Identification of Options and Policy Instruments for the Internalisation of External Costs of Electricity Generation

Dissemination of External Costs of Electricity Supply Making Electricity External Costs Known to Policy-Makers

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Summary

In the present paper, after reviewing the results of the ExternE project and its follow-up stages in the estimation of the external costs of electricity production, we look at the policy instruments for the internalisation of such costs. Emphasis is given to subsidies, such as feed-in tariffs, competitive bidding processes and tradable green certificates to stimulate the use of renewables in the production of electricity. When policy-makers are asked to choose the instrument(s) to internalise the externalities in the electricity production, they have to find a solution that gives the best outcome in terms of efficiency, cost minimisation, impact on the job market, security of energy supply, equity of the instrument, technological innovation, certainty of the level of the internalisation, and feasibility. The choice of the instrument will require some trade-offs among these criteria. Conjoint choice analysis can help in investigating how stakeholders and policy makers trade off the criteria when choosing a policy for the internalisation of the externalities. In this paper we present the first results of a questionnaire that employs conjoint choice questions to find out how policy makers and stakeholders of the electricity market trade off some socio-economic aspects in the selection of the policy instruments for the internalisation of the externalities. The results of this first set of interviews will be useful for further research.

Keywords: Policy instruments, ExternE, External costs, Electricity, Conjoint choice analysis

JEL Classification: Q42, Q48, Q51

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1. Introduction

The generation of electric power entails external costs, which are defined as costs incurred by parties that are not engaged in any market transaction with the generator of the externality. An externality arises when the social or economic activities of one group of persons have an impact on another group and that impact is not fully accounted for by the first group. Thus, a power station that generates emissions of SO_2 causing damage to building materials and human health is generating an externality because the resulting impacts are not taken into account by the electricity generator when deciding to operate the power station.

While the externality was recognized as an issue long time ago, and was formalized in economic analysis by the English economist Pigou in the 1930s, it was only over the last 10-15 years that serious estimates have been made of the magnitude of the externalities originated from the production of electricity. In Europe, the research on the external costs of electricity production has grown into a major body of work on the topic, and one major European end of it is referred to as the ExternE project. Every EU member state has used the framework to estimate external costs of different sources of electric power, and the framework has also been extended to other types of energy, especially transport. The results have influenced policy in a number of ways, but particularly in assessing proposed directives that involve changes in energy technology and its use in particular situations. A Europe wide software model has been developed called ECOSENSE, which allows national policy makers to evaluate the impacts of changes in emissions at the national and European level.

In this report we first summarize some key findings from the ExternE research and its follow-up projects. Then we provide an insight of the regulatory framework for the electricity market in Europe. Next, we describe a list of policy instruments that can be used to internalize externalities. Further, we describe which policy instruments might be used to internalize the external costs of electricity production. We follow such description by an analysis of the effectiveness of some policy instruments in terms of efficiency, cost-effectiveness and impacts on the economy. Finally we suggest how the conjoint choice analysis can be used to obtain recommendations for the use of policy instruments by governments to internalize electricity production externalities.

2. The external costs of electricity production: the ExternE experience

Researchers within the ExternE network have applied a "bottom up" approach to assess the external costs of electricity production. In this approach each source is taken and its "ecological and social footprint" is analyzed.

The approach is also characterized using the "impact pathway," in which emissions from a source are traced through as they disperse in the environment, following which the impacts of the dispersed pollutants are estimated. Finally these impacts are valued in monetary terms where possible. Figure 1 shows the impact pathway and Table 1 provides a description of the main effects estimated. A number of points should be noted about the impacts assessed:

(i) The dispersion modelling takes account not only of the local effects from the source but also the long distance dispersion of the pollutants, through the formation of particles as they are transformed into sulphates and nitrates

(ii) The impacts are assessed not just for generation stage but for the full life cycle of the process, including the extraction of the fuel (e.g. coal), its transportation, transformation into electric energy, disposal of the waste, and the transport of the electricity. Hence accidents in transportation are included.

(iii) Not all the impacts can be valued in money terms, although the most important ones (i.e. the health ones) have been. Monetary valuation has not generally been possible for ecosystems, including forest damages. Not all items that have external effects have been valued. Furthermore some impacts have not been valued in physical terms either. These that are on the list to be investigated include: neonatal mortality, non-bronchitis chronic respiratory disease, behavioural effects (e.g. learning disabilities), neurological disorders and allergies.

Figure 1: The Impact Pathway Approach

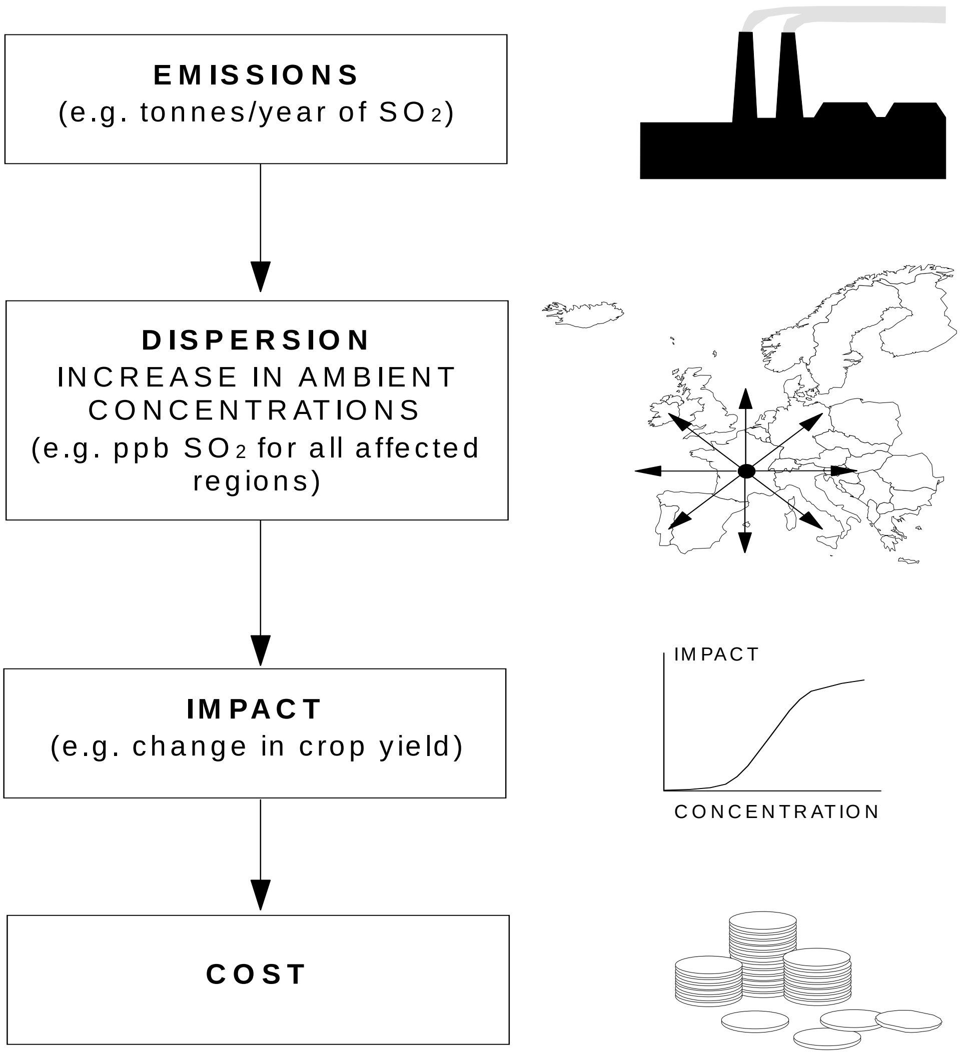


Table 1: Impacts Pathways Included in the Analysis of the Electricity Sector

Impact Category	Pollutant/Burden	Effects
Human Health – Mortality	PM_{10}, SO_2, NO_x O_3 Benzene, Benzo-a-pyrene 1,3-butadiene, Diesel particles Accident Risk	Reduction in life expectancy Cancers Fatality risk from transport of materials and at workplace
Human Health - Morbidity	PM_{10}, SO_2, O_3 PM_{10}, O_3 PM_{10}, CO Benzene, Benzo-a-pyrene 1,3-butadiene, Diesel particles PM_{10} O_3 Accident Risk	Respiratory hospital admissions Restricted activity days Congestive heart failure Cancer risk (non fatal) Cerebro-vascular hospital admissions Cases of chronic bronchitis Cough in asthmatics Lower respiratory symptoms Asthma attacks Symptom days Myocardial infarction Angina pectoris Hypertension Sleep disturbance Risk of injuries from traffic and workplace accidents
Building Materials	SO_2 Acid deposition Combustion particles	Ageing of galvanized steel, limestone, mortar Sandstone, paint, rendering and zinc Soiling of buildings
Crops	SO_2, NO_x O_3 Acid deposition	Yield of wheat, barley, rye, oats, potato, sugar beet Yield of wheat, barley, rye, oats, potato, rice, tobacco and sunflower seed Increased expenditure on liming
Global Warming	CO_2, CH_4, N_2O, N, S	World-wide effects on mortality, morbidity, coastal impacts, agriculture, energy demand and economic impacts due to temperature change and sea level rise
Amenity Losses	Noise	Amenity loss
Ecosystems	Acid deposition Nitrogen deposition	Acidity and eutrophication

Source: European Commission (2003)

(iv) The scientific data on which the impacts stage is based are of course, not certain. Nor are the methods used to elicit the monetary values. Hence there is a great deal of uncertainty in the estimates, which is reflected in the ranges of external costs that are given. As new information comes about the values will also change.

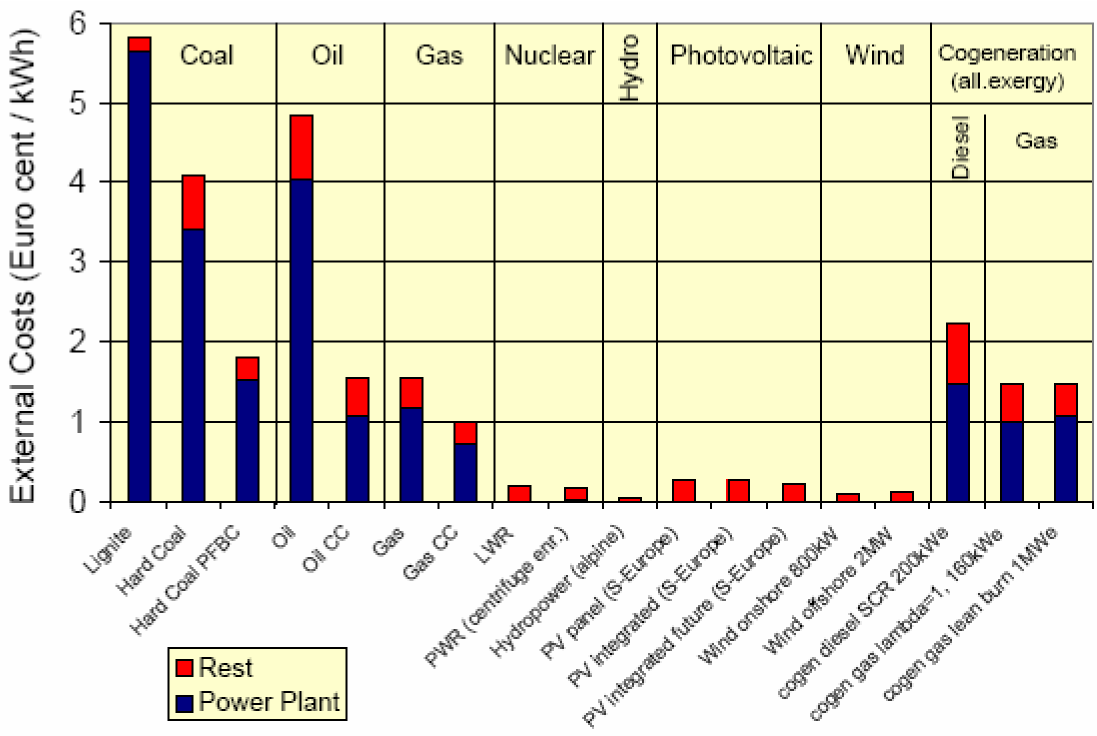
(v) The method of valuation used is based on individual preferences, i.e. what individuals are willing to pay (WTP) to avoid the negative external effects. Only where this is not possible has the valuation been based on 'avoidance costs' – i.e. what it would cost to avoid or mitigate external effects. The reason for choosing the WTP approach is that it gives central place to the values of the persons affected and does not take the values of some expert or government official as the ones on which to base policy. The argument against the WTP approach is that it reflects inequality in society and poor people have a lower WTP than rich people. The counter argument is that this can be corrected for at the policy level, but it is better to give the policy makers the raw information on WTP and let them decide. If one uses the avoidance costs as a measure one cannot answer the question of whether the avoidance action is justified.[1]

The main results for electricity generation are summarized in Figure 2 below. The highest external costs are exhibited by current fossil systems that cause external costs in the range of 1.6 - 5.8 €cent/kWh. Advanced technology, such as CC and PFBC, has a substantial decrease the external costs of fossil systems, but they still remain in the range 1 - 2 €cent/kWh.

The ExternE-Pol researchers estimated that nuclear external costs are less than 0.2 €cent/kWh, but they also recommended to rework the estimation of damage factors from radioactive emissions in future projects of the ExternE series in order to have more reliable estimates.

Finally, the figure highlights the good performance in terms of external costs that hydro, photovoltaic and wind obtain. For example, hydropower exhibits the lowest external costs of all systems, below 0.05 c€/kWh. This estimate may however increase on sites with higher direct emission of GHG from the surface of reservoir occur (ExternE-Pol, 2004).

Figure 2. External costs of current and advanced electricity systems, associated with emissions from the operation of power plant and with the rest of energy chain. Source: ExternE-Pol, 2004.



[1] One issue which has arisen is the valuation of the impacts of electricity generation on workers in the plant or in related activities (e.g. mines). According to economic theory such impacts are considered internal and not external to the activity, as the worker is paid, and to some extent the rate of pay reflects such risks. ExternE took the view that such internalization is at best imperfect and such impacts should be valued as external costs.

The reader should keep in mind that generalization of external costs estimates are difficult because external costs estimates are quite *site dependent.* However a few observations are possible:

(i) The external costs for *coal* and *lignite* and for *oil* are very substantial, and mostly much greater than the direct costs of generation, making these sources much less socially attractive than they are privately attractive. Gas by contrast has a smaller gap between the private and social costs, i.e. the external costs are about half those of coal and lignite.

(ii) By far the greatest monetary damages are to *health*, which account for around 98 percent of the total. Within the health category, *mortality* damages are about half the total, and could be more depending on what valuation is taken for a loss of life.

(iii) Even for a single plant the range of values is substantial, although it has not been reported for all studies in all countries. In the case of the fossil fuels, however, the estimates are provided with ranges, which show that the higher value is often as much as double the lower value and sometimes even more. This range reflects uncertainties at each stage of the fuel cycle, which compound to give an overall uncertainty range[2].

(iv) The renewable sources of electricity also have some externalities associated with them, partly because they involve amenity externalities (e.g. wind generators) and eco-system effects (e.g. hydro plants). Furthermore, for these sources of generation account has also been taken of the external costs arising from the production of the capital equipment (e.g. solar panels, wind turbines). It was felt that such production was a more critical part of the generation process for such units than for fossil fuel plants, where the impacts of including them would be dominated by the direct effects. Even with these impacts included, however, the external costs are modest, with the possible exception of hydro plants, where the costs are highly site specific.

3. A short overview of the EU energy policy

The European Union has acknowledged the importance of the external costs in the production of electricity and has required that measures be undertaken to take these costs into account. The recent Community guidelines on state aid for environmental protection explicitly foresee that EU member states may grant operating aid, calculated on the basis of the external costs avoided, to new plants producing renewable energy (European Commission, 2003).

The recommendations regarding the external costs of electricity production fall within a broader European policy for energy that aims at (European Commission Communication, 23 April 1997):[3]

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[2] For a formal derivation of confidence intervals for the uncertainty see Friedrich and Bickel (eds. (2001)), Chapter 11.

[3] These goals have been stressed in several occasions: Council Decision 1999/21/EC, Green Paper of 29 November 2000 "Towards a European strategy for the security of energy supply," Decision No 1230/2003/EC

(i) ensuring the security of the energy supply through managing the growing external dependence of the Union in this sector;
(ii) facilitating closer integration of the Community energy markets, so as to improve the competitiveness of European industry, without in any way neglecting the safety, quality and durability of energy equipment, or public service objectives;
(iii) implementing an energy policy compatible with sustainable development objectives, particularly through more rational use of energy and the development of renewable sources;
(iv) promoting research and technological development in the energy sector;
(v) liberalizing energy markets in which monopoly market structures are to be replaced by competitive markets (Directive 96/92/EC).

The European Union is increasingly dependent on energy imported from third countries. Its member states import 50% of their energy requirements. This external dependence has economic, social, ecological and physical risks for the EU. Energy imports represent 6% of total imports, which means in geopolitical terms that 45% of oil imports come from the Middle East and 40% of natural gas comes from Russia. This weakness has been clearly recently highlighted by the strong increase in oil prices.

The EU has frequently acknowledged that energy and transport play a large part in climate change, since they are the leading sources of greenhouse gas emissions; this is why energy policy is particularly important in the European Union's sustainable development strategy. In the Commission's White Paper on renewable energy (COM (1997) 599) an indicative objective specifies that EU governments must double their share of renewable energy supplies from the present 6% to 12% of gross inland energy consumption by 2010. Another goal to be reached by year 2010 is to raise the part of new and renewable energies in electricity production from 14 to 22%.

The EU therefore wishes to reduce its dependence from foreign energy sources and improve its security of supply by promoting other energy sources and cutting demand for energy. Consequently, it is putting the accent, above all, on improving energy efficiency and promoting renewable energy sources and on internalizing the external costs of electricity production.

4. Policy instruments to internalize externalities

Until recently the measures taken to internalize externalities involved passing a law, or issuing an administrative order, proscribing certain practices and requiring others to be undertaken. In the UK, for example, factories were ordered, by various parliamentary acts passed between 1820 and 1926, to reduce the output of smoke, and more recently the burning of coal was banned in certain urban areas.

These environmental measures are referred to as *command and control* regulations. The authorities tell what the economic agent must or must not do, and there are penalties under civil and/or criminal law if the agent fails to comply.

When economists turned their attention to the environment, their instinctive reaction was to look for alternative methods of regulation that did not involve compulsion but that relied on economic incentives to achieve the same goals. Pigou first noted that if you could

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of the European Parliament and of the Council of 26 June 2003, Directive 2001/77/EC on electricity production from renewable sources, Directive 2002/91/EC on energy saving in buildings, Directive 2003/30/EC on the promotion of biofuels.

tax the activity generating a negative externality, the party responsible would reduce the intensity of that activity. And by selecting the tax level suitably, the authorities could achieve whatever goal they wished in terms of reducing the negative external effects (Pigou, 1932).

It was not until the early 1970s that governments in the industrialized world started to look at economic instruments – i.e. ones that rely on economic, fiscal and financial incentives – to address environmental problems. But since then the idea has been catching on, and the number of cases of economic instruments is large and growing.

Economists have long advocated the use of economic instruments as an alternative, or supplement, to direct regulation. They argue that command and control instruments offer little flexibility in meeting environmental standards.

One of the crucial properties of economic instruments is that firms not only take different actions, but may also end up with different levels of pollution abatement. Firms that find it relatively cheap to undertake reductions do more than firms that find it more expensive, ensuring that the *overall* cost of reduction is less expensive than if all firms were required to meet a uniform standard.

Second, under a command and control approach, industries invest to meet the standard and then stop. In contrast, placing a price on effluents creates a permanent incentive for environmental improvement.

Finally, the use of many economic instruments allows the state or federal regulatory agency to raise money. A charge, for example, raises funds that can either be used to finance environmental cleanups, or to replace existing taxes. The same is true if permits are initially allocated through an auction (Austin, 1999).

There is no formal count of the number of such instruments world-wide, but it must run into the thousands. In the EU, a survey carried out in its 15 member states in 2001, found 142 examples of environmental taxes or related instruments alone, not including some taxes that have environmental effects but that are imposed for largely non-environmental reasons (e.g. a tax on motor fuels). The full list of economic instruments would be much greater if one included such taxes, as well as charges for services that have an environmental dimension (e.g. charges on water delivery, disposal etc.). Using a wider basis of economic instruments, the Sustainable Action Programme for the Mediterranean Action Plan (SAPMED) identified 178 cases in the 12 countries that it covered, averaging 20 instruments per country.

Finally, a new class of instruments has been introduced which are often also labelled economic instruments: voluntary agreements. From a theoretical perspective, voluntary agreements include commitments made by individual companies or by trade and industry and are a result of negotiations with public authorities and/or have been accepted by them. Voluntary agreements represent a policy instrument for applying new knowledge, routines or technology to specified issues. The traditional role of an authority when using information and taking economic or administrative measures is that of an initiator and controller. Voluntary agreements, on the other hand, represent a communication process between an authority and a partner where relations of dependency and mutuality are more important in advancing the programme (Lindén and Carlsson-Kanyama, 2002). The definition spans a broad spectrum ranging from voluntary commitments and non-binding agreements to legally binding agreements. On a scale indicating the potency to influence actors to change behaviour or technology to promote environmental qualities, voluntary agreements fall between informative measures and economic or administrative instruments (OECD, 1997).

Table 2 illustrates the main policy instruments available to policy-makers to internalize externalities.

The empirical evidence on Economic Instruments has shown that the environmental effect of taxes is estimated to be positive but small, with some exceptions. This has largely been due to low rates at which they are levied and the myriad exemptions that have been granted, on the basis of hardship, possible employment and competitiveness effects, etc. Moreover, the design of taxes has given more emphasis to revenue raising than the incentive effects (Markandya and Povh, forthcoming).

5. Policy instruments to internalize externalities in the electricity market

In this section we discuss the policy instruments that have been used or that are currently being debated in the electricity market for the internalization of externalities.

As the previous section has shown, from a government's viewpoint, there are many possibilities to internalize these costs: taxes, permits, subsidies, regulatory standards, voluntary agreements. A complementary set of voluntary measures, such as the dissemination of knowledge and information to try to educate and influence consumers' behaviours are presented as well.

Technology-based command and control

The regulator specifies the methods and equipment that firms must use to meet the target. This policy does not stimulate firms to increase research efforts towards new technologies because the latter are provided by the government. The positive element is that information on the best technology (provided by the regulator) is spread in the economy and all firms have access to it.

Performance-based command and control

The regulator sets an overall target for each firm, or plant, and gives firms some discretion in how to meet the standard. Technology forcing standards demand a performance (energy consumption level, emission level) that is not feasible with the existing technology. The requirements induce firms to invest in developing innovative technologies. As an example, this instrument is applied in California to stimulate the development and introduction of zero emