementation of the Energy Act may to a large extent be explained by changes in economic activity and climatic conditions. Lower prices to those final consumers active in the market may have contributed to a small increase in household consumption. Consumers have experienced a decrease in the price of electricity compared to oil. The substantial decrease in oil consumption during the last 10-12 years has reduced emissions of CO_2.

With the exception of 1994, when high spot prices led to a stronger focus on substitution, this trend continued following the implementation of the Energy Act. The environmental impacts of a sustained movement away from oil must be weighed against the alternative: the continued development of watercourses or import of coal-based power will also have environmental consequences. By offering prices partly or fully connected to spot prices in contracts to both industrial customers and households, a more rational balance between oil, electricity and bio power could be a longer-term result of the Energy Act.

A new framework for foreign trade in electricity has ensured an effective power exchange with companies in other countries. One logical consequence of the Energy Act was to remove the Statkraft's former export monopoly. After the reorganisation of the electricity sector, three long-term cable agreements were granted a license. These developments make power trade with countries outside the Nordic area possible after the year 2000. The exchange agreements will make the Norwegian electricity balance more robust and help to stabilize electricity prices in Norway.

The environmental impacts of Norwegian power exchange are not straightforward, and depend on whether Norway is a net exporter or a net importer of power. Norways hydropower system is unique as regards supply of electricity at times of the day when the demand is high. Unlike electricity production based on thermal power, hydropower production can be easily adjusted up or down. The natural advantages of the hydropower system's ability to supply electricity during peak periods, and its rapid and cost-effective adjustment capacity represents a substantial revenue potential for Norway.

With Norwegian net export and Norwegian hydropower replacing coal-fired thermal power in neighboring countries, overall and regional emissions will be reduced. Countries with systems based on thermal power can reduce investments in new capacity by entering into long-term contracts based on peak load power from Norway. Conversely, the connections with neighbouring countries give Norway the possibility of importing power in dry years. The need for capacity expansion in the Norwegian hydropower system will then be lower, and this will have a positive effect on the environment.

Private sector efforts in the field of energy conservation have not declined since 1994, when the system of investment grants was discontinued. Energy efficiency activities in the public sector have declined due to the evaluation of policy instruments and a reduced budget, and not because of the introduction of market reforms. However, the Energy Act has at the same time forced policymakers in the area of energy efficiency to reassess how to undertake energy efficiency policies in a deregulated market. The authorities have reorganised the energy conservation work and selected instruments that are far better adapted to the situation after the implementation of the Energy Act. Energy prices are the most important signals to encourage consumers to use energy efficiently. A lack of information (e.g. proper access to or a proper understanding of price signals) can, however, create a lack of awareness of the benefits of conservation, both on the supply and on the consumer side. In response, the authorities have focused their energy efficiency efforts on information activities, education, introduction of energy conservation technologies and on the establishment of regional energy conservation centres. These measures are alternatives to expensive subsidies. However, the greatest gain in energy efficiency after the implementation of the Energy Act has resulted from changes in the incentives towards more effective investments in production.

The current objective of public energy efficiency policy is to develop a greater awareness of the possibilities for more efficient energy use. The potential for energy conservation will be to a great extent determined by the general price level, and will depend more specifically on the costs of new energy supply and the environmental taxes imposed on energy activities.

The power market is a mechanism that can effectively transmit signals on the economic and environmental cost of electricity to the individual decision maker.

The reorganisation of the electricity sector has led to a more conscious and rational development of hydropower. Direct encroachment on natural areas has been reduced by a decline in capacity investments due to more effective investment criteria. In spite of this, it should be pointed out that the public authorities still are in charge of the administration and resource management of power resources. Licensing procedures and protection plans ensure an environmentally-benign use and expansion of hydropower developments. The Energy Act has not changed the fundamental objectives of the energy sector, but is considered a better means to reach the goal of an effective and environmentally sound electricity market.

Chapter 11

Electricity-Related Supports in the United Kingdom[1]

Laurie Michaelis, OECD

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 electricity supply industry (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 wider market conditions facing the ESI changed with the privatisation of British Gas in 1986, British Coal in 1994 and British Energy (part of the nuclear industry) in 1996.

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

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. Several investigations have been carried out into the economics and technical prospects of the various electricity sources, and of energy technology in general. This case study draws on the various investigations to evaluate what is known, or can be anticipated, regarding the effects of market liberalisation on the environmental effects of electricity production and use in the United Kingdom.

The case study takes the early 1980s as the starting point for the analysis. It looks at the government supports in place at that time, and considers through a set of scenarios what might have happened if those supports had remained in place through to 2020. Thus, the "without-subsidies" scenarios are the business-as-usual cases, and the "with-subsidies" scenarios are the counterfactuals.

The study focuses on the removal of the following types of subsidies or market distortions related to:

- Government support for the use of coal and nuclear power.
- Government support for new electricity investment and for electricity consumption. Support for electricity investment includes the provision of financing at rates of return below those typically required in the private sector. Support for consumption includes the absence of value added tax (VAT) on domestic fuel purchases.

The policy discussion in the report relates mainly to the electricity industry in England and Wales and to

1. The study summarised here has been published as "Case Study on Electricity in the United Kingdom", in "Supports to the Coal Industry and the Electricity Sector", vol 2, "Environmental implications of Energy and Transport Subsidies", OECD/GD(97)155, OECD, Paris.

Figure 11.1: **Power generation mix in the United Kingdom, 1960-1992**

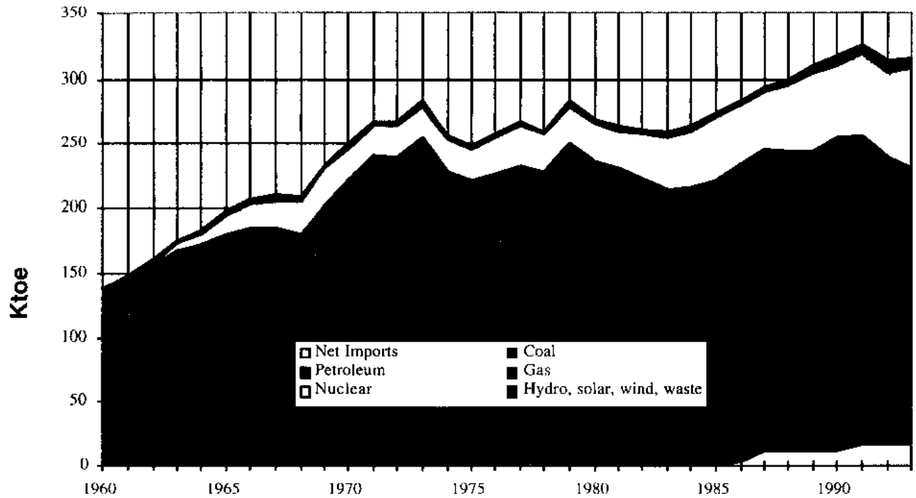
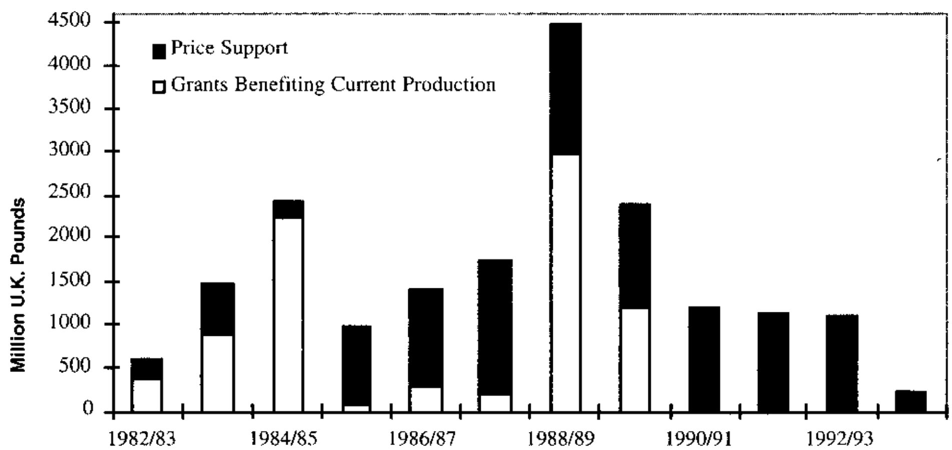


Figure 11.2: **Estimated support to British Coal, 1982-1994**



Source: IEA, 1991, 1994, 1995

some extent in Scotland. The industries in Scotland and Northern Ireland have undergone deregulation under separate legislation from that in England and Wales.

11.1 Supports to coal production

Power generation in the United Kingdom has been based mainly on coal throughout this century. The amount of coal burned in power stations peaked in 1980 at 56.4 Mtoe. The generation mix over the last three decades is shown in Figure 11.1. Oil-fired generation has been important, mainly for meeting peak power demand, though there was a considerable increase in its use for baseload generation in the early 1970s followed by a rapid decline after the oil price rises of 1973/74 and 1989/90. Oil also played an important role in maintaining baseload power supply during the 1984 coal miners' strike. Nuclear power became a significant source from the 1960s, supplying 26% of electric power in 1994. Little power was generated from natural gas until the 1990s, except for a small amount used in gas turbine peaking plant during the 1970s.

Other energy sources began to displace coal more rapidly in the late 1980s and early 1990s as a result of imports of electricity from France, increased nuclear output and the entry into service from 1991 of combined cycle gas turbine (CCGT) plant burning natural gas. By early 1995, 15 GW of CCGT was in operation or under construction, exceeding the total nuclear capacity in service.

The price of British coal for power generation until the late 1980s was marginally higher than the average for OECD Europe and very much higher than that in the United States or Australia. Nevertheless, coal was cheaper than gas for baseload power generation at least until the mid- to late 1980s. At this point several key changes occurred: in 1984, a coal miners' strike, aimed at forestalling management efforts to streamline the industry, failed; from the mid-1980s, a new natural gas-based generating technology, CCGT, became available; and the European Council repealed a directive that had limited the use of gas for baseload power generation. In addition, U.K. commitments to reduce national emissions of sulphur and nitrogen oxides (SO_x and NO_x) implied rising costs of coal-fired power generation because of the cost of emission controls, although one lower cost alternative was to import low sulphur coal for use in existing power stations.

Coal production in the United Kingdom was supported during the 1980s by government grants to cover operating losses, and by understandings with the electricity industry that a substantial amount of domestically produced coal would be purchased for power generation. Figure 11.2 shows the IEA's estimates of coal production support over the twelve years to 1994. It should be noted that the whole of this period was a time of transition for the coal industry and the support does not necessarily represent "business as usual".

11.2 Supports to nuclear power

Government support for nuclear power in the early 1980s took the form of:

- ***The use of low test discount rates in technology choice***: if a 10%-11% required rate of return (RRR) is taken as the benchmark for the market rate, the 5% RRR required by the government in the early 1980s reduced the apparent cost of nuclear-generated electricity by approximately 1.6 p/kWh (nearly 40%). Some would argue that a discount rate around 5% is appropriate for considering public sector investment, on the basis that it reflects the real social cost of capital. On the other hand, the main reason the private sector uses higher test discount rates is the need to account for risk. In theory, governments may be in a position to do this explicitly through a stochastic analysis of investment options, but in practice it is not always obvious that risk is adequately addressed in public sector investments.

- ***Government involvement in ESI planning***, which was perhaps influenced by optimism about nuclear technology, resulting in the industry accepting, or overlooking, the high costs involved.

- ***Government-funded R&D*** for conventional nuclear power, similarly influenced by technology optimism, which peaked at about £295 million (1993 pounds) in 1983.

- ***Limited liability*** for nuclear operators. This is often cited as the most important form of government support for nuclear power. No private company has been prepared to shoulder the risk associated with final disposal of high level nuclear waste, nuclear plant decommissioning and nuclear plant accidents. The monetary valuation of this risk is discussed below in the section on externalities.

11.3 VAT on residential fuel use

VAT is applied to most goods and services sold in the United Kingdom, including energy-using appliances and energy efficiency-improving equipment and services, at a rate of 17.5%. Prior to 1994, electricity and fuel sales to domestic customers (along with certain other goods, such as food and children's clothes) were zero rated for VAT. The difference in tax treatment between energy consumption and energy saving, as well as more general retail of goods and services, can be viewed as a market distortion encouraging higher energy consumption and hence environmental impacts.

There is no "correct" rate of VAT and, therefore, no correct basis for calculating the size of the distortion or of any implicit subsidy to consumption, but the normal rate of 17.5% can be taken as a benchmark against which to estimate government support for electricity consumption. Taking the implicit support simply to be the amount that would have been paid if electricity sales had been subject to 17.5% VAT, the national total would be £1.09 billion in 1990 and £1.33 billion in 1993.

In April 1994, the government began to levy VAT at a rate of 8% on domestic fuel and electricity sales. Electricity prices increased correspondingly, although they subsequently fell substantially.

An increase in the prices of all domestic fuels as well as electricity is expected to result mainly in a reduction in electricity demand. Overall, the long term effect of the 8% VAT introduction, on top of underlying price changes, could be a reduction in annual CO_2 emissions by perhaps 150 000 to 200 000 tonnes. There might be an increase in oil use in residential boilers, largely in rural areas and small towns without access to natural gas. This would result in higher emissions of pollutants in these areas.

