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Energy subsidies in the European Union: A brief overview

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Contents

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1. Summary and conclusions

There is no agreed definition of energy subsidies among European Union (EU) Member States. The term may include cash transfers paid directly to producers, consumers and related bodies, as well as less transparent support mechanisms, such as tax exemptions and rebates, price controls, trade restrictions, planning consent and limits on market access. It may also cover government failure to correct market imperfections, such as external costs arising from energy production or consumption. This results in a wide range of economic estimates and confusing policy arguments.

Beyond the annual report of direct state aid for the coal industry, there is no harmonised reporting mechanism for energy subsidies. The European Parliament (Oosterhuis, 2001) and the European Commission (2003a) have attempted to provide a full audit of energy support in the EU 15[1]. Both reports are snapshots based upon best available data, rather than structured ongoing reviews, and have not been updated since.

This report has synthesised data from a range of sources to estimate the size of support to the energy sector within the EU 15. Total subsidies (excluding external costs) were estimated to be in the order of EUR 29 billion in 2001.

Despite significant emissions of carbon dioxide and residual air pollutants emanating from the burning of fossil fuels, the amount of fossil fuel subsidies remains high, particularly for coal[2]. Support for renewable energy, which is on balance considered environmentally beneficial[3], is increasing steadily through the introduction of regulatory support mechanisms. With the exception of large hydro-electric power, renewable energy represents a much less mature industry with arguably greater need for technological and market support to enable full commercial development. It can be expected that subsidies for renewable industry will fall as costs decline and the technologies mature.

There is some evidence to suggest that, in historical terms, renewable energy subsidies in the EU 15 are relatively low in comparison with other forms of energy during periods of fuel transition and technology development. More mature fuels, such as natural gas, continue to benefit from the technological and industrial infrastructure built up during previous decades.

The lack of consistent subsidy data is an obstacle to reaching more definite conclusions on the appropriateness of the amounts and structures of subsidies for the different fuels across the EU 15. There is a need for a harmonised energy subsidy reporting framework on the basis of an agreed definition. There are also a number of other aspects that should be duly taken into account in the subsidy debate.

Energy market liberalisation and privatisation have led to lower energy prices, greater price volatility and increased commercial risk for new capacity investment across all fuel types. Energy planners have begun to voice concerns over current limited levels of private sector investment in new capacity, given projected energy demand growth over the next 30 years. These concerns are heightened by the projected retirement

1 EU 15 corresponds to the pre-May 1 2004 EU Member States.

2 There has been a reduction in support to coal production over the past years in a number of Member States, leading to reductions in coal production in these countries. These reductions may lead to domestic coal being replaced in the short term, at least in part, by imported coal (Mountford, 2000). However, it has been argued that in the medium and longer term, as the markets react to the ensuing higher coal prices, there would probably be increased use of gas and renewable energies (OECD, 2004).

3 It should be noted that renewable energy sources, such as large hydro-electric power, energy crops and wind turbines (when placed near bird sanctuaries), can have significant environmental impacts.

of a substantial number of fossil fuel-fired plants in the EU 15. A forced delay in decommissioning of these plants to ensure supply will increase greenhouse gas emissions.

At current levels of political and financial support, the EU 15 renewable energy targets for 2010 will not be met. Renewable technologies offer the benefits of both increased energy security and reduced environmental impacts. The policy rationale for their economic support will most likely be strengthened as their contribution to reducing price volatility and overall emissions is better understood and quantified.

Unlike governments, individual companies carry little or no obligation to address long-term energy security or environmental challenges. It is the responsibility of governments to ensure, through market pricing and legislative frameworks, that the market responds to these concerns. Governments would be prudent to value the environmental and security of supply benefits of renewable energies and to set long-term price signals for industry development that reflect these benefits.

2. Introduction

This report has been prepared for the International Renewables Conference in Bonn in June 2004. It sets out a brief definition, rationale and reporting overview of energy subsidy, and provides an indicative estimate of subsidies by fuel type in the EU 15. The report also discusses aspects of historical levels of support to energy fuels, and summarises findings on both the environmental external costs from energy sources and the role of renewable energies in diversifying energy supply and reducing import dependence.

Due to data and time limitations, the report does not examine the issue of energy conservation subsidies and includes only the EU 15.

Economic and policy context

Energy subsidy reform and the environment. The sixth environmental action programme of the European Union encourages 'reforms of subsidies with considerable negative effects on the environment and that are incompatible with sustainable development' and emphasises the need to undertake 'as soon as possible an inventory and review of subsidies that counteract an efficient and sustainable use of energy with a view to gradually phasing them out' (European Parliament and Council, 2002).

According to the OECD (2004), 'In general, subsidies supporting fossil fuels — particularly coal and oil — represent greater threats to the environment than those that aid renewable energy sources. Those that support nuclear power contribute to unique environmental and safety issues, related mostly to the 'risk' of high-level environmental damage, rather than ongoing degradation[4]. Subsidies to renewable energy are generally considered, on balance, environmentally beneficial, although the full range of environmental effects of renewable energy (including those beyond the energy sector) need to be taken into account.'

Renewable energy targets[5]. EU countries have committed to 2010 indicative renewable energy targets[6]. Discussions on more ambitious 2020 targets[7] have begun, driven to a large extent by an interest in spurring technological development, improving energy security and reducing environmental impacts (including those related to climate change). Renewable energy is forecast to be a significant component in meeting new demand (International Energy Agency — IEA, 2003a). However, these targets are unlikely to be met on the basis of current policies and measures.

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4 Nuclear power contributes positively to the environment in the areas of air pollution and climate change as it does not emit greenhouse gases or air pollutants. The question of how to safely store long-lived radioactive nuclear waste remains unresolved.

5 At the World Summit on Sustainable Development in Johannesburg in 2002 an agreement was reached to increase urgently and substantially the global share of renewable energy sources. A 'coalition of the willing' was formed at the summit that includes countries and regions willing to set themselves targets and timeframes for the increase of renewable energy sources in the energy mix. More than 80 countries are now members of this coalition including EU Member States.

6 The targets indicate a 12 % share of gross inland energy consumption (European Commission, 1997) and a 22 % share of electricity (European Parliament and Council, 2001) produced from renewable energy sources by 2010, and a 5.75 % share of biofuels in petrol and diesel for transport purposes by 2010 (European Parliament and Council, 2003).

7 The European Parliament called for a target of 20 % for renewable energy as a share of gross inland energy consumption by 2020 (European Parliament, 2004). The European conference for renewable energy in Berlin, January 2004 which was a preparatory conference to the international renewable energies conference in Bonn, June 2004, concluded that a 'target of at least 20 % of gross inland energy consumption by 2020 for the EU is achievable'.

Liberalisation and new capacity. Since the 1990s, the energy sector in western Europe (particularly the electricity sector) has undergone significant liberalisation and privatisation, resulting in declining and more volatile (fluctuating) electricity prices. Existing fossil fuel and nuclear generators, established with public money and benefiting from depreciated assets, have lower marginal costs than new renewable technologies and are better able to manage the downward price pressures. To some extent, electricity prices in the EU 15 reflect only the marginal costs of production from existing capacity and do not include a contribution to the capital cost of the capacity used (or to the capacity that will be needed to replace this when it is retired). This fact and volatile energy prices have created barriers to private investment in new capacity, resulting in falling reserve margins in a number of countries compared with those present in the 1990s as the replacement of old capacity lags behind retirement.

Delayed retirement and carbon dioxide emissions. Without additional measures, annual power sector emissions are expected to rise by a third in the EU 15 by 2030 (from 2000 levels) as a result of a forecasted increase in energy demand during the same period (IEA, 2003a). A substantial number of fossil fuel plants in Europe are due to be decommissioned. However, the increased capacity investments required to replace these plants might give rise to pressure to defer those decisions. If fossil fuel plants remain in operation longer than currently assumed in the projections, carbon dioxide emissions will be much higher.

The private sector carries no obligation to address long-term energy security or environmental issues. It is the responsibility of governments, through market pricing and appropriate regulatory frameworks, to ensure that the private sector adequately responds to these challenges. A debate on reforming energy subsidies ought to take these considerations into account.

3. Energy subsidies — an overview

Governments have justified financial intervention in the energy sector on the basis of one or more of the following aims:

Security of supply. Since the oil crisis of the 1970s, governments have used subsidies to ensure adequate domestic supply. Subsidies have been provided to support indigenous fuel production in order to reduce import dependency. Energy subsidies have played an important role in a wider geo-political context[8], often to support overseas activity by national energy companies.

Environmental improvement. Energy subsidies have also been used to reduce pollution (sulphur dioxide, nitrogen oxide, particulates or greenhouse gas emissions), and to fulfil responsibilities under related international protocols and treaties. While they do not internalise external costs, they compensate for imperfections in market pricing.

Economic benefits. Energy subsidies in the form of reduced prices are sometimes used to stimulate particular sectors of the economy or segments of the population. They can also build domestic industrial sectors and provide opportunities for growth and export in energy technology markets.

Employment and social benefits. Energy subsidies are often used to maintain local employment, especially in periods of economic transition. The political imperative to protect jobs has been a major factor in the aid provided to the German[9] and Spanish coal industries.

Reforms to subsidies are resisted for a range of reasons, commonly known as 'lock-in mechanisms'. Those in receipt of economic support may use their economic and political influence to maintain a given subsidy regime (rent seeking). On an international stage, individual governments find it difficult to pursue subsidy reform or elimination for fear of ceding markets to other nations not pursuing a similar agenda[10]. Arguments may also be made that the removal of subsidies will not result in the desired positive effects in the short term (e.g. abolition of domestic coal subsidies may lead to a switch to cheaper imported coal, rather than cleaner technologies)[11], or that subsidised industries return more to the state in tax than they receive.

Defining energy subsidies

Within the EU, there is no agreed definition of energy sector subsidies, though the Producer Subsidy Equivalent[12] is reported for the coal industry on an annual basis.

The OECD (1998) defines subsidies as: 'any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers and producers.'

Energy subsidy definitions that refer only to a direct cash payment to an energy producer or consumer ignore a range of other indirect support mechanisms, including tax measures, and the effects of trade restrictions and other government interventions (such as purchase obligations and price controls) on prices received by producers and paid by consumers. Table 1 provides a broad overview of the various types of support.

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8 A recent World Bank review of extractive industries shows that 94 % of World Bank funding has gone to the development and exploitation of fossil fuel resources world-wide (World Bank, 2003).

9 The German Federal Environment Agency (2003) compared the subsidies received by the German coal industry with the number of employees in this sector. It concluded that safeguarding employment in the coal sector for 2001 was costing EUR 82,000 a year in subsidies for each coal miner's job saved.

10 It should be noted that, in many developing countries, the costs of coal and oil production are low and are not supported by government subsidy.

11 For an alternative view, see Steenblik and Coroyannakis (1995).

12 The Producer Subsidy Equivalent counts budgetary transfers including tax expenditures and market price support arising from price regulations and trade restrictions.

Table 1 Types of energy subsidy

Government intervention	Examples
Direct financial transfers	Grants to producers Grants to consumers Low-interest or preferential loans to producers
Preferential tax treatments	Rebates or exemption on royalties, duties, producer levies and tariffs Tax credit Accelerated depreciation allowances on energy supply equipment
Trade restrictions	Quota, technical restrictions and trade embargoes
Energy-related services provided by government at less than full cost	Direct investment in energy infrastructure Public research and development
Regulation of the energy sector	Demand guarantees and mandated deployment rates Price controls Market-access restrictions Preferential planning consent and controls over access to resources
Failure to impose external costs	Environmental externality costs Energy security risks and price volatility costs

Source: Table adapted from IEA/UNEP (2002).

The last item in Table 1 refers to an absence of government intervention and hence a failure to ensure that costs and benefits are fully reflected in prices. While failure to impose external costs is not a subsidy in the traditional sense, it nonetheless subsidises users by permitting a transfer of these costs from the private to the public domain. External costs vary considerably among energy sources and, were these to be accurately reflected in prices, certain sectors would benefit at the expense of others. The difficulty comes in quantifying these external costs with a level of certainty sufficient for policymaking. Externalities are therefore not included in the energy subsidy estimates in the following section.

Subsidies can be classified in many ways: initial incidence (consumers or producers; outputs, intermediate inputs or value-adding factors), instrument, pathway of benefit (direct or indirect, explicit or implicit), purpose (Steenblik, 2003). The major economic issue is whether they are oriented towards production (initial) or consumption (final) and whether they are tied to specific inputs or technologies (wind turbines) or outcomes (wind generated power). This report does not assess which form of support is more suitable or efficient. Instead, a simple 'on-budget' and 'off-budget' classification has been used, as this allowed a level of transparency. On this basis, it was possible to obtain a sufficient amount of data to provide estimates of the size of the subsidies to the different energy sources.

Aid to the coal sector

On-budget aid to the EU coal industry is authorised under a Council Regulation which replaced the expired European Coal and Steel Community (ECSC) treaty in July 2002. This allows for the continued support of domestic coal mining in the remaining coal producing Member States until 2010. In 2001, under the ECSC treaty, the amount of aid granted was approximately EUR 6.3 billion.

On-budget subsidies are cash transfers paid directly to industrial producers, consumers and other related bodies, such as research institutes, and appear on national balance sheets as government expenditure. Grants may be given to producers, mainly to support commercialisation of technology or industry restructuring, and to consumers. On-budget subsidies also include low interest or reduced-rate loans, administered by government or directly by banks with state interest rate subsidy.

Infrastructure subsidies to the gas industry in the EU 15

On-budget aid to the gas industry through infrastructure development continues to be permitted by the EU to:

- promote the economic development of a region where the standard of living is low, and create local employment;
- extend the gas network to guarantee security of supply, thereby extending the use of an energy source whose combustion generates lower emissions than burning coal or oil;
- be in line with EU policy, in particular with regard to developing trans-European energy networks.

Between 1996 and 2000, state aid to gas infrastructure was approved by the EU to projects in Denmark, Greece, Ireland, and Spain. On-budget subsidies are also given to the gas industry by the EU. Between 1996 and 2000, these included structural funds of EUR 2 billion, and EUR 3 billion in preferential loans from the European Investment Bank.

Off-budget subsidies are typically transfers to energy producers and consumers that do not appear on national accounts as government expenditure. They may include tax exemptions, credits, deferrals, rebates and other forms of preferential tax treatment. They also may include market access restrictions, regulatory support mechanisms, border measures, external costs, preferential planning consent and access to natural resources. Quantifying off-budget subsidies is complex, in some cases impossible. It often requires that the benefit be calculated on the basis of differential treatment between competing fuels, or between the energy sector and other areas of the economy.

Taxation policy is a key mechanism for off-budget support in energy markets. A fuel may be exempted from certain taxes, or enjoy lower rates of value added tax (VAT) and excise duty in relation to other fuels or to the wider economy. Tax exemptions, rebates and incentives for investments in the energy sector and for the installation of energy related materials and equipment may allow industry and consumers to offset their costs. Accelerated tax depreciation may also be permitted, allowing energy-related equipment to be amortised (have the costs written off) more quickly, thereby lowering effective tax rates in the early years of an investment.

Tax incentives for exploration and production of oil and gas

Producer countries, such as Denmark, the Netherlands and the UK, support the exploration and production of oil and gas through use of the taxation system:

- Denmark has abolished the payment of royalties on gas and oil production.
- Ireland has implemented a pre-exploration preferential tax scheme for oil.
- Tax exemptions have been provided to less profitable Dutch gas fields.
- In the UK, taxation levied on new gas fields developed since 1993 has been lowered, creating an incentive for investment, especially for smaller gas fields or fields where exploration is difficult.

Calculating the benefits individuals and companies derive from tax exemption policies is complex. Tax rebates, such as for fuels, are usually conferred on a per volume basis, which means that estimating the total amount of exemptions or rebates requires detailed consumption or production data. The scale of these subsidies must be calculated on the basis of differential treatment against a norm or baseline. Judgement must therefore be applied in determining the base for comparison against which the implicit subsidy can be calculated. If all fuels are taxed equally, then the effect of the subsidy on competition between fuels would effectively be zero. If a tax is levied on only some fuels, then the fuels that are exempt are relatively subsidised. In addition, consumption of all fuels may be taxed at a lower rate than on other goods and services in the rest of the economy, as is the case with lower-than-standard VAT on electricity in many countries. It remains an area of contention whether this should be considered an energy subsidy, but it has been included for the purposes of the estimation in the following section.

Environmental externality costs can be internalised through taxation, such as the imposition of carbon dioxide taxes favouring carbon-neutral or zero-carbon sources of energy. The aim of such taxation policy is to correct market imperfections; therefore such indirect benefits are not subsidies[13], and they have not been included in the estimates. It should however be noted that it is difficult to assess how well governments have linked environmental taxation to actual environmental costs and outcomes.

Regulatory support mechanisms make up the other most significant area of off-budget support for the energy sector. These mechanisms most commonly take the form of price guarantees and demand quotas for specific energy sources. They are introduced to support environmental, economic, employment or energy security policy objectives. Some of these mechanisms, such as feed-in tariffs or competitive tenders can be described as 'supply push' mechanisms, in that they stimulate production. Others, such as purchase obligations are 'demand pull' mechanisms in that they create an artificial demand to which the market responds.

An overview of regulatory support mechanisms for renewable energies

Fixed feed-in tariffs have been widely and successfully deployed throughout Europe to support renewable technologies, most notably in Denmark, Germany and Spain. Governments set a price at which the country's electricity supply companies must purchase all renewable energy delivered to the distribution grid. Price premiums are passed on to consumers in the form of higher electricity prices.

Competitive tender invites producers to bid to provide specific amounts and types of renewable energy from the market at cap (maximum price) or below cap (lower) prices. Contracts are then signed with the lowest cost bid to deliver output over a number of years. End consumers pay the premium on wholesale price through a levy.

Purchase obligations set targets for consumption of electricity (usually percentage based) that should be sourced from a certain fuel source. This mechanism has been deployed for renewables and combined heat and power in several Member States. Energy distribution companies must prove the origin of purchase, pay a penalty or produce the required amount themselves, creating an artificial demand and price premium for renewable generation. If the overall system target cannot be met, prices rise until new market entrants and investors are attracted. Tradable certificates often accompany such schemes. The cost of this subsidy is borne by consumers.

Adapted from Irish Government (2003) pp. 31–36

13 Provided the taxes were set proportionally to the externality.

4. Estimating energy subsidies in the EU 15

Various attempts have been made to quantify the type and amount of aid provided to energy industries. There is no comprehensive official record of historical and ongoing energy subsidies in the EU. Collation and presentation of information on energy sector support is fragmented and is managed by multiple actors: energy agencies, Member State governments, the International Energy Agency (IEA) and the European Commission. Only for the Producer Subsidy Equivalent have Member States agreed a format and annual reporting mechanism through the IEA.

A number of studies have attempted to throw light on support for energy sector within the EU 15. The most recent and comprehensive reports were prepared by Oosterhuis (2001) and the European Commission (2003a). Both are 'snapshots' based on best available information and are not ongoing monitoring projects. Other reports, e.g. Eurelectric (2004), have focused on specific industry support mechanisms such as renewables. This report synthesises available studies and reports to estimate the type and size of energy subsidies throughout the EU 15. Together, they provide at best an incomplete overview of energy-sector support for the period 1995–2001, indicating a total subsidy (excluding external costs) to the energy sector of about EUR 125 billion for the period, with the greatest recipients in France, Germany, Spain, and the UK. Oosterhuis (2001) estimates annual support (excluding external costs) to be in excess of EUR 27 billion. There is a lack of continuous and accurate data over time, and a lack of specific detail. Figures are often presented as a total sum for multiple years with no further breakdown.

Given the issues discussed above, this report presents a more detailed analysis for a single year, 2001, which is the most recent for which relatively reliable and comprehensive subsidy data are available. The analysis follows closely the work of Oosterhuis (2001) and includes a broad range of on- and off-budget energy support mechanisms, including subsidies arising from taxation differentials and the effects of regulatory price support. Subsidies for electricity are allocated to primary energy sources based on the share of thermal inputs. The data have been compiled from a range of primary sources (IEA R&D Database, 2004; EU State Aid scorecard, 2003b; IEA World energy prices and taxes, 2003b) and secondary sources, including Eurelectric, 2004; European Commission, 2003a; and Oosterhuis, 2001[14].

Often, it is practically impossible to assign a monetary value to an individual support mechanism, due either to the nature of the mechanism itself (such as the ability to allocate priority to up to 15 % of indigenous fuels), or to lack of data. Where no attempt has been made in the reviewed literature, this report does not attempt primary calculations. For reasons explained in the previous section, uninternalised costs of environmental externalities are not included in the estimates.

[14] The following provides a brief indication of source and methodology. Subsidies for coal under the ECSC treaty are taken from the European State Aid Scorecard (2003) and from the Commission staff working paper on energy subsidies (European Commission, 2003a). Aid to the oil and gas, and nuclear sectors is based primarily on the European Commission (2003a) and Oosterhuis (2001) reports. Renewables data on direct price support, such as quota and fixed price systems, is are taken primarily mainly from the Eurelectric (2004) report, with cross-referenced information from the EREF (2002) and Irish Government (2003) reports. Data on renewables capital investment, taxation support and other aid to related sources is taken from European Commission (2003a) and Oosterhuis (2001). Research and development subsidies paid by Member States to all fuel sources are taken from the IEA R&D database (2004), while those paid by the European Community are taken from European Commission (2003a) and Oosterhuis (2001). Fuel taxation exemptions/differentials represent an updated version of the Oosterhuis report and are calculated using IEA (2003b) energy prices and tax data, and consumption/production figures using Eurostat 2001 data. Data on preferential tax treatment for medium and large users of gas and electricity in the Netherlands is taken from Van Beers *et. al* (2002); and it is the arithmetic mean of the data that has been used. Electricity consumption subsidies represent updated versions of the Oosterhuis report using more recent taxation and consumption data, and are allocated to individual fuels on the basis of Eurostat 2001 data on primary energy inputs in the generating mix.

The results are given in Table 2, which provides a summary of the estimated total 2001 support provided to the various energy fuel sectors. These figures should be regarded as indicative, due to the lack of consistent data and assumptions made.

Table 2 2001 Indicative estimates of total energy subsidies, EU 15, (EUR bn)

	Solid fuel	Oil and gas	Nuclear	Renewables	Total
2001 On- budget	> 6.4	> 0.2	> 1.0	> 0.6	> 8.2
2001 Off- budget	> 6.6	> 8.5	> 1.2	> 4.7	> 21.0
Total	> 13.0	> 8.7	> 2.2	> 5.3	> 29.2

Note: Electricity subsidies allocated to fuels on basis of generation inputs. Excludes external costs.

Solid fuels received the largest share of on- and off-budget subsidies in 2001. The renewables industry received significantly higher support on a per-energy unit basis than other fuel sources in the majority of Member States. This can be attributed to the relatively young age of the industry and the limited levels of current consumption. Subsidies to the various fuel groups are outlined as follows:

Solid fuels. On- and off- budget support to the coal industry is the single most important funding regime in the EU 15. State financing to coal mines was commonplace throughout the last century, and exists today in a more rationalised form to protect high-cost domestic industries from competition with cheap foreign coal imports. On-budget subsidies continue to the coal industries in Germany (over EUR 4 bn), Spain (over EUR 1 bn), and the UK (circa EUR 0.1 bn), whereas subsidies in other countries, such as Belgium, France[15], Ireland, the Netherlands and Portugal have more or less ceased. Germany and Spain are still committed to sustaining their output, and use subsidies to reduce producer costs in order to align consumer prices with imports. The UK uses subsidies to support industrial restructuring. Off-budget support to coal is particularly high in Germany (circa EUR 3.5 bn) as coal remains untaxed under the ecological tax reform introduced in 1999. In Denmark, reduced rates of energy and carbon dioxide taxation for energy intensive industries (those holding an energy efficiency voluntary agreement with the Danish Energy Agency) indicated an estimated EUR 0.6 billion off-budget subsidy.

Oil and natural gas. There is little aid to investment in the oil sector, reflecting the fact that the bulk of oil reserve development is occurring outside Europe. The industry across Europe is largely privatised and receives no on-budget aid for oil production, transport or storage. Italy, the Netherlands and the UK provide the highest level of support to the oil and gas sector. In the Netherlands, preferential tax treatment under the regulatory energy tax for medium and large users of gas is significant (estimates range from EUR 0.9 to EUR 2.4 bn). The UK supports oil and gas with reduced rates of VAT (5 %) on domestic oil and gas (circa EUR 1.4 bn), while Italy allows reduced VAT rates (10 %) on domestic gas (circa EUR 0.9 bn).

Nuclear power. The on-budget support to nuclear energy comes from R&D grants by Member States (mainly France, Germany and Italy) and the European Community. The figures in Table 2 exclude the potential cost of not having to pay for full-liability insurance cover for a critical nuclear accident or fuel incident since commercial and state liabilities are limited by international treaty. This risk would be too large to be commercially insurable.

15 France is in the process of closing its last coal mine. In 2001 (as well as in 2002 and 2003), France subsidised the restructuring of the coal industry by almost EUR 1 billion per year.

Renewable energy. Support for renewable energy is now well established across the EU 15. Every Member State provides a combination of price support through feed-in tariffs, obligations or competitive tender, together with a range of capital subsidies and fiscal mechanisms (Table 3). In 2001, total levels of support were greatest in Germany and Italy, where over EUR 1 billion was provided, mainly in the form of feed-in tariffs.

Electricity. Preferential treatment under the regulatory energy tax for medium and large users of electricity provided a subsidy in excess of EUR 1.5 billion in the Netherlands. Elsewhere, reduced VAT on electricity in the UK (circa EUR 1.5 bn) and reduced tax rates in Germany for industry and agriculture (circa EUR 1.8 bn) contributed to over EUR 6 billion of subsidies to electricity consumption across the EU 15.

Table 3 Support policies for renewable technologies in the EU 15

Country	Capital subsidies	Feed-in tariffs	Certificates/ obligations	Competitive tender	Fiscal mechanisms
Austria	X	X	H		X
Belgium	X	X	X		X
Denmark	H	X			X
Finland	X				X
France	X	X		X	X
Germany	X	X			X
Greece	X	X			X
Ireland	X			X	X
Italy	X	H	X		X
Luxembourg	X	X			
Netherlands	X	X	X		X
Portugal	X	X			X
Spain	X	X			X
Sweden	X		X		X
UK	X		X	H	X

X: Mechanism currently present
H: Historical policy, now changed

Source: Adapted from Stenzel, Foxon and Gross (2003).

It is not possible to make accurate temporal comparisons. However, it is clear that support for renewables has increased significantly over recent years. Support for coal and nuclear may have been in gentle decline due to redirection of investment towards infrastructure for natural gas and renewable energy.

State ownership and transparency

It is difficult to quantify the economic benefits a firm receives by virtue of state ownership. Concern has been expressed over the lack of transparency regarding the internal financing and accounting practices of state-owned firms, and a number of cases involving illegal state aid have been reported.

Across the EU 15, there are currently 12 fossil-fuel companies and a smaller number of nuclear generators in which national governments retain majority or significant minority ownership. These are former state monopolies that have played a major role in infrastructure development, production and distribution over a number of decades. There are no state-owned companies whose primary activity is the development and production of renewable energy.

5. Historical perspective

It is not possible to assess historical support levels which well-established energy sources, such as oil, natural gas, and fission-based nuclear power, received during their developmental phases. Such subsidy data are largely unavailable. However, there is some evidence to suggest that the infrastructure for mature fuels benefited significantly from support received under state ownership. Such support was generally in the form of R&D, capital investment and the subsidisation of operating costs.

These energy sources continue to benefit from state-assisted infrastructure and technology. Oosterhuis (2001) highlights the cases of Denmark and the Netherlands, where significant historical investment in the natural gas network, through fiscal measures and tariffs, has created a gas infrastructure that continues to benefit consumers after the support measures have been withdrawn. Energy consumers pay prices lower than might be expected if a similar capacity had been funded on purely commercial terms.

Renewable energy, with the exception of large hydro-electric power, represents a range of technologies still in their infancy. Due to R&D inputs and wider commercial application, the capital costs of renewable energy are expected to fall substantially, making production from renewable energy sources increasingly competitive, although this will be heavily influenced by regional factors. Improvements in wind-turbine technology and greater efficiencies in biomass conversion are expected (IEA, 2003). Currently, several of the technologies are approaching commercial maturity, including on-shore wind power, small-scale hydropower, biomass and solar-thermal water heaters. Others, such as photovoltaic electric cells, are further from being competitive with current market prices. It is clear that all will benefit from increased production volume and technological investment (European Commission, 2004).

Research undertaken in the United States[16] provides a useful indicator of the respective levels of total subsidy support for nuclear power and wind power at similar stages of technological development. Goldberg (2000) estimates that the nuclear industry received about 30 times more support per kWh output than wind power in the first 15 years of the industry's development (Table 4).

Table 4 Nuclear vs. renewable industry development, USA

15 year industry development period	Gross electricity production (bn KWh)	Effective subsidy (USD/KWh)	Total subsidy over 15 year period (billion USD)	1999 generation (bn KWh)
Nuclear (1947–1961)	2.6	15.3	39.4	727.9
Wind (1975–1989)	1.9	0.46	0.9	3.5

Source: Goldberg (2000).

The study indicates that the support for technological development for nuclear power, when compared with renewable energy sources over a period of 15–25 years, allowed the creation of economies of scale in the industrial infrastructure, from which the industry has obtained a competitive advantage.

[16] A high proportion of generation capacity in the United States since 1945 has typically been in private ownership rather than being state controlled. This has resulted in a greater level of transparency in financial transfers and support than has been the case for EU Member States.

6. Addressing market failures

The areas of subsidy previously highlighted are examples of government intervention in energy markets in order to achieve particular economic, social, environmental or political outcomes. Another aspect of the state's relationship with the energy market must also be raised: the failure to intervene in the case of market failure. This study examines two such specific areas.

Environmental and social externality costs

Fuel cycle externalities are the costs imposed on society and the environment that are not accounted for by the producers and consumers of energy, i.e. are not included in the market price. They include damage to human health, the natural and built environment, and include non-compensated effects of air pollution, occupational disease and accidents. They also include the external costs of climate change.

In theory, if the costs of energy sector external impacts are known, they should be incorporated into the price of the energy activity concerned. In that way, producers, consumers and decision makers could get accurate price signals and reach optimal decisions about how to use the resources. In practice, the measurement of environmental impacts and associated costs is a complex and evolving science, and neither markets nor governments effectively price these costs. EU governments have recognised this and have invested in modelling, in particular through the European Commission's on-going ExternE project.

Table 5 shows the aggregated ranges of external costs associated with the electricity production fuel cycle in the EU 15, as calculated with data from ExternE.

ExternE research has demonstrated so far that most renewable energy sources have significantly lower environmental impact per KWh than fossil fuels, and have similar immediate impacts to nuclear power[17], without the same risk of accident.

Table 5 External costs of electricity production in the EU 15 (EUR bn/Year) [18]

	Low range estimate	High range estimate
Solid fuels	25.6	46.2
Oil and gas	12.0	21.4
Nuclear energy	2.7	2.7
Renewables	2.0	2.7

Source: European Commission (2003c), Eurostat.

17 The calculation of externalities from nuclear power excludes mortality and morbidity associated with human exposure to high-level nuclear waste and the contribution of civilian nuclear power programmes to the risk of nuclear proliferation and terrorism, all of which have been considered too difficult to value. In the same way, the risk of nuclear power accidents has not been fully priced. Oosterhuis (2001) reports that there have been various estimates of the economic cost of a large-scale nuclear accident, ranging from EUR 83 billion to EUR 5,469 billion. However, liability for nuclear accidents is currently limited by the Paris (1960) and Vienna (1963) Conventions and the Joint Protocol (1988). The liabilities can be as little as EUR 6.5 million for a single nuclear operator to EUR 390 million for national public liability. This could mean that 'The risks associated with the use of nuclear energy (…) are socialised, because the producers are not fully liable for the damage' (Irrek, 2002).

18 Figures based upon average high/low estimates of external cost data per KWh from European Commission report (2003c) on external costs and 2001 Eurostat gross electricity production data by fuel and by Member State. These figures provide an indicative range only and are presented with the caveats outlined by the ExternE team including extrapolation of data from individual measurements to sector and geography based models. There remain uncertainties in the monetary valuation of mortality effects, and from the omission of certain impacts on ecosystems due to acidification, eutrofication and global warming. In addition, the study does not take into account contamination of water and soil, and the impact of long-term accumulation effects.

Environmental costs are indirectly imposed through the setting of air quality, air emission and greenhouse gas emission regulations that are based partly on cost-benefit analyses and partly on political considerations. In addition, as mentioned in section 3, environmental taxation policies also aim to partly internalise external costs.

Valuing energy security and diversity — applying portfolio theory

Managing the risk associated with energy supply is an increasingly important policy driver. Security of energy supply covers a wide range of issues — from protecting energy distribution infrastructure from disruption, to diversifying sources of supply and developing strategic stockpiles. In economic terms, risk is best measured by price volatility. Governments have traditionally made planning decisions for new capacity based upon the lowest cost option between different technologies and fuels. This has tended to support more established fuel sectors rather than renewable technologies, which have higher capital costs but which may have other benefits in terms of diversifying supply and reducing import dependence[19]. With investment decisions transferred to the private sector and downward pressure on electricity prices, the demand for lowest cost options has become even greater.

This creates problems for energy planners, who have recognised that 'current market designs do not guarantee an adequate level of security of supply' (IEA, 2003a). Over-reliance on fossil fuels can increase fuel price volatility — the likelihood that energy prices will fluctuate more widely and more often — and expose economies to significant macroeconomic costs[20].

Awerbuch and Berger (2003) examined the use of portfolio theory in reducing risk and potential costs and demonstrated that current energy mixes can be significantly enhanced, and that by adding renewable energy to energy portfolios dominated by fossil fuels, price risk could effectively be hedged[21]. They compared the 2000 and projected 2010 EU 15 electricity generation mix and concluded that risk and cost can be reduced 'by adjusting the conventional mix and including larger shares of wind or similar renewable technologies' and that 'any expansion in natural gas should be accompanied by an increased deployment of renewables'.

The presence of each primary fuel in an energy portfolio with minimised risk has a real economic value, but this is currently disconnected from mainstream discussion on subsidy mechanisms, energy models and private sector investment decisions. Further work needs to be done to quantify the economic benefits of risk and cost management to ascertain the extent to which current levels of support reflect the potential benefits of renewable energy. What is clear is that the role of technologies for exploiting renewable energy in diversifying energy price risk is not yet fully recognised by the market[22].

19 Renewables also have lower variable costs.

20 According to Sauter and Awerbuch (2003), a number of studies have examined the link between increases in world oil price and reduction in economic activity as expressed in terms of GDP and have estimated that a 10 % rise in the oil price might cut GDP growth by 1.5 % for a period of 3–6 months following the price increase. Extrapolating this to the EU 15 would result in GDP reductions of between EUR 35 billion and EUR 70 billion. These calculations reflect a rise in world oil price, rather than the effects of volatility itself, and more work is required in this area.

21 Portfolio modellers seek to identify the 'efficient' or optimal assets mix that produces the most economically efficient outcome for a given level of risk: efficient portfolios maximise expected return (or minimise expected cost) at any given level of risk, while minimising risk for every given level of expected return (Awerbuch and Berger, 2003).

22 Also to be considered is why taxpayers who are economical in their use of energy have to subsidise the contribution to economic risk created by profligate users. This externality should be internalised, not socialised.

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