11.4 Evaluation of effects of subsidy reform

The U.K. case study explores the effects of market reform through 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[2]) are taken from the government's 1995 projections of energy use and CO_2 emissions. The Department of Trade and Industry (DTI) developed several scenarios based on various GDP and energy price levels; these are published by the U.K. Government in Energy Paper 65 (EP65). The U.K. 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 EP65 scenarios, and using two alternative sets of assumptions about the relative capital costs of coal-fired power stations, nuclear power and CCGT. Key common assumptions in these scenarios are:

- coal supports are phased out gradually, as opposed to 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 base construction decisions on discounted cash flow at a 5% discount rate[3]; the reference scenarios take account of the effects of privatisation and competition, including increased own generation by industry, and ESI construction decisions are based on an 8% discount rate[4];
- the pre-1985 capacity demand ratio is maintained, implying a load factor for baseload plant in the region of 60%-70%, and construction of a combination of the cheapest and second-cheapest supply options at any time, to maintain flexibility in the generating mix; in the reference scenarios, the capacity demand ratio declines considerably, with baseload plant operating at its design limit of around 85% and with most new construction being CCGT;
- the renewable energy subsidies known as NFFO are retained as in the reference scenarios, resulting in the same level of deployment, and power imports are assumed at the same level;

2. Some supports are retained in these scenarios, however.

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

4. This may be below the rate of return actually sought by the privatised and competitive ESI in the United Kingdom.

- 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 market reform and subsidy removal, 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% discount rate is an essential component of ESI support. Without it, no new construction of coal-fired or nuclear capacity would occur.

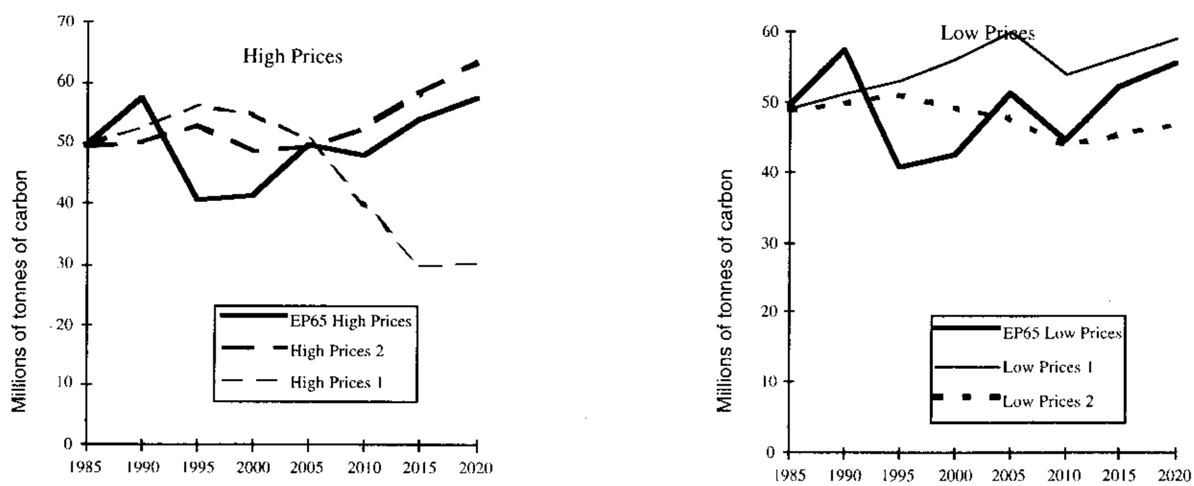
- The removal of the subsidies to coal and nuclear power would not necessarily have had much effect on the use of these energy sources if a 5% RRR had been retained. If relatively high construction costs are assumed for coal and nuclear, such as existed in the United Kingdom prior to the recent market reforms, CCGT would be the technology of choice even with high gas prices. On the other hand, if lower estimates of construction costs 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 historical rate, would result 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 lead 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 would nuclear subsidies result in new nuclear construction beyond 2000.

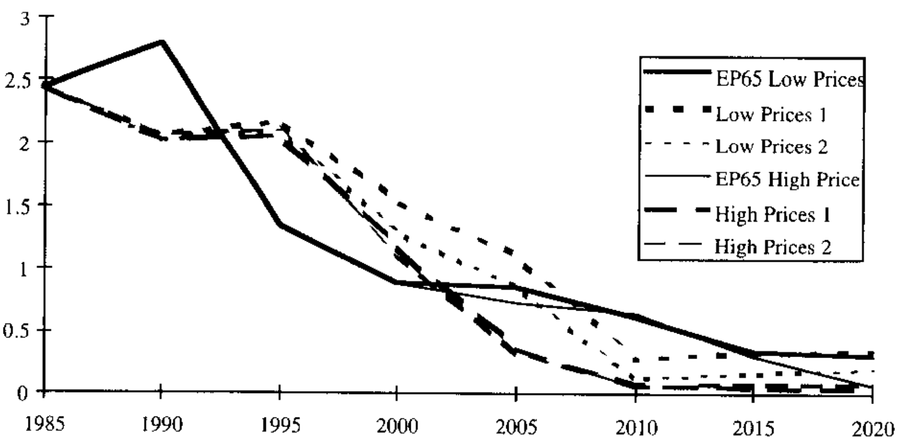
The implications for CO_2 emissions are summarised in Figure 11.3, which compares annual ESI emissions in the various scenarios. Note that it is possible to identify situations in which subsidies result in very much higher CO_2 emissions (with a combination of capital subsidies via low RRR and direct or indirect subsidies to coal) and situations where subsidies lead to lower CO_2 emissions (as in the case of nuclear subsidies combined with low RRR). In all of the with-subsidies scenarios, CO_2 emissions are higher in 2000 than in the EP65 scenarios, essentially as a result of the assumption that domestic coal production would

Figure 11.3: **CO_2 emissions with and without subsidies**



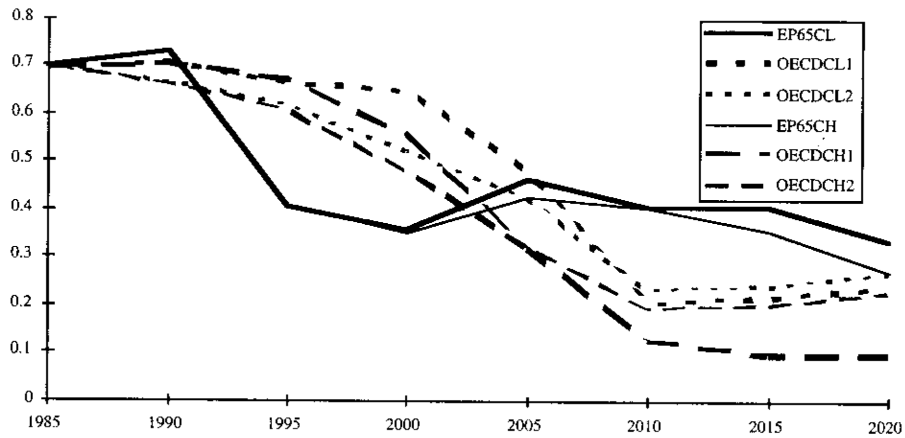
Note: EP65 scenario data are estimated based on information from U.K. DTI. High Prices 1 is a scenario in which nuclear power is cheaper than coal; in High Prices 2 the converse is true. Low Prices 1 is a scenario assuming substantial use of fuel oil in the ESI. In Low Prices 2 the main fuel is natural gas.

Figure 11.4: **SO_2 emissions with and without subsidies**



Note: EP65 scenario data are estimated based on information from U.K. DTI. High Prices 1 is a scenario in which nuclear power is cheaper than coal; in High Prices 2 the converse is true. Low Prices 1 is a scenario assuming substantial use of fuel oil in the ESI. In Low Prices 2 the main fuel is natural gas.

Figure 11.5: **Emissions of NO_x with and without subsidies**



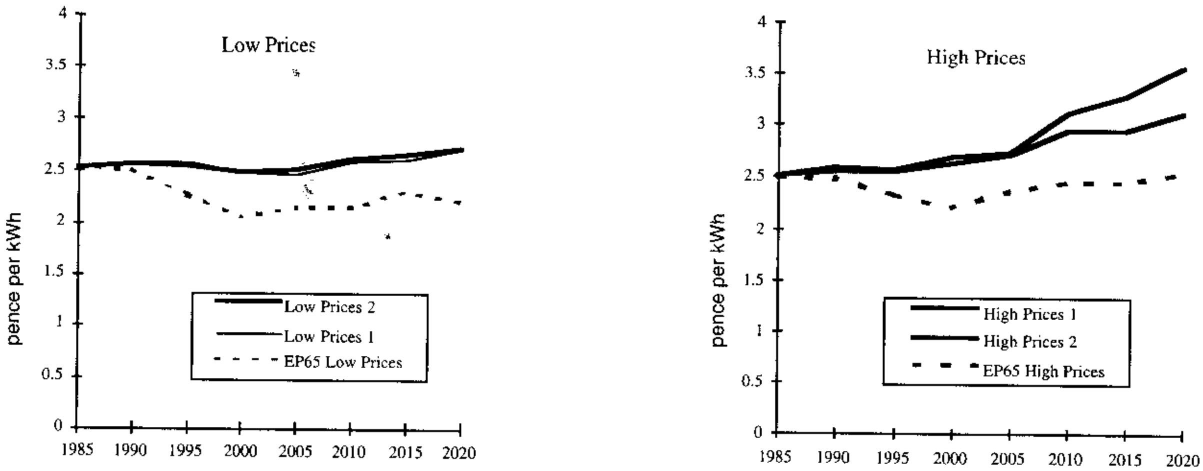
Note: See note to Figure 11.4, above.

be allowed to decline no faster than historical trends in the with-subsidies scenarios.

Figures 11.4 and 11.5 provide similar results for emissions of SO_2 and NO_x. One effect of the less precipitous shift in the generating mix in the with-subsidies scenarios is that more of the existing coal-fired plant is retrofitted with FGD in the early 1990s. This results in lower SO_2 emissions through most of the period.

Average electricity generation costs are increased in the with-subsidies scenarios by up to 40%, or 1 p/kWh, depending on the scenario and time (see Figure 11.6). Much of this increase is due to the larger capacity planning margin in the with-subsidies sce-

Figure 11.6: **Average cost of electricity generated under several scenarios**



Note: EP65 scenario data are estimated based on information from U.K. DTI. High Prices 1 is a scenario in which nuclear power is cheaper than coal; in High Prices 2 the converse is true. Low Prices 1 is a scenario assuming substantial use of fuel oil in the ESI. In Low Prices 2 the main fuel is natural gas.

narios, which results in roughly 40% 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 of £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.

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% higher electricity prices and 5% 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% 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% instead of the general rate of 17.5%, 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 price changes affect all fuels.

11.5 Effects of removing externalities

This section considers the effects of introducing "externality adders" to the costs of electricity generation from various fuels and technologies, using the working values for externalities reviewed in the case study. The case study calculates the levelised cost for existing and new plant including such adders. The adders are taken to be: 0.1 p/kWh for nuclear power, 2 p/kWh for old coal-fired plant without emission controls; 0.75 p/kWh for old or new coal-fired plant with FGD and low-NO_x burners; 0.75 p/kWh for new oil-fired plant with FGD and low-NO_x burners; and 0.2 p/kWh for CCGT.

The large adder for existing coal-fired plant without emission controls makes this the most expensive plant for baseload operation. However, it might be competitive for use lower in the merit order (at load factors well below 30%), as the capital cost of new plant makes it uneconomic to operate at low load factors. Nor is retrofitting FGD to existing coal-fired plant competitive with alternative options under most circumstances. The cheapest baseload technologies with the externality adders used here are nuclear power and CCGT. In all but one scenario, CCGT is cheaper than nuclear power unless the latter is subsidised. However, subsidised nuclear power is cheaper than CCGT in all scenarios to 2000, and in all but one thereafter.

The introduction of externality adders based on the working values used here would thus be expected to result in a very substantial shift to CCGT and nuclear power, and a reduction in emissions of conventional air pollutants and greenhouse gases. The extent of these reductions has not been quantified in the current study. It should also be noted that the value used for the nuclear power externality lies below the middle of a range from the literature that spans three orders of magnitude (i.e. from a factor of 12 smaller to a factor of 80 larger). A nuclear externality ten times higher than that used here would make nuclear power more costly than CCGT in all scenarios.

In conclusion, the use of externality adders to generating costs would be expected to work largely in the same direction as subsidy removal in terms of encouraging the use of CCGT at the expense of coal. However, whereas removing subsidies may leave a large tranche of existing economic coal-fired power stations, externality adders would render these power stations unable to compete with CCGT for baseload generation.

Chapter 12

Evaluation of the External Costs of Road Transport in France and the Consequences of Cost Internalisation

J-P Orfeuil, INRETS, Arceuil

In the framework of a global study on the environmental implications of support for the energy sector organised by the OECD, research teams in the United States, France and Japan undertook an analysis of the overall costs of the road transport system in their respective countries and their rate of coverage by specific revenue, as well as an analysis of the effects that a strategy of complete cost coverage by specific revenue would have in each country. In all three countries, the analysis was constructed around the same reference year (1991), and the effect of the possible strategies was evaluated for the same time horizon (2010). This report summarises the French contribution to the study.

After a brief overview of the characteristic features of road activity in France in 1991 (Chapter 1 of the full report, cited below), the report deals in turn with the evaluation of the overall revenue (Chapter 2) and expenditure (Chapter 3) connected with road activity in France[1].

In this first balance, only specific tax revenue (i.e. for the most part excluding VAT) is taken into account and only the direct monetary expenditure (excluding VAT) of the public authorities on road investment, maintenance and operation. Table 12.1 summarises the overall balance. As one can easily observe on the basis of the figures presented in the table, the French fiscal situation – fairly representative for Europe – leads to a surplus of specific revenue over direct monetary expenditure connected with road activity.

However, road activity generates costs other than public authority expenditure on roads. Chapters 4 and 5 are devoted to estimating these costs, which are known as "external" or "social" costs and concern in particular the harm to human health and the environment caused by noise, local and regional pollution, the greenhouse effect, road accidents, as well as by the congestion imposed on road users other than private motor vehicle owners, including pedestrians, cyclists and public transport users.

Even a partial review of the literature on the external costs of transport poses certain difficulties. This is chiefly due to three related reasons:

- Enormous disparities exist between estimates;
- The magnitude of the estimates is independent neither of the body commissioning the study nor of the relative importance attributed to the problem in question (e.g. acid rain, greenhouse effect, etc.) during the period when they were made;
- The concepts themselves (definition of costs, method of attributing monetary values) are not always precisely defined.

1. The Chapter notations refer to the full text of the French study published as "Evaluation of the External Costs of Road Transport in France and the Consequences of Cost Internalisation", in "Supports to the Road Transport Sector", vol. 3 of "Environmental Implications of Energy and Transport Subsidies", OECD/GD(97)156, OECD, Paris.

Table 12.1: **Specific road revenue and direct public expenditure**
(billion francs 1991, excluding VAT)

Revenue	billion FF	**Expenditure**	billion FF
Acquisition related	11.4	Investment	44.8
Ownership related	26.7	Maintenance	33.1
Use related	118.9	Operation + Social security	27.5
Total	157	**Total**	105.4
Total per km (FF)	0.356		0.239
Total per km ($)(*)	0.063		0.042

(*) 1991: 1 dollar = 5.64 francs.

Table 12.2: **Estimated ranges of the external costs of road traffic in France**
(billion francs 1991)

	Cost
Noise	10-16
Local and regional pollution	16-37
Greenhouse effect	4-14
Accidents	45
Congestion	15-29
Total	90-141
Total per km (FF)	0.20-0.32
Total per km ($)(*)	0.035-0.057

(*) 1991: 1 dollar = 5.64 francs.

It is this last point in particular that encouraged us to make our own estimates. Our intention was less to make a "better" estimate than those available in the literature, than to clearly set out the terms of the approach, the necessary assumptions and the goal to be achieved; in short, to produce estimates that are transparent, subject to discussion and refutable.

For noise and pollution, estimation of avoidance costs appears to be the most appropriate means to estimate damage costs, since the technological potential for abatement of these problems is still very considerable and capable of responding to any significant social demand. For road safety and congestion, the avoidance costs are much more difficult to estimate, inasmuch as control of these phenomena implies substantial changes in user behaviour. Therefore, in these last cases, we adopted a direct method of estimating damage costs. Table 12.2 summarises the ranges of values obtained.

In spite of the efforts presented here, it must be admitted that it is not possible to estimate these costs with any great precision: the low and high values lie some 30% below or above the mean. However, regardless of the specific assumptions made and the uncertainties involved, it is clear that these costs are far from negligible. The overall balance of specific revenue with respect to direct public expenditure on the road system becomes very negative when the external costs are taken into account, showing a deficit of FF 38 billion with the low assumption and

FF 89 billion with the high. These balances are obviously very considerable in relation to specific taxation (24% and 57% respectively).

On the other hand, in relation to total expenditure (fiscal and non-fiscal), of road users, the balances are less significant, representing 4% and 9%, respectively, of the total cost of road use. Accordingly, an overall strategy of "pure and simple" internalisation can lead neither to radical changes in behaviour nor to tight control over the negative effects of road transport.

To refine the balance, it was necessary to break down the analysis by type of vehicle (two-wheeled vehicles, light vehicles, heavy trucks), type of fuel (notably because French taxation is very different for gasoline and diesel) and driving conditions (urban or rural). In Chapter 6 of the study, the balance is broken down according to the two basic types of driving conditions and seven types of vehicle: two-wheeled vehicles, gasoline and diesel passenger cars, gasoline and diesel light trucks, heavy trucks and public transport vehicles.

The attribution of road investment, maintenance and operating costs between urban and rural areas is based on a detailed analysis of the public accounts (Comptabilités Publiques de l'Etat and des Collectivités Territoriales). For each type of driving milieu, the attribution of costs to the different vehicle categories is made on the basis of their contribution to the burden on the infrastructure (connected in particular with different levels of wear), assuming more or less active maintenance, and taking into account their share in total traffic. The attribution of revenue by type of vehicle and driving milieu is made on the basis of vehicle stock (taxes on acquisition and ownership), fuel consumption (fuel tax) and tolls and charges (charges for motorways or parking). Finally, the external costs are attributed on the basis of the relative contribution of each vehicle type, and are divided into costs incurred by pollutant and greenhouse gas emissions, relative contributions to accidents and congestion, and both the emission and reception aspects for noise. Tables 12.3 through 12.6 bring together the principal estimates obtained.

As one can easily observe from the data presented in the above tables,

- Road accidents account for a very significant share in overall external costs;
- Two-wheeled vehicles have a very negative balance per kilometre covered, notably because they are substantially more accident-prone than other types of vehicle;
- The urban balance is always very negative (FF -43 to FF -80 billion), whereas the rural balance, which concerns considerably higher volumes of traffic, is on the whole close to equilibrium (from FF -9 to FF +5 billion);
- The balance for diesel vehicles is very negative (FF -34 to FF -55 billion) compared with that for gasoline vehicles (FF -6 to FF -34 billion), despite the far greater number of the latter.

Table 12.3: **Urban traffic balance**
(Low estimate of external effects, billion francs 1991)

	Two wheeled vehicles	Cars		Light trucks		Heavy trucks	Buses	Total
		gasoline	diesel	gasoline	diesel			
Tax revenue	1.5	37.5	5.1	4.6	5.5	2.1	0.7	57.0
Road expenditure	1.3	20.3	5.8	3.6	8.0	4.7	0.5	44.2
External costs	6.4	28.9	8.3	3.3	6.7	1.9	0.5	56
Noise	0.5	4.1	1.2	0.6	1.2	0.3	0.1	8
Pollution	1.2	4.6	1.2	0.8	1.4	0.9	0.3	10.4
Greenhouse effect	0	0.9	0.2	0.2	0.3	-	-	1.6
Accidents	4.7	11.8	3.4	0.2	0.5	0.3	0.1	21
Congestion	0	7.5	2.3	1.5	3.3	0.4	0	15
Balance	- 6.2	- 11.7	- 9.0	- 2.3	- 9.2	- 4.5	- 0.3	- 43.2
Balance/km (centimes)	-62	-13	-36	-19	-35	-225	-50	-

Table 12.4: **Traffic balance in rural areas**
(Low estimate of external effects, billion francs 1991)

	Two wheeled vehicles	Cars gasoline	Cars diesel	Light trucks gasoline	Light trucks diesel	Heavy trucks	Buses	Total
Tax revenue	1.6	54	11.8	3.6	3.8	22.5	2.9	100.2
Road expenditure	0.9	23.0	10.0	2.3	3.5	19.8	1.7	61.2
External costs	2.7	15.6	6.4	0.7	1.0	6.9	0.5	33.8
Noise	0	1.0	0.4	0.1	0.1	0.4	0	2
Pollution	0.3	1.4	0.3	0.1	0.1	3.1	0.3	5.6
Greenhouse effect	0	1.0	0.4	0.1	0.2	0.7	-	2.4
Accidents	2.4	12.2	5.3	0.4	0.6	2.7	0.2	23.8
Congestion	-	-	-	-	-	-	-	-
Balance	- 2.0	+ 15.2	- 4.6	+ 0.6	- 0.7	- 4.2	+ 0.7	+ 5.2
Balance/km (centimes)	-29	+ 10	- 7	+5	-4	-18	+32	-

Table 12.5: **Urban traffic balance**
(High estimate of external effects, billion francs 1991)

	Two wheeled vehicles	Cars gasoline	Cars diesel	Light trucks gasoline	Light trucks diesel	Heavy trucks	Buses	Total
Tax revenue	1.5	37.5	5.1	4.6	5.5	2.1	0.7	0.7
Road expenditure	1.3	20.3	5.8	3.6	8.0	4.7	0.5	0.5
External costs	8.4	46.5	13.1	6.3	13.1	4.2	1.1	1.1
Noise	0.8	6.6	1.9	1.0	1.9	0.5	0.1	0.1
Pollution	2.8	10.7	2.8	1.8	3.2	2.0	0.8	0.8
Greenhouse effect	0.1	2.9	0.7	0.4	1.2	0.4	0.1	0.1
Accidents	4.7	11.8	3.4	0.2	0.5	0.3	0.1	0.1
Congestion	0	14.5	4.3	2.9	6.3	1.0	0	0
Balance	- 8.2	- 29.3	- 13.8	- 5.3	- 15.6	- 6.8	- 0.9	- 0.9
Balance/km (centimes)	-82	-34	-55	-44	-60	-340	-150	-

There are thus certain categories of traffic which more than cover their total costs – this is the case with gasoline cars in rural areas – and others which have very large deficits – this is the case with urban traffic and diesel vehicles. It is thus simply not possible to arrive at equilibrium for each category of use and user with just one economic instrument.

Chapter 7 of the report presents a balance sheet corresponding to a "steady-state" trend through the year 2010. For these projections, we assumed moderate economic growth of 2.5% a year, very slightly higher than the estimate used by the International Energy Agency for its world energy outlooks. The review of the literature concerning traffic forecasts to this horizon gives a fairly coherent view of car traffic to 2010. On the other hand, estimates for truck traffic are much more scattered, which is why we asked the Transport Economics Laboratory of the University of Lyon 2 to estimate the evolution of heavy duty vehicle traffic and examine the impact of economic measures on the trends. The estimates finally adopted, consistent with the anticipated economic growth, appear in Table 12.7. Road expenditures have also been calculated with reference to economic growth. Road

Table 12.6: **Traffic balance in rural areas**
(High estimate of external effects, billion francs 1991)

	Two wheeled vehicles	Cars gasoline	Cars diesel	Light trucks gasoline	Light trucks diesel	Heavy trucks	Buses	Total
Tax revenue	1.6	54	11.8	3.6	3.8	22.5	2.9	100.2
Road expenditure	0.9	23	10.0	2.3	3.5	19.8	1.7	61.2
External costs	3.2	20.2	7.9	1.1	1.6	13.1	1.1	48.2
Noise	0	1.6	0.6	0.1	0.2	0.6	0.1	3.2
Pollution	0.7	3.2	0.6	0.3	0.2	7.3	0.6	12.9
Greenhouse effect	0.1	3.2	1.4	0.3	0.6	2.5	0.2	8.3
Accidents	2.4	12.2	5.3	0.4	0.6	2.7	0.2	23.8
Congestion	-	-	-	-	-	-	-	-
Balance	- 2.5	10.8	- 6.1	0.2	- 1.3	- 10.4	0.1	- 9.2
Balance/km (centimes)	-36	7	-10	2	-5	-43	5	-

revenue is estimated on the basis of stable specific unit tax in constant francs, which would lead, with no changes in behaviour, to a trend parallel to that of traffic. In addition, historical trends led us to integrate the following likely developments into the analysis: a slight increase in the energy efficiency of vehicles, a strong penetration of diesel engines in the light vehicle stock, greater use of toll motorways and more widespread charging for parking.

The cost trends are without a doubt the most difficult to estimate. The economic evaluation of the external costs depends on two types of anticipation: the physical values of the damage (tonnes of pollutants, number of accidents, etc.) and the unit monetary value attributed to this damage. The projection of physical values involves some risk of error (anticipation of the evolution of technical standards, rates of renewal of the vehicle stocks, fuel consumption, etc.), but these are normal risks common to any kind of forecasting. This is not the case with the unit value attributed to damage: if this study had been carried out 15 years ago, it would probably not have mentioned the greenhouse effect and would probably have valued local pollution differently, since catalytic converters were less efficient than they are today. We use two hypotheses in estimating the monetary value of the negative effects of road traffic. In the first, we maintain unit costs at their 1991 levels; we thus assume that there is neither an increase nor a decrease in concern for the environment, that the marginal costs of emissions are equal to the average costs (i.e. limit capacities of ecosystems are not reached in the case of increasing or cumulative emissions, and vigilance is not relaxed if emissions decrease). In the second, we assume that unit costs increase in line with economic growth. This hypothesis appears entirely natural on certain points, such as for example the "value of a human life", which is the basis for the economic quantification of accident costs. Still, it must be admitted that this link between the cost of damage and a given country's standard of living gave rise to a heated debate when it was used to justify higher admissible pollution levels in developing countries. We shall therefore use both hypotheses for our estimates.

In physical terms, only fuel consumption (and hence the corresponding greenhouse effect) is likely to increase substantially, while noise will increase slightly. On the other hand, pollutant emissions and accidents should decline fairly significantly.

However, in the case where the value of the effects follows the standard of living, all external costs increase very substantially. It is clear that this hypothesis implies that specific taxation must increase with the standard of living if we wish to maintain a certain level of coverage of total cost by specific revenue.

Table 12.7 gives a consolidated view of these trends. The following points are particularly noteworthy:

- Total traffic is expected to grow at a lower rate than the economy as a whole;

- Specific revenue will increase more slowly than traffic volume because of the slight

Table 12.7: **Estimated changes in traffic statistics and related externalities in France, 1991-2010**

	Variation (%)
Total traffic, of which	+47
Gasoline light vehicles	-13
Diesel light vehicles	+168
Trucks	+59
Urban areas	+39
Rural areas	+52
Toll motorways	+125
Road expenditure	+59
Specific revenue	+51
External costs	-10
(valuation stable at 1991 levels)	
Noise	+10
Pollution	-30
Greenhouse effect	+39
Accidents	-23
Congestion	-10
External costs	+45
(trend matching the standard of living)	
Noise	+74
Pollution	+12
Greenhouse effect	+125
Accidents	+23
Congestion	+59
Overall balance, 1991 value	-6
Overall balance, trend value	+94

increase in vehicle efficiency and the considerable increase in the proportion of diesel vehicles. The increase in toll revenue will not suffice to re-establish a balance;

- In physical terms, the external costs fall slightly in spite of the increase in traffic. This is due to the diffusion of technical progress (pollution), the greater maturity of users (accidents) and a certain reduction in exposure connected with the suburbanisation of the territory (noise, congestion). In monetary terms, however, they increase substantially if their value follows that of the standard of living.
- On the basis of the 1991 value, the overall balance improves slightly, but deteriorates considerably if unit costs follow the standard of living.

The last chapter of the report proposes an alternative view of the development of the French transport system and its management rules. This approach is designed to meet two primary objectives:

- The first objective is to reduce external costs while leaving mobility virtually unchanged. To accomplish this, the trend towards increased negative effects must be delinked from increased mobility, as in the

Table 12.8: **Forecast balance for 2010**
(billion francs 1991)

	Gasoline light vehicles	Diesel light vehicles	Heavy vehicles	Total
REFERENCE SCENARIO				
Urban areas				
Revenue	35.1	25.9	3.7	64.7
Road expenditure	20.6	34.7	7.6	62.9
External costs	27.3 to 43.7	33.7 to 53.9	38 to 6	64.8 to 103.6
Balance	-12.8 to -29.2	-42.5 to -62.7	-7.7 to -9.9	-63 to -101.8
Rural areas				
Revenue	49.9	46.4	43.2	139.5
Road expenditure	22.7	39.2	34.4	96.3
External costs	11.9 to 19.1	16.1 to 25.5	9.8 to 15.9	37.8 to 60
Balance	+8.1 to +15.3	-8.9 to -18.3	-1 to -7.1	+5.4 to -17.3
Overall balance	-21.1 to +2.5	-51.4 to -81.1	-8.7 to -17	-57.6 to -119.1
ALTERNATIVE SCENARIO (before fuel tax changes)				
Urban				
Revenue	41.5	39.9	3.9	85.3
Road expenditure	20.1	33.1	6.4	59.6
External costs	18.9 to 30.2	23.9 to 38.2	3.5 to 5.5	46.2 to 73.9
Balance	-8.8 to +2.5	-17.1 to -31.4	-6 to-8	-20.6 to -48.2
Rural areas				
Revenue	47.4	44.3	43.1	134.8
Road expenditure	23.6	40.6	34.6	98.8
External costs	9 to 14.4			
Balance	+9.4 to +14.8	-9.8 to -17.9	-0.5 to -5.9	-14.4 to +4.5
Overall balance	+0.6 to +17.3	-26.9 to -49.3	-6.5 to -13.9	-16.1 to -62.6
Balance/km in centimes (FF 0.01)	+0 to 7	-7 to -14	-14 to -30	-2 to -10
Balance/km in U.S. cents ($0.01)	0 to +1.3	-1.3 to -2.4	-2.5 to -5.4	-0.4 to -1.7

past the trend in energy consumption was delinked from economic growth, or again road accidents from traffic growth (accidents halved while traffic doubled). Three fields in particular are concerned: road accidents (orientation of demand towards safer vehicles, increased surveillance, orientation of demand to motorways, etc.); pollution (vehicle inspection and elimination of old vehicles); noise (active "anti-noise" investment programmes, dissuasion of truck transit through urban areas, etc.). The measures proposed for these different fields could make possible an 18% reduction in total external costs.

– The second objective is to reduce external costs where they are highest, i.e. in urban areas, thanks to the use of parking management mechanisms, chosen in preference to urban road pricing because they seem to us to be more likely to be rapidly accepted. Unlike the first series of measures, this package is intended to affect behaviour and generate new revenue. Such efforts would likely reduce urban traffic by 11%, leading to a reduction of 6.5% in total external costs and an FF 17.4 billion increase in urban area revenue.

After applying these two series of measures, the unfavourable balance between revenue and total cost is significantly reduced in the low hypothesis, but still considerable in the high hypothesis for the valuation of the externalities (see Table 12.8).

In comparison to the initial projections, the overall negative balance is reduced by 72% in the low hypothesis and by 47% using the high assumptions.

Seeking a balance through changes to the average taxation on fuels implies an increase in the TIPP of 32 centimes/litre in the low hypothesis and 123 centimes/litre in the high. These increases are not at all unrealistic: in both cases the rate of increase in fuel prices would be far lower than that of the standard of living.

On the other hand, such increases give rise to serious problems in sectoral terms, when a distinction is made between gasoline and diesel. If we use the low hypothesis for the estimation of external costs, it would be appropriate to significantly reduce the price of gasoline and increase the price of diesel – slightly for heavy trucks and very significantly for light vehicles. This proposal is quite reasonable from the standpoint of transport, but would pose problems of industrial strategy that lie outside the scope of this study.

Chapter 13

The Social Costs of Motor Vehicle Use in Japan

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13.1 Introduction

To evaluate to what degree the external costs incurred by road transport activities are paid by motor vehicle users, the study summarised here constructed a balance sheet comparing public tax revenues and loans borne by automobile users in Japan with public expenses for road works and the external costs arising from motor vehicle use[1]. The exercise was conducted for the years 1991, 2000 and 2010.

The balance is defined as the amount paid by motor vehicle users minus the sum of road expenditures plus external costs. If the balance is negative, then the indication is that some of the social costs of road transport remain unpaid by automobile users, and that it would be reasonable to increase taxation on road transport activities to the point necessary to bring the balance down to zero. Conversely, a positive balance would be a sign that the present tax burden on motor vehicle users is too high. Such policies can be deemed fair according to the logic of the user-pays principle.

Two basic features of our approach should be noted at the outset. First, this study seeks to estimate a fair tax level instead of an efficient tax level. The latter is defined as the Pareto optimal tax level, where economic theory advocates marginal social cost pricing. Normally, in estimating the marginal social cost of road transport activities, congestion costs should be included among the cost items. However, since this study attempts to calculate a fair pricing level, congestion costs have not been taken into account in the estimation of externalities. Congestion is a phenomenon caused by motor vehicle users and affecting motor vehicle users, and thus its cost is in a sense already internalised and should be excluded from the calculation of external costs. To a certain degree, the same rationale can be applied to accident costs. Since the monies paid through the insurance system can be regarded as internalised, the external cost of accidents represents only publicly-paid items such as legal costs, accident consulting costs and so on.

Second, as the basis of the fair pricing policy modelled here, the present study uses a fuel tax system for gasoline and diesel that favours neither fuel and results in equal after-tax prices for each of them. As a result of industry priority policies, the present fuel tax system in Japan favours diesel fuel. As a result, stocks of diesel light trucks and diesel passenger cars have been rapidly increasing and are at the root of NO_x and SPM problems in urban areas. On the basis of a previous simulation study, it would probably be necessary to bring diesel fuel prices up to the same level as gasoline prices if NO_x emissions were to be kept at current levels through 2005.

Finally, the fair fuel price level defined above should be balanced so that the public revenues paid

1. The complete study has been published as "The Social Costs of Motor Vehicle Use in Japan", in "Supports to the Road Transport Sector", vol. 3 of "Environmental Implications of Energy and Transport Subsidies", OECD/GD(97)156, OECD, Paris.

Table 13.1: **Annual motor-vehicle related tax revenues and costs: Summary (1991)**

Items	Annual tax revenues and costs				
	billion ¥	billion $[a]	% of GNP[b]	¥/Vehicle[c]	¥/Vehicle-km[d]
1. Public revenues and loans paid by automobile users	**9 530**	**71.80**	**2.08**	**159 360**	**14.51**
1.1 Earmarked tax revenues for road works	4 812	36.25	1.05	80 466	7.32
1.2 Loans from government investment and loans program for toll road system works	2 670	20.12	0.58	44 648	4.06
1.3 Other motor-vehicle related tax revenues excluding half of consumption tax revenues	1 953	14.71	0.43	32 658	2.97
1.4 Traffic violation penalty payments	95	0.72	0.02	1 589	0.14
2. Public expenses for road works					
Case 1	**11 665**	**87.89**	**2.54**	**195 052**	**17.75**
Case 2 (2-2.5)	**7 577**	**57.09**	**1.65**	**126 702**	**11.53**
2.1 Government general road works	4 469	33.67	0.97	74 722	6.80
2.2 Independent regional road works	3 965	29.87	0.86	66 298	6.04
2.3 Toll road system works	3 031	22.84	0.66	50 688	4.61
2.4 Government personnel costs	200	1.51	0.04	3 344	0.30
[2.5 expenses for road works funded by general tax revenues.]	[-4 088]	[-30.80]	[-0.89]	[-68 360]	[-6.22]
3. External costs	**2 742 (=7 335-4 593)***	**20.66**	**0.00**	**45 853**	**4.17**
3.1 Noise	425 (=425-0)*	3.20	0.09	7 102	0.65
3.2 Pollution	1 654 (=1 654-0)*	12.46	0.36	27 652	2.52
3.3 Accidents	124 (=4 717-4 593)*	0.93	0.03	2 079	0.19
3.4 GHG emission	534 (=534-0)*	4.02	0.12	8 935	0.81
3.5 Elimination of natural areas	5 (=5-0)*	0.04	0.00	85	0.01
4. Balance					
Case 1 {=1-(2+3)}	**-4 877**	**-36.74**	**-1.06**	**-81 545**	**-7.42**
Case 2 {=1-(2-2.5+3)}	**-789**	**-5.94**	**-0.17**	**-13 194**	**-1.20**

Notes: Case 1 : all costs completely shared; Case 2 : road works expenses funded by general tax revenue deducted from total public expenses for road works

* The first figure in parenthesis represents total damage costs; the second shows the costs borne by automobile users.

a. 132.73 ¥/$, mean current exchange rate in 1991;

b. GNP in 1991 was ¥ 458 599.1 billion;

c. Vehicle stock in 1991 is estimated at 59 801 591 units;

d. Vehicle kilometers travelled (VKT) in 1991 is estimated at 657 billion.

by motor vehicle users equal the sum of road expenditures and external costs, all of which are functions of fuel prices. Therefore, to obtain a fair fuel price level for the years 2000 and 2010, this study constructs a partial equilibrium model of the above three items, on the basis of projections for total passenger-km and freight ton-km.

13.2 Balance sheet for 1991

Table 13.1 presents a balance sheet of the motor-vehicle related revenues and costs for 1991. The revenues appear as item 1, and are subdivided into specific revenue sources (items 1.1 - 1.4). Items 2 and 3 represent two types of cost: public expenditure on road works (item 2) and external costs (item 3). Each cost item is divided into specific cost elements as shown in the table.

The balance is calculated as follows:

Balance = (item 1) - (item 2 + item 3).

A variant of the main balance (called "Case 1") has been prepared for this exercise. The second balance, referred to as "Case 2", is identical to the main balance in all respects with the exception that road works expenses funded from general tax revenues have been subtracted from the overall figure for public road expenditures (item 2). Thus, for Case 2, the balance is calculated in a slightly different manner:

Balance = (item 1) - {(item 2- item 2.5) + item 3)}.

As Table 13.1 shows, both Case 1 and Case 2 have a negative balance, suggesting that motor vehicle users do not fully pay the costs they incur.

The public tax revenues and loans borne by automobile users in Japan for the year 1991 consist of earmarked tax revenue for road works (item 1.1); loans from the government investment and loans program for toll road system works, which are repaid following completion of the road by the toll collection from vehicles (item 1.2); other automobile related tax revenues, minus 50% of the revenue from the consumption tax (item 1.3); and payments of traffic violation penalties (item 1.4).

Concerning item 1.3, only half of the consumption tax revenues are counted, since the 1991 consumption tax rate for motor vehicles is 6%, or twice that placed on other goods. As for item 1.4, in spite of the fact that these monies are not tax revenues, they have been included here because Japanese law mandates that this revenue be spent exclusively on traffic accident countermeasures. Public expenditure for road works is composed of general government road works conducted by the national and local governments and funded by tax revenues (item 2.1); regional road works carried out independently by local governments and funded solely by local tax revenues (item 2.2); and toll road system works funded by public or private-sector loans and conducted mainly by four public road corporations (item 2.3).

In addition to the three items mentioned above, the annual cost of road-related personnel and highway patrol or traffic enforcement personnel has also been estimated (item 2.4). Van der Kolk found that in the Netherlands these costs represented Gld 3.3-5.3 billion in 1987, for an infrastructure construction cost of Gld 5.8 billion. On the basis of these figures, it is our guess that the average cost of a single public road employee in Japan is ¥ 10 million per year. Assuming that Japan counts a total of 20 000 road personnel, the resulting cost would be ¥ 200 billion per year.

As shown in Table 13.1, the total public expense for road works was ¥ 11 665 billion in 1991. This is the sum used for total public expenditure on road works in the main balance (Case 1). This method of calculating the road works expense figure ignores the public goods characteristics of road infrastructure mentioned below and assumes that motor vehicle users should pay the full amount of public expense for road works.

The external costs attributed to road activities in this exercise exclude congestion costs since congestion is only imposed on users of motor vehicles and is already in a sense internalised. Instead, external costs were estimated in reference to five other effects of motor vehicle use: noise (item 3.1), air pollution (item 3.2), accidents calculated by damage cost minus amount paid by insurance (item 3.3), greenhouse gas (GHG) emissions (item 3.4), and elimination of natural areas due to road construction (item 3.5). The evaluation of the external costs mentioned above draws heavily on three different studies' estimates of unit damage costs as described in Table 13.2.

Table 13.2 presents an international comparison of external unit costs per vehicle-km between Japan, the USA and France. Although the evaluation methods differ and are occasionally opaque or subject to uncertainty, the resulting figures are fairly convergent.

As mentioned earlier, this exercise attempts to estimate a fair fuel tax rate for motor vehicle use based on balancing the relevant costs with revenues paid by users. To remove the negative balance in Case 1, a uniform fuel tax increase of ¥ 58.3/l would need to be added to 1991 fuel prices, this figure being derived by dividing ¥ 4 877 billion by total 1991 fuel consumption (83.7 billion liters). In Case 2, where the negative balance is smaller, the tax increase required to balance the costs and revenues is only ¥ 9.4/l. A more detailed description of the elements of each cost and revenue item, as well as a discussion of the differences between Case 1 and Case 2 is given in the sections below.

Public road expenses, especially items (2.1) and (2.2) above, account not only for facilities directly related to motor vehicle use, but also for non-users'

Table 13.2: **Comparison of external unit cost**
(unit: cents per vehicle-km)

Items	JAPAN*	USA (Low)	USA (High)	FRANCE**
Noise	0.49	0.12	0.19	0.35
Vibration	-	0.01	0.01	-
Air pollution	1.90	0.38	5.75	0.89
Accidents	0.14 (5.40)***	1.58	1.58	1.06
GHG emissions	0.61	0.05	0.19	0.53
Elimination of natural areas	0.001	-	-	
Subtotal	3.14 (8.40)	2.14	7.72	2.83
Congestion	-	1.23	2.80	-
Congestion to public transport and pedestrians	-	-	-	0.89
Total external cost	3.14 (8.40)	3.37	10.52	3.72

* ¥ 132.73/$, mean current exchange rate in 1991.
** FF 5.64/$, mean current exchange rate in 1991.
*** The figure in parenthesis is the total damage cost of accidents including the cost internalised by insurance.

facilities such as pedestrian walks, open space in front of railroad stations, public transport constructed on the road space, free supply of space for public utilities beneath roads, and so forth. One can thus argue that a certain share of these costs are directly incurred by the public in general, and not only by motor-vehicle users. Japanese tax policy seems to recognise this logic, since it allocates general as well as earmarked tax revenue for road works. To account for these public goods characteristics of road works in our balance calculations, we prepared a variant (Case 2) of the main balance in which the general tax contribution to road works expenses was excluded from the costs. Therefore, since ¥ 4 088 billion out of the ¥ 11 665 billion spent on road works in 1991 was funded by general tax revenues, this leaves a value of ¥ 7 577 billion, the figure used in Case 2 for total expenditure on road works.

13.3 Prediction and simulation for 2000 and 2010

13.3.1 Forecasting system and simulation models

The first scenario run carried out with the model is a business as usual (BAU) scenario which fixes the fuel price at 1991 levels, i.e. ¥ 110/l for gasoline and ¥ 74/l for diesel. Under this assumption, projections are made for 2000 and 2010, and the balances of costs and revenues are estimated. The results of the BAU scenario are discussed in detail in the following section. A zero balance would suggest that 1991 fuel prices were in fact at the "fair" level, and the simulation would be concluded. However, the balances for the BAU scenario are in fact negative. In this case, in the subsequent steps of the simulation, fuel prices are adjusted upwards until a zero balance is achieved. The results of this part of the exercise are presented in section 13.3.3.

During the first step of the simulation, two types of total transport activity levels – passenger-km and freight ton-km – are estimated by fitting a logistic curve to a time series of historical data. Second, the road transport split is estimated by a typical binary logit model for passenger-km and ton-km, and the fuel price level is introduced as the explanatory variable. Third, by multiplying the result of the share model by the total transport volume, the model calculates road transport volume in terms of passenger-km and ton-km, which are then converted to the number of registered vehicles by simple regression analyses. Fourth, each item of road-related public revenues, expenses for road works and external costs is estimated by constructing a simple regression model using the total number of registered vehicles in each year as the explanatory variable.

13.3.2 *Projections for business as usual (BAU) case for 2000 and 2010*

13.3.2.1 Case 1

As shown in Table 13.3, the Case 1 balances in the BAU scenario are still negative and their absolute values are growing throughout the period of analysis due to an increase in road transport activities. As a result of this growth, all of the various road activity indicators are increasing, even the per-vehicle values and the distances travelled by individual vehicles.

The negative balances in 2000 and 2010 for the BAU scenario, ¥ -5 707 billion and ¥ -6 428 billion, respectively, are equivalent to a uniform tax increase on gasoline and diesel fuel of ¥ 56.3/1 in 2000 and ¥ 59.3/1 in 2010. These figures are close to the increase necessary to even the balance in 1991, ¥ 58.3/l. The equivalent uniform tax increases in 1991, 2000 and 2010 are all about at the same level, in spite of the increase in all the relevant road transport statistics due to growth in total fuel consumption.

13.3.2.2 Case 2

In Case 2 of the scenario runs, road works expenses funded by general tax revenues are deducted from the total public expenses for road works. This

Table 13.3: **Annual motor-vehicle related revenues and costs: Summary (Business as Usual)**
(billion yen)

Items	Annual tax revenue and costs *1991*	*2000*	*2010*
1. Public revenues and loans paid by automobile users	**9 530**	**10 765**	**11 713**
1.1 Earmarked tax revenues for road works	4 812	5 389	5 853
1.2 Loans from government investment and loans program for toll road system works	2 670	3 062	3 365
1.3 Other automobile related tax revenues excluding half of consumption tax revenues	1 953	2 215	2 388
1.4 Traffic violation penalty payments	95	99	107
2. Public expenses for road works			
Case 1	**11 665**	**13 517**	**14 930**
Case 2 (2-2.5)	**7 577**	**8 550**	**9 325**
2.1 Government general road works	4 469	5 577	6 152
2.2 Independent regional road works	3 965	4 194	4 647
2.3 Toll road system works	3 031	3 546	3 931
2.4 Government personnel costs	200	200	200
[2.5 expenses for road works funded by general tax revenues.]	[-4 088]	[-4 967]	[-5 604]
3. External costs	**2 742**	**2 955**	**3 212**
3.1 Noise	425	456	496
3.2 Pollution	1 654	1 781	1 938
3.3 Accident	124	139	149
3.4 GHG emission	534	573	622
3.5 Elimination of natural areas	5	6	7
4. Balance			
Case 1 {=1-(2+3)}	**-4 877**	**-5 707**	**-6 428**
Case 2 {=1-(2-2.5+3)}	**-789**	**-740**	**-824**

Notes: Case 1 : all costs completely shared; Case 2 : road works expenses funded by general tax revenue deducted from total public expenses for road works variant of the balance sheet was prepared to reflect the assumption that the road works expenses funded by general tax revenues represent the share of road facilities benefiting non-drivers – e.g. public transport, pedestrian walkways, free space for utilities beneath road surfaces, etc. – and are thus not costs specifically incurred by private motor vehicle use.

As shown in Table 13.3, the balances for Case 2 are also negative throughout the period of analysis. In contrast to Case 1, however, we can see that while the improvement is not very great, the absolute value of the Case 2 balance for 2000 is lower, i.e. less negative, than in the base year. This movement reverses in the following decade, and by 2010, the absolute value of the Case 2 balance is greater than in 1991. This can be explained by the fact that in our simulation model, the amount of road works funded by general taxes (item 2.5) increases much faster over time than the other cost items.

The negative balances in 2000 and 2010 for Case 2 of the BAU scenario, ¥ -740 billion and ¥ -824 billion, respectively, are equivalent to a uniform fuel tax increase of ¥ 7.3/1 in 2000 and ¥ 7.6/1 in 2010. Compared to ¥ 9.4/1 in 1991, the tax increases necessary to even the balance in 2000 and 2010 are slightly lower, due to the growth of fuel consumption.

13.3.3 Simulation of fair pricing

13.3.3.1 Simulation model

The fact that the balances of both Case 1 and 2 for 2000 and 2010 are negative in the BAU scenario suggest that an increase in fuel tax is in order if fair price levels are to be attained. For the reasons mentioned in the introduction, these increases should be applied in such a way that consumer prices for gasoline and diesel are brought to an equal level.

Were a tax increase introduced, road transport activities can be expected to decrease, as the resulting costs provoke a change in the modal split towards other forms of transport. In turn, road expenses, external costs and fuel consumption will also decrease. The public revenues and loans paid by motor-vehicle users will, on the contrary, increase, since additional public revenue is generated by the tax increase. Since the balance is defined as the revenues minus the sum of expenses and external costs, the resulting balance ends up moving toward zero. The tax rate necessary to bring fuel prices to a fair level is based on the amount of increase necessary to attain a balance of exactly zero. For this reason, it is necessary to carry out a simulation at different taxation levels so that the fair price level can be determined.

Thus, in addition to the BAU scenario, a second set of simulations for Case 1 and Case 2 were carried out to determine the balances that could be expected under the additional assumption of an increase in the price of gasoline and diesel.

13.3.3.2 Case 1

In Case 1 of what we will refer to as the Fair Pricing scenario, gasoline and diesel prices increase by ¥ 42/1 and ¥ 78/1, respectively, so that in 2000 one liter of either gasoline or diesel costs ¥ 152 (Table 13.4). For the simulation of the balance in the year 2010, the 1991 fuel price is increased by ¥ 45/l and ¥ 81/l for gasoline and diesel respectively, so that the price of a liter of either fuel in 2010 is ¥ 155/l (Table 13.4).

Under this tax system, passenger-km and ton-km drop in comparison to the BAU scenario by about 3% and 10%, respectively, both in 2000 and in 2010. The larger reduction in the case of ton-km is due to the comparatively higher hike in diesel fuel prices; in response to the ¥ 78/l increase, freight transport by road is significantly reduced in favour of other modes such as railways and ocean freighters.

Compared with the business as usual (BAU) scenario, public revenues and loans increase by about ¥ 3 700 to ¥ 4 000 billion as a result of the tax increases. Public expenses are about ¥ 2 000 billion less than in the BAU scenario, while the external costs remain at almost same level as the BAU scenario.

13.3.3.3 Case 2

Because a large share of road costs are deducted from the balance in Case 2, the gasoline price increase necessary to even the balance is comparatively low: ¥ 5/l for 2000 and ¥ 4/1 for 2010. Due to the currently low level of diesel prices, however, the necessary price increase for diesel fuel is still quite significant: ¥ 31/l and ¥ 32/l, respectively, for 2000 and 2010. After these increases, the price for a liter of either fuel is ¥ 105/1 in 2000 and ¥ 106/1 in 2000, as shown in Table 13.4.

Since the price adjustments are relatively small, under this tax system, the relevant road transport statis-

Table 13.4: **Fair fuel price levels**

	1991	*2000*	*2010*
Balance (billion yen)			
-Case 1-	-4 877	-5 707	-6 428
-Case 2-	-789	-740	-824
Fair fuel price levels – Case 1 (yen/l)			
-Gasoline-	**110 (+0)**	**152 (+42)**	**155 (+45)**
-Diesel fuel-	**74 (+0)**	**152 (+78)**	**155 (+81)**
Fair fuel price levels – Case 2 (yen/l)			
-Gasoline-	**110 (+0)**	**105 (-5)**	**106 (-4)**
-Diesel fuel-	**74 (+0)**	**105 (+31)**	**106 (+32)**

tics are little different from the BAU scenario. The only exception is road ton-km, which drops roughly 4%, due to a 42% increase in the price of diesel fuel.

Similarly, although public revenues increase slightly and public expenses decrease somewhat, overall, the differences between the main revenue and expenditure figures in Case 2 of the Fair Price and the BAU scenarios are relatively insignificant.

Because the diesel fuel tax was increased by ¥ 8/1 in 1994, and due to the rapid devaluation of Japanese yen vs. the U.S. dollar, the current market prices for gasoline and diesel fuel are ¥ 105/1 and ¥ 75/1, respectively. In other words, putting aside the fact that diesel fuel is still ¥ 30/l cheaper than in this segment of the model, the current pricing situation closely resembles Case 2 of the Fair Price scenario.

13.4 Concluding remarks on fair tax level simulation

This study attempts to estimate the balance between public revenues paid by motor vehicle users and the public expenses and external costs they incur, for the years 1991, 2000 and 2010. According to the model used in this study, under the present tax system on motor vehicle use and ownership, the balance is negative, i.e. motor vehicle users do not pay their full social costs.

On the basis of this finding, this report tried to estimate a fair fuel tax level, that is, a fuel tax rate that would bring the balance mentioned above to zero.

However, such an exercise must address the controversial issue of estimating to what degree road infrastructure directly benefits not only motor vehicle users, but the public in general. Among those characteristics of road facilities which may be considered public goods are the free supply of space for public transport such as subways, street cars and buses, pedestrian walkways, utility lines such as power, water supply and gas supply, landscaping and disaster prevention space. Rather than attempting to estimate the cost of these road-related public goods directly, this study assumed that they were equal to the share of public road expenditures financed by general tax revenues (rather than specific revenues). The balances made for the study thus analyse two parallel cases: Case 1, where costs included the full amount of road works expenditures, and Case 2, where road expenses financed though general tax revenues were subtracted from overall public road works expenses.

Assuming that Case 2 accurately represents the public good value of road infrastructure, the base-case shows a negative balance for 1991, and suggests that motor vehicle users failed to pay for some ¥ 789 billion of the costs they incurred. A uniform tax increase of approximately ¥ 9/l, relative to 1991 prices, would be necessary to even this balance. Since the Japanese government increased the tax on diesel fuel by about ¥ 8/l, in 1994, and because the depreciation of the yen against the dollar in the intervening years has caused the price of gasoline to rise, it may be argued that the present pricing system is balanced, and that motor vehicle users pay their way. In fact, the Case 2 projections suggest that present fuel prices are nearly sufficient to ensure an even balance through 2010, although a ¥ 30/l hike in diesel taxes would be necessary to bring gasoline and diesel prices into parity.

The above discussion is heavily dependent on the estimations of external costs adopted for this study.

These estimations are subject to major uncertainties. Moreover, several other items which could reasonably be counted as induced costs have been left out of the present estimations, notably, the loss of wetlands due to road construction, the free supply of road sites by non motor-vehicle users (e.g. by land readjustment projects), the induced costs of pedestrian facility construction, scenery damage by parking, and the induced congestion costs affecting pedestrians and users of forms of public transportation such as buses. On the other hand, there are a number of items that could also be deducted from the cost side, including congestion costs incurred by public works such as such as lifeline and public transport construction. As discussed above, the value of the public good characteristics of road space, estimated as the share of road works expenses paid out of general tax revenue, was deducted from Case 2 of the projections.

Taking into account all of the items mentioned above, it is our guess that a reasonable fair fuel price level would be around ¥ 130/1 for both gasoline and diesel fuel. This is the level reached in Case 2 of the Fair Pricing scenario when the base-case external costs are doubled ("Scenario B" in the unabridged version of the study). In this case, to achieve uniform fuel prices, the gasoline tax would need to increase by ¥ 25/1, while the price of diesel fuel would need to increase by ¥ 55/1. The increase rates remain stable through 2000 and 2010.

Before such a policy can be recommended, however, its potential effects on socio-economic activities need to be analysed. With the exception of the projection of the price-induced changes in the transport modal split, this study did not focus on these aspects. Finally, an estimation of the socially most efficient price for road fuels, obtained by comparing the social costs and benefits of road transport, could serve as a useful adjunct to this study.

Chapter 14

Transport Subsidies: U.S. Case Study[1]

Susan Haltmaier, DRI/McGraw-Hill

14.1 Introduction

In the USA, energy use in the transportation sector is one of the largest sources of greenhouse gas emissions, only marginally smaller than the electricity sector. Transportation in the USA has historically received direct subsidies in the form of general tax revenues to pave roads, build bridges, provide emergency services and the like. Moreover, the existing structure of user fees may be providing incentives to consume the wrong types of transportation services. Given the concern about the consequences of global warming, the role of subsidies as well as existing user fees in encouraging non-optimal use of energy is being analyzed to help policymakers understand the costs of actions to reduce emissions connected to such non-optimal use.

Three categories of costs were evaluated for the United States in 1991[2]:

- ***Private costs of motor vehicle ownership and operation*:** Total private costs of automobile use, including vehicle ownership, fuel, maintenance and insurance, amounted to $396 billion in 1991, while the total expenditure for road freight transportation was $278 billion. Thus the total private cost of road transportation was $674 billion for the year.
- ***Costs of infrastructure and highway services*:** Public expenditures on highway construction, repair, maintenance and services totaled $74.5 billion in 1991. Retirement of debt used to finance such expenditures added another $3.8 billion, for total disbursements of $78.3 billion, of which 80% was covered by revenues from user fees.
- ***External costs*:** Negative externalities, including global warming, congestion, land loss, parking, injury due to accidents, health, crop and material damage due to particulate emissions, and the like, are estimated to incur $118 to $372 billion per year that is not fully reflected in user fees or in private costs.

Thus, motor vehicle use is indirectly subsidised, leading to a greater than optimal use, as well as to overconsumption of transportation services in general.

14.2 Characteristics, extent and usage of the highway system

In 1991, the highway system in the United States consisted of 3.9 million miles of roadway, of which

1. The study summarised here has been published as "U.S. Case Study: Transportation Sector Subsidies", in "Supports to the Road Sector", vol. 3 of "Environmental Implications of Energy and Transport Subsidies", OECD/GD(97)156, OECD, Paris.

2. The 1994 data now available for the United States indicate a decline in expenditure of non-user-fee tax receipts on roadways. However, the issues of indirect subsidies and designing a structure of user fees that optimises consumption of transportation services are still being debated.

approximately 20% was urban and 80% was rural. Relative to total land area, this network is of low density compared with other developed countries such as France, Japan and the United Kingdom. This lower density is associated with lower population density and more widely dispersed economic activity. In per capita terms, the United States has over twice the road mileage of France, for example, and correspondingly higher per capita maintenance costs.

Motor vehicles are used more intensively in the USA than in most industrialised countries, with an average of about 15 500 vehicle miles per capita annually in 1991. The majority of this travel takes place on urban roads and the share is rising; between 1981 and 1991, urban travel rose from 55% to 60% of miles travelled. Furthermore, traffic volume has been increasing faster than highway capacity, particularly in urban and suburban areas. A growing concentration of population in metropolitan areas, a decline in the use of carpools and mass transit for commuting, and increasing reliance on the highway system for freight transportation have caused congestion delays in urban and suburban areas to worsen. For example, (c.f. dates below) the percentage of peak hour travel experiencing congested conditions (defined as a volume/capacity flow ratio in excess of 0.80) increased from 41% of total traffic in 1975 to 70% in 1991.

14.3 Structure of roadway user taxes

The administration of the highway system in the United States, including expansion and maintenance of infrastructure, regulation, and collection and disbursement of user fees, is shared among Federal agencies, state agencies and close to 39 000 county, township, and municipal governments. Federal funds are allocated to states based on a formula incorporating population, area, mileage and relative need; such funds account for about half of capital outlays by state agencies. Jurisdiction over roads is decentralised, with about 80% of total road mileage administered at the local level. The interstate system and all major arterial roads are administered by the states. Only about 5% of road mileage is directly under Federal control.

As shown in Table 14.1, user taxes and fees constituted the major portion of the $78.3 billion of funds made available for highway expenditures in 1991, amounting to $62.7 billion, 80% of total disbursements. Other funds included $5.5 billion of investment income, bond issue proceeds of $6.3 billion, less funds placed in reserve of $2.9 billion, and $18 billion from property taxes and general fund appropriations. These other funds were offset in part by $7.6 billion of user fees that were diverted to mass transit and other non-highway expenditures. Fuel taxes accounted for 62% of gross user tax collections. Registration fees collected by state agencies amounted to 17% of the total, followed by 13% from other Federal excise taxes plus other state taxes and fees, 6% from tolls and 2% from local user fees.

14.4 Market costs associated with roadway use

The Federal Highway Administration (FHWA) separates highway expenditures into six major classes:

- capital outlay (associated with improvements such as land acquisition, construction engineering, construction and reconstruction, resurfacing, rehabilitation and restoration, and installation of traffic service facilities);
- maintenance (routine repair work such as road patching and bridge painting, as well as traffic services such as snow removal, litter cleaning and toll collection);
- administration (includes general overhead, as well as engineering and research costs not assigned to particular projects);
- highway law enforcement and safety (state highway patrols, highway safety education, enforcement of vehicle size and weight restrictions, and inspection programs);
- interest on debt; and debt retirement.

A comparison of Tables 14.1 and 14.2 shows the discrepancy between revenues associated with user fees, which totaled $62.7 billion in 1991, and total disbursements of $78.3 billion. The imbalance could be greater if the opportunity cost of funds allocated to the highway system were included. To justify these expenditures, the rate return of return should be equivalent to that available elsewhere, and, as it is effectively part of highway costs, it should be borne by users.

14.5 Externalities

Roadway use also imposes a number of social costs that are not reflected in the cost of owning and operating the vehicles involved. Since drivers pay only

Table 14.1: **Revenue sources associated with roadway receipts, 1991**
(Million $)

		$/VMT	Million 1991 $
Federal Excise Taxes			
Fuel[1]			17 806
Automobiles	From users to Federal govt.		8 161
Light Trucks	From users to Federal govt.		5 681
Freight Trucks	From companies to Federal govt.		3 964
Other			1 980
State Fuel Taxes[1]			
Automobiles	From users to state govts.		9 748
Light Trucks	From users to state govts.		6 785
Freight Trucks	From companies to state govts.		4 734
State Registration Fees[1]			
Automobiles	From users to state govts.		6 327
Light Trucks	From users to state govts.		3 080
Freight Trucks	From companies to state govts.		666
Other Vehicles	From users to state govts.		596
Other State Taxes & Fees[2]			6 156
Local User Fees			1 222
Tolls	From users to state, local govts.		3 647
Gross User Taxes & Fees[3]			62 747
Less: Collection Expenses			3 642
Net User Taxes & Fees		0.027	59 105
Less:			
Non Highway Expenditures[4]			2 914
Mass Transit			4 735
User Taxes & Fees Allocated for Highways		0.024	51 456
Plus:			
Property Tax & Assessments	From users to state, local govts.		4 525
General Fund Appropriations			13 347
Investment income			5 535
Total Current Income		0.035	74 863
Plus: Bond Issue Proceeds			6 297
Total Receipts		0.037	81 067
Funds Drawn/Placed in Reserve			(2 900)
Total Funds Available		0.036	78 260

1. Allocation by vehicle type estimated by author based on vehicle miles travelled, fuel consumed and units registered.
2. Includes drivers' license fees, certificate of title fees, special title taxes, fines and penalties, mileage, ton-mile and passenger-mile taxes, special license fees and franchise taxes, permit fees and miscellaneous receipts less refunds.
3. Equals the sum of total receipts at Federal (FE-9), state (DF), and local (LGF) level plus an adjustment for Federal excise tax receipts dedicated to deficit reduction and leaking underground fuel tanks, and therefore not included in Table FE-9.
4. Excludes Federal amounts collected as user fees and disbursed for non-highway purposes.

Table 14.2: **Expenditures associated with roadway use, 1991**
(Million $)

	Cars & LDTs*	Freight Trucks	Urban	Non-Urban	Total
Total Construction	23 377	12 777			36 154
State Administered Highways					25 716
Local Rural Roads					4 403
Local Municipal Roads					5 799
Not Classified					236
New Road Construction[1]			2 442	1 468	3 910
Road Repair[1]					
Reconstruction			2 619	1 460	4 079
Resurfacing			303	705	1 008
Restoration			494	821	1 315
Bridges[1]					
New			1 129	246	1 375
Replacement			1 109	898	2 007
Major Rehabilitation			1 090	237	1 327
Minor Rehabilitation			192	65	257
Maintenance and Traffic Services	19 408	1 012			20 420
Snow Removal[2]					789
Highway Police and Safety					
Administration and Research	6 535	341			6 876
Law Enforcement and Safety	7 371	385			7 756
Interest on Debt	3 120	162			3 282
Total Current Disbursements	59 811	14 677			74 488
Bond Retirements	3 585	187			3 772
Total Disbursements	63 396	14 864			78 260
Parking Subsidy					19 000
Employers					19 000
Pollution Control Devices[3]					
Expenditures					
Personal Consumption					8 747
Business					5 454
Operating Costs					
Personal Consumption					206
Business					206
Inspections[2]					439

* Light duty trucks.
1. Highway improvement projects authorised and started in FY1991.
2. Disbursements for state administered highways.
3. For 1990, updated to 1991 dollars based on BLS producer price index for consumer durable goods.

a fraction of social costs, their individual consumption choices exceed optimal levels from a social perspective. The degree of overconsumption of motor vehicle transportation depends on the magnitude of externalities and the price elasticity of demand, as well as the degree of subsidy associated with alternative modes.

There is a substantial body of literature on the estimation of external costs associated with roadway use, although considerable uncertainty remains. Table 14.3a presents consensus estimates, based on a review of the literature. In Table 14.3b, reasonable rules of allocation are used to distribute these estimates across rural and urban areas, as well as between automobiles and trucks.

External costs associated with air pollution from motor vehicles may account for as much as half of total external costs. However, there is a large degree of uncertainty associated with estimated costs, particularly in the area of damages to human health.

Congestion and accidents also carry large shares of total external costs, particularly at the low end of the range. Estimates of the social costs of accidents and congestion are generally quite large, of the order of two to five or six times the costs associated with health effects of air pollution.

14.6 Full user fee funding scenarios

Optimally, not only should user fees fully fund roadway services, but they should also be designed according to the marginal cost an additional user imposes upon society, including damage to roadways, delays suffered by other users through reduced speed, and the various other external costs. Such a fee would vary according to the characteristics of the vehicle, location of route and time of day. It would also be contingent upon the current status of highway infrastructure and the characteristics of the existing fleet of motor vehicles. If a system of fees could be designed to fully reflect costs, it would create incentives to reduce the marginal costs on which it was based, as the characteristics of vehicles and roads adjusted to minimise these costs.

In the initial phase of this analysis, presented to the Expert Steering Group of the Environment Directorate of the OECD in January 1994, the effects of a second-order user pays system of taxes on fuel consumption were explored. Based on those results, it was decided that a first-order user pays system of externality pricing should be examined, as well as the second-order effect of using fuel taxes as a proxy. At a minimum, an optimal system of road charges would appear to include weight-per-axle fees for heavy vehicles, possibly adjusted for miles travelled by type of roads, time of day pricing for passenger vehicles in congested areas, some type of price for parking, and a version of the current system of excise taxes, registration fees and tolls to pay for general highway services.

Only the market costs of driving were evaluated; no external costs were explicitly included. The rationale for this approach was the large degree of uncertainty surrounding the estimates of external costs. As indicated above, the external costs of driving in the United States vary by a factor of three, from $118 billion to $372 billion annually.

The reductions in driving and associated greenhouse gas emissions that would occur under the first- and second-order user pays systems of fully-funded market costs were compared with a reference case that continued the present system of partial subsidies. No measurement was made of the reduction in other social costs, although such reductions could be expected, insofar as they relate to roadway travel. Nor was an attempt made to measure possible increases in the social costs of other forms of transport that might be substituted for roadway transport.

14.6.1 Road wear vs. congestion

To develop an optimal pricing and investment scheme, it is necessary to separate the issue of road wear from that of congestion. It is widely accepted in the literature that heavy vehicles cause road wear (compounded by some weather-related deterioration in certain climates) and light duty vehicles cause congestion. However, because traffic volume and traffic loadings occur jointly on the single capital item (roads), the allocation of costs and revenues will depend on the interactions between roadway durability and roadway capacity, the "economies of scope".

14.6.2 Parking

Private expenditures not directly borne by roadway users include parking provided without explicit charge. Employer provided parking is tax exempt; thus it is in part compensation and in part government subsidy. To the extent that no alternative compensation is offered to those who use other modes of transportation,

Table 14.3a: **External costs associated with roadway use**[1]
(Billion 1991 $ per year)

	Low	High
Air Pollution		
Human Health	7.5	181.3
Materials	3.9	11.7
Crops	2.0	8.0
Climate Change	1.8	8.6
Congestion	43.0	100.0
Accidents	55.0	55.0
Noise	4.1	6.6
Vibration	0.3	0.3
Improper Disposal	na	na
Total External Costs	**117.8**	**371.7**

Table 14.3b: **External costs: modal and rural/urban allocation**[1]
(Billion 1991 $ per year)

	Rural		Urban	
	Cars	*Trucks*	*Cars*	*Trucks*
Air Pollution				
Human Health	2.0 to 48.0	1.1 to 25.8	2.9 to 70.0	1.5 to 37.5
Materials	1.0 to 3.1	0.6 to 1.7	1.5 to 4.5	0.8 to 2.4
Crops	0.5 to 2.2	0.3 to 1.1	0.8 to 3.1	0.4 to 1.6
Climate Change	0.5 to 2.2	0.3 to 1.3	0.7 to 3.3	0.4 to 1.8
Congestion	–	–	25.8 to 59.9	17.2 to 40.1
Accidents	11.2	5.8	28.6	9.6
Noise	–	–	0.6 to 0.9	3.5 to 5.6
Vibration	–	–	0.05	0.26
Total External Costs	**15.1 to 66.3**	**8.1 to 35.4**	**61.0 to 169.7**	**33.6 to 98.5**

1. See full text of study (referenced in footnote 1 at the beginning of this chapter) for sources.

this represents a transfer to motor vehicle users from non-users. Shoup estimates that 90% of workers in the USA commute by private vehicle with an average occupancy of 1.1 persons per vehicle, and that 10% of drivers pay for parking. Thus, 82% of workers ride in private passenger vehicles, with 72% receiving subsidised parking. Given 108 million workers in 1991, this suggests that 78 million people did not pay the full cost to park at work. Shoup estimates the total amount of the subsidy associated with employer provided parking at $19 billion per year.

14.6.3 Methodology

The U.S. Transportation Submodel uses a stock vintaging approach to project the composition of the light and heavy duty vehicle stocks, the number of miles travelled, the weighted average fuel economy of the stock and the amount of fuel consumed. The primary assumption in modeling the demand for travel is that drivers operate with a fixed budget constraint. That is, to the extent that drivers pay more for some aspect of travel, such as fuel, they will spend less on some other input, such as the vehicle itself. There is both empirical and theoretical evidence supporting the fixed budget constraint. In the 1960s, U.S. consumers spent 9.6% of their budget on motor vehicles and fuel; 20 years later, after two significant price shocks, the figure was still 9.6%. Furthermore, in the years that fuel prices rose substantially, the share was as likely to fall as to rise. Moreover, numerous citations are found within the economic literature supporting a long-term elasticity of one for any consumer good.

14.6.4 Optimal pricing charges

Currently, the variable cost of driving in the United States is modest, just $0.058 per mile for car drivers and $0.073 per mile for light duty truck drivers. Gasoline currently costs an average of $1.20 per gallon while the average car in the fleet gets 20.7 miles to the gallon and the average LDT fuel economy is 16.4 miles to the gallon. Of the $1.20 per gallon cost of fuel, Federal, state and local taxes account for $0.385 or nearly one-third of the cost.

As noted above, congestion pricing, parking charges and weight-per-axle fees are applied in the place of gasoline and diesel fuel taxes and non-user funds. For congestion and parking charges, the new fees are estimated as costs per mile driven. Other user fees are assumed to be left in place. The charges are phased in during 1998 with full implementation in 1999.

Taken together, congestion and parking fees raise the cost of commuting miles travelled. At the same time, the elimination of fuel taxes reduces the cost of non-commuting and fleet travel by light duty vehicles. The cost per mile is not significantly different on average for freight travel, although the costs within categories change, shifting driving from medium to heavy trucks.

14.6.5 Optimal investment

In the base case, total highway disbursements are projected to increase in nominal terms from $90 billion in 1993 to $163 billion by 2010, or 3.6% annually. In real terms, the increase averages 1% per year, reaching $105 billion (1993 $). The literature suggests that, in the long run, optimal spending on road construction and maintenance is about 65% of today's levels. The amount spent on traffic services, law enforcement and safety, and administration could also decline, as less driving could lead to fewer accidents and associated costs. However, because of the long time frame required to adjust roadway durability and capacity to optimal levels as well as the modest increases expected in base case roadway disbursements, highway capital and maintenance spending is brought back to today's levels over the 13-year program implementation period from 1998 through 2010, while other spending is held at base case levels. By 2010, spending is 90% of the base case level, at $94.5 billion (1993 $), as shown in Table 14.4.

14.6.6 Results of optimal pricing scenario

In the base case, the cost per mile of travel was expected to fall between 1991 and 2000 and then recover to the 1991 levels of $0.064 for cars and $0.084 for light duty trucks by 2010. Initially, in the Optimal Pricing Scenario, the cost of driving increases dramatically for peak travel and falls significantly for non-peak travel. Once the initial adjustments occur, however, the cost per mile for peak travel declines in real terms through 2010 as the congestion fee needed to collect target revenues falls. For non-peak drivers who pay only for gasoline under the Optimal Pricing Scenario, costs of driving decline in real terms between 2000 and 2010. The combination of parking and congestion fees raises the cost of com-

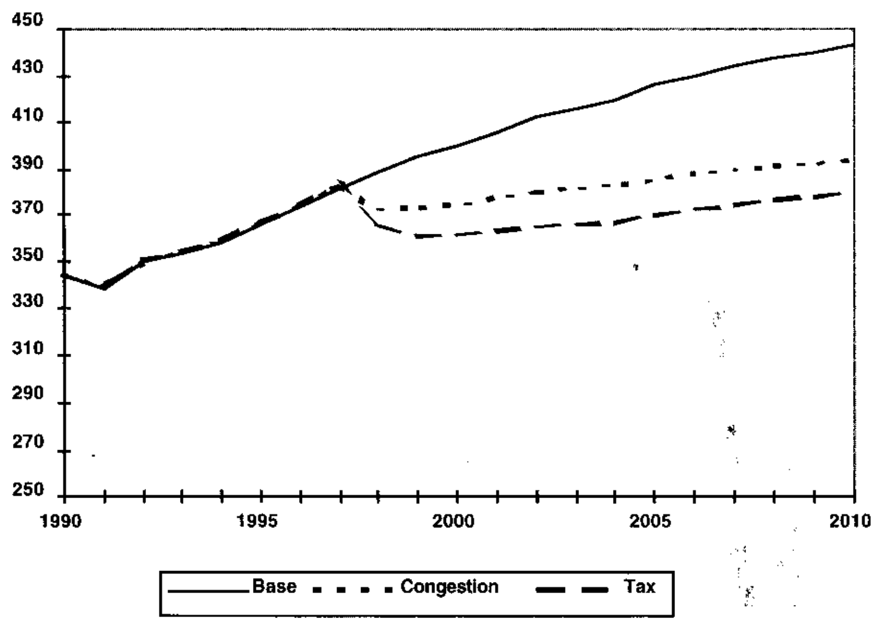
Table 14.4: **Highway expenditures: optimal spending case versus base case**
(Million $)

	1993 (Million $)	Base Case 2010 (1993 $)	Base Case Change vs. 1993	Optimal Case (1993 $)	Optimal Case Change vs. 1993
Capital Outlays	42 128	49 108	16.6%	41 869	-0.6%
Maintenance	18 966	22 108	16.6%	18 849	-0.6%
Subtotal	61 094	71 216	16.6%	60 718	-0.6%
Services	4 808	5 605	16.6%	5 605	16.6%
Admin., etc.	19 796	23 076	16.6%	23 076	16.6%
Debt Retirement	4 376	5 101	16.6%	5 101	16.6%
Total	90 074	104 998	16.6%	94 500	4.9%

muting travel to $0.158 per mile for cars and $0.146 for LDTs by 2010 because the longer average commute of LDT drivers lowers the effective cost per mile of the flat fee parking and congestion charges. By 2010, commuting by car is 150% more expensive than in the base case while LDT commuting costs are 76% greater. For light duty vehicles as a group, commuting travel costs increase by 110% in 2010. By 2010, the cost for non-peak travel averages just $0.039 per mile for cars and $0.052 per mile for LDTs, a decrease of 37% for both cars and LDTs relative to the base case. On balance for both types of driving, travel costs are 24% higher for cars and 16% greater for LDTs by 2010 with the average cost of travel up 20% for all light duty vehicles.

The largest response is seen in the initial years of the simulation. The higher cost of commuting travel reduces overall light duty vehicle travel by 5%, based on a 16.5% decline in commuting miles and a 3%

Figure 14.1: **Comparison of carbon emissions from highway fuel consumption**
(Million tonnes)



increase in non-peak travel. In addition, the fixed budget constraint reacts to the higher overall cost of travel by causing drivers to prefer cars over light trucks for reasons of fuel economy. Because the cost per commuting mile travelled declines on a year-over-year basis after 1999, the effect on travel demand diminishes marginally over the forecast period. By 2010, total light duty vehicle travel is 4% lower than the base case, with commuting travel down 13% and non-peak travel remaining 3% higher. Thus, commuting as a share of total private travel declines from 43% in 1994 to 39% by 2010 for cars and from 54% to 51% for LDTs.

In terms of fuel consumption and emissions, better fuel economy means the improvements are larger than the decline in miles travelled would suggest. Drivers' demand for fuel economy grows with an increase in the cost of travel because of the assumption of a fixed budget constraint. New vehicle fuel economy by 2010 is 20% above the base case while stock average fuel economy is 17% improved. Thus, fuel consumption in light duty vehicles falls by 15% in 2010.

Close to 99% of light duty vehicle fuel in 1991 was gasoline. Over the forecast period, small amounts of methanol, natural gas and electricity will be used as highway fuels. By 2010, light duty vehicle fuels are expected to be 94.5% gasoline, 1.5% diesel fuel and 4% alternative fuels. On the freight side, the shifts among truck configurations are largely offsetting. Medium truck miles travelled decline by 1.3% while heavy truck miles rise by 0.7%. In all, freight miles are 0.2% greater in the Optimal Pricing Scenario than in the base case in 2010.

Furthermore, since medium trucks are slightly more fuel efficient than heavy, fuel consumed is 0.3% higher in 2010 than in the base case. Approximately 90% of freight truck fuel use is diesel fuel over the entire forecast period. Adding light and heavy vehicle changes together gives a reduction in transportation fuels and associated emissions of 12% in 2010. Carbon emissions fall by 50 million tonnes by 2010, as shown in Figure 14.1. Cumulative carbon emissions fall by 473 million tonnes between 1998 and 2010, equivalent to 7% of total base case carbon emissions from energy use by highway vehicles.

14.6.7 Gasoline tax increase

The increase in travel costs must be greater with a gasoline tax than with an optimal pricing scheme in order to collect the same amount of revenue as in the Optimal Pricing Scenario, since fuel economy improvements cause gallons consumed to decline by more than miles travelled. In the base case, the gasoline tax as a share of the final retail price is about 30% over the period. In the Gasoline Tax Scenario, the tax as a share of the final price reaches 48% in 2000 and falls to 39% in 2010. In nominal terms, the total of Federal, state and local taxes on gasoline increases from \$0.47 nominal to \$0.98 in 2000 and from \$0.74 to \$1.15 per gallon in 2010. The final retail price is 33% higher in 2000 and 16% higher in 2010 compared with the base case. In addition to higher fuel costs, commuters see a higher cost of parking, as in the Optimal Pricing Scenario. Thus, commuting costs are 72% higher than the base case by 2010 while non-commuting costs are just 2% higher as a result of improvements in fuel efficiency.

In terms of miles travelled, commuting miles decline by more than non-commuting miles for light duty vehicles. Furthermore, total miles travelled decline by a greater amount than in the Optimal Pricing Scenario because the cost of all driving, not just of commuting, rises, particularly in the earlier years of the simulation. However, as the increases in the gasoline tax become a smaller percentage of the retail price, the impact on miles travelled diminishes, similar to the pattern in the Optimal Pricing Scenario. In 2010, light duty vehicle travel is 6% below the base case, with a 10% drop in commuting travel and a 2% reduction in non-peak light duty vehicle travel. Light duty fuel consumption is 18.5% below the base case in 2010.

Although diesel fuel costs are unchanged, higher gasoline prices, which affect 45% of medium truck travel, combined with lower economic growth result in 1% fewer freight truck miles and fuel gallons. Thus, in total, highway fuel consumption in 2010 is 15% lower than in the base case and 3% lower than in the Optimal Pricing Scenario. Emissions from the transportation sector are 14% lower in 2010 relative to the base case, or 63 million tonnes. On a cumulative basis, savings of 655 million tonnes are equal to 9.5% of total emissions of 6 922 million tonnes from the highway sector between 1998 and 2010.

In summary, the Optimal Pricing Scenario results in a 4% drop in light duty vehicle miles travelled, no change in total freight miles and a combined 12% fall in fuel consumed in 2010. Under the Gasoline Tax Scenario, light duty miles travelled decline 6%, freight mileage is down 1% and total highway fuel use is 15% below the base case by 2010.

14.6.8 *Climate change impacts*

Implementation of either the optimal pricing scheme or the second-best gasoline tax increase for roads has a negligible, albeit negative, effect on economic activity over the forecast period. The average annual growth rate between 1997 and 2010 is barely changed from the base case rate of 2.10% over the period; optimal pricing lowers the rate to 2.07% per year while the higher gasoline tax gives a 2.06% growth rate. Over the period, the cumulative reduction of \$85 to \$100 billion in dollars of output forgone in the Optimal Pricing and Gasoline Tax scenarios, respectively, amounts to just 0.1% of cumulative baseline GDP of \$87 181 billion (1987 \$). Because the reduction in carbon emissions is greater in the Gasoline Tax case with essentially identical GDP losses between 1998 and 2010, the cost per tonne of carbon removed is slightly higher in the Optimal Pricing case than in the Gasoline Tax case, as shown in Figures 14.2 and 14.3.

14.6.9 *Macroeconomic impacts of optimal pricing scenario*

In this scenario, gasoline taxes are eliminated and replaced by congestion, parking and weight-per-axle fees that fully finance road and highway construction. The new fees replace existing sources of funding for road and highway construction, which are reduced by a corresponding amount. These sources include Federal personal income taxes, state and local property taxes, state sales taxes and state corporate and personal income taxes. While the congestion and parking fees raise consumer prices, only the reductions in state and local property taxes and lower state sales taxes result in lower prices. Thus, the net impact of the shift in financing is an increase in indirect taxes on consumers and an increase in consumer prices.

In the short run, economic activity is boosted above the baseline because of the shift in consumption from gasoline, which on the margin is entirely imported, toward other consumer goods and services, which are produced primarily by domestic factors of production. During 1998-99, these positive impacts are almost offset by a drop in motor vehicle purchases, associated with bringing the actual motor vehicle stock in line with the new desired stock. Because of the higher cost of driving, the new desired stock of vehicles is smaller than the old. A shift in light vehicle preferences from light trucks to cars pushes car sales slightly higher than in the baseline despite the reduction in total vehicle sales; the entire burden of lower vehicle sales falls on light trucks.

Without the Federal Reserve accommodating the increased inflation, real economic activity is eventually reduced below baseline levels by an increase in interest rates. Since the higher rates reduce investment and thus trim the private capital stock, potential GDP is reduced below baseline levels, boosting the loss of GDP. During 2006-10, state and local spending on road construction falls, because of reduced road usage, pushing GDP further below the baseline. This reduction in spending reduces interest rates back to baseline levels by the end of 2010. Interest rates would likely fall below baseline levels in later years, eventually raising investment above baseline levels, adding to both actual and potential GDP.

Nominal reserves are assumed to remain at baseline levels. If DRI/McGraw-Hill's U.S. Macro Model Federal Reserve reaction function is turned on, interest rates rise somewhat more than in the Optimal Pricing Scenario during the early years, as the Fed tries to combat the extra inflation caused by higher net indirect taxes. In the later years of the simulation, however, as the initial inflation impact disappears and the unemployment rate rises above baseline levels, the Federal reserve becomes more accommodative than in the Optimal Pricing Scenario, and interest rates are lower. GDP losses after 2006 are reduced, at the expense of less GDP in earlier years.

14.6.10 *Differences between gasoline tax and optimal pricing scenarios*

Core consumer price index (CPI) inflation excludes gasoline taxes, but includes user fees such as congestion pricing. Thus, while overall CPI inflation during 1998-99 is similar in the two scenarios, core inflation is higher in the Optimal Pricing case. Because the Federal funds interest rate is a function of core, rather than overall, consumer price inflation, it is also higher during 1998-99 in the Optimal Pricing case. This rise in rates reduces demand for interest-rate-sensitive GDP components, such as housing, business investment and consumer durables, including vehicles. Real GDP falls below the baseline during 1998-2000 in the Optimal Pricing case, while it rises above baseline levels in the Gasoline Tax case, as shown in Figures 14.4 and 14.5. Because the Federal Reserve reaction function uses overall CPI inflation,

Figure 14.2: **Cumulative carbon savings and cost per tonne removed with optimal pricing**
(Million tonnes; 1987 $/tonne)

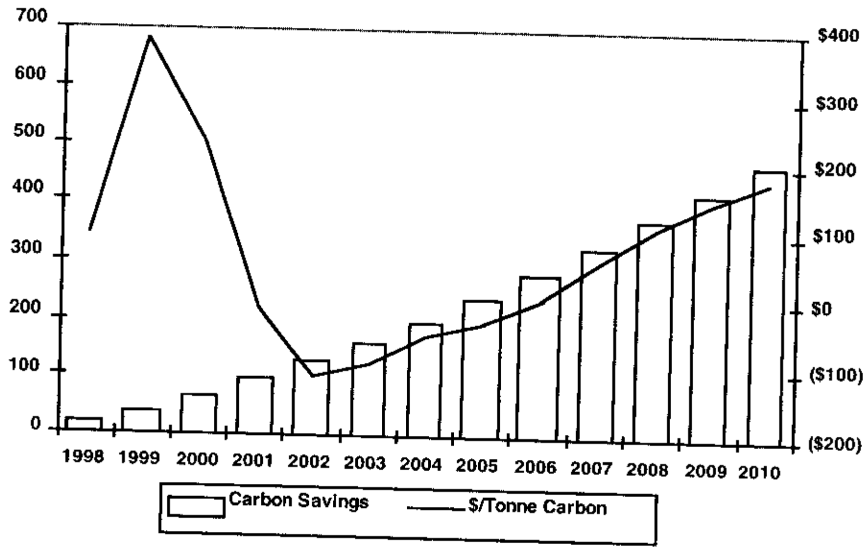


Figure 14.3: **Cumulative carbon savings and cost per tonne removed with gasoline tax increase**
(Million tonnes; 1987 $/tonne)

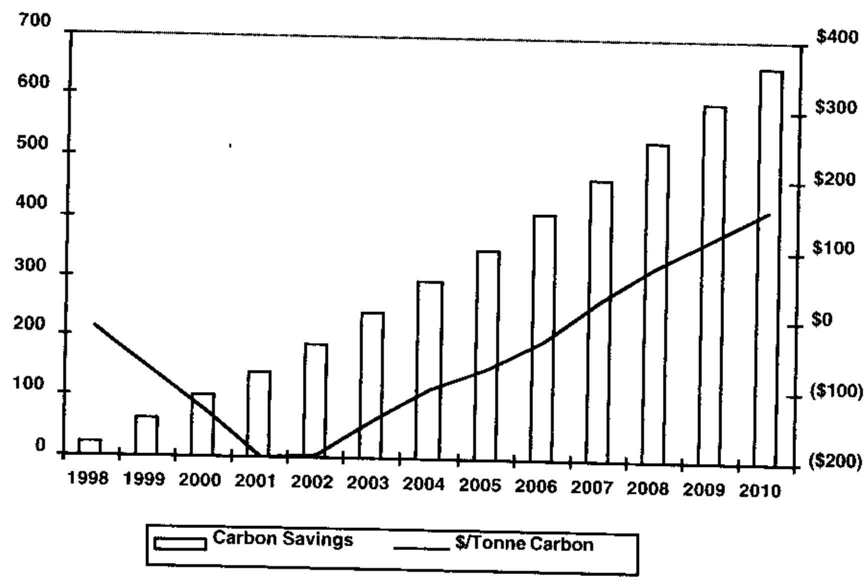


Figure 14.4: **Loss in output due to optimal pricing**
(Cumulative loss in billions of 1987 $; annual percentage difference)

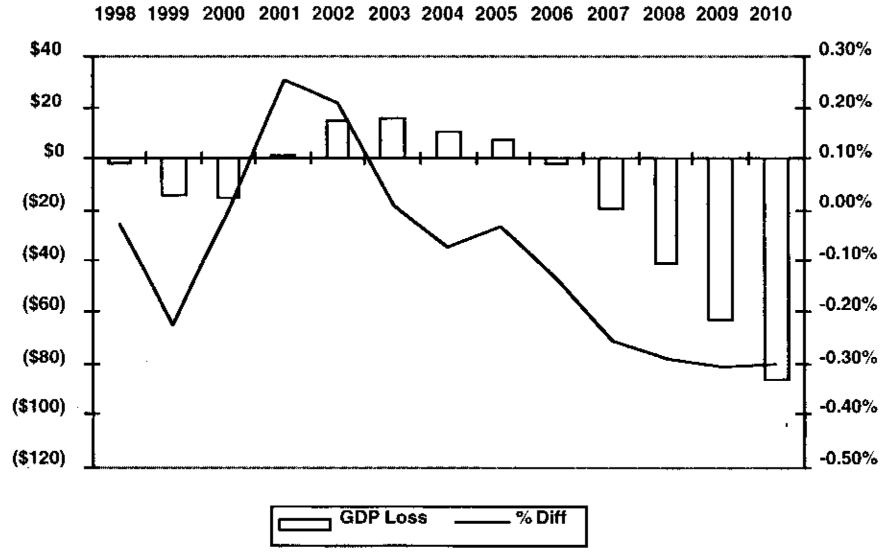


Figure 14.5: **Loss in output due to gasoline tax increase**
(Cumulative loss in billions of 1987 $; annual percentage difference)

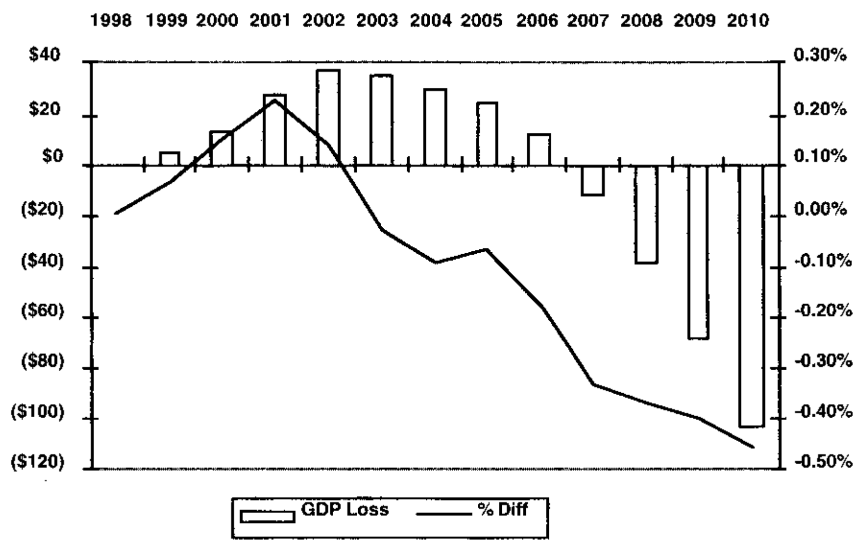


Table 14.5: **Highway revenues and expenditures**
(Billion $)

	1991	2000			2010		
		Base	Cong Fee	Gas Tax	Base	Cong Fee	Gas Tax
Expenditures	78.3	123.1	123.1	123.1	163.4	147.1	147.1
Revenues	78.3	123.1	123.1	123.1	163.4	147.1	147.1
User Fees	59.1	93.0	123.1	123.1	130.7	147.1	147.1
Fuel Taxes	36.8	72.6			110.7		
-Light Duty	29.9	58.0			86.2		
-Heavy Duty	6.9	14.6			24.5		
Congestion Fees			105.3	106.6		123.1	122.1
Maintenance Fees			15.1	14.5		22.0	23.0
Other User Fees	22.3	20.4	2.7	2.0	20.0	2.0	2.0
Less:							
Non-Highway Uses	-7.6	-12.0			-19.5		
Non-User Fees	26.8	42.1			52.2		

rather than core CPI inflation as in the Federal funds equation, the interest rate differences between the scenarios would be reduced if Federal Reserve accommodation were assumed.

By the end of the period, the losses in GDP are very similar. However, the GDP losses in the Optimal Pricing case have stabilized while those in the Gasoline Tax case have not. The initial adjustment is more severe in the Optimal Pricing case than in the Gasoline Tax Scenario due to the divergent interest rate movements resulting from higher core inflation in the former.

14.6.11 Issues with full user funding of roads

In this analysis, full user funding of roads is assumed to begin to lower expenditures on road construction and maintenance toward optimal levels after 2006. By 2010, road costs are 90% of base case levels, as shown in Table 14.5. The base case expenditures that were funded by non-user fees have been replaced by a combination of congestion and weight-per-axle fees. Under the Gasoline Tax case, higher gasoline taxes replace non-user fees; diesel taxes are not changed. Heavy duty vehicle revenue contributions in the base case are close to optimal levels, although the split between medium and heavy trucks is not. With only diesel taxes as an instrument, it is not possible to optimise the medium/heavy revenue shares under the second-best solution.

Full user funding of roads should eventually bring use of roads to optimal levels. Optimal use of roads should in turn result in lower maintenance costs as vehicle loadings are adjusted, and lower construction costs as well as time savings as vehicle congestion is reduced. A macroeconomic model such as the one used by DRI/McGraw-Hill in this analysis can capture the impacts of lower maintenance and construction costs but cannot measure the benefits of time savings. Thus, the economic impacts described above exclude the increase in allocative efficiency when drivers' time is used more productively. In spite of this shortcoming, however, the economic impacts are negligible over the period. Furthermore, the decline in GDP growth rates has moderated in the Optimal Pricing Scenario by 2010.

Furthermore, in this analysis, only two market costs are priced: road wear and congestion. We have not attempted to measure what happens to most of the external costs of driving, such as accidents, noise, land loss, etc. The only measure of improvements in external costs included in this analysis is the reduction in greenhouse gas emissions.

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Reforming Energy and Transport Subsidies

Environmental and Economic Implications

Reforming subsidies to polluting activities can benefit both the environment and the economy. While some recent studies may have overestimated these benefits, reforming policies that encourage environmentally damaging activities is a first step towards environment policy objectives. But to what extent is it worth reforming energy and transport subsidies?

This unique set of case studies shows that reforming supports to coal, electricity and transport could offer substantial environmental benefits in some countries. In others, the environmental improvement would be minimal. The social, economic and environmental outcome of reforms depends heavily on national and local circumstances and on the way reforms are implemented.

This report identifies key types of support whose reform might benefit the environment, pointing out some of the pitfalls of ill-considered reforms. It also suggests some ways in which national governments and the international community might proceed, bringing together environmental, social and economic policy agendas.

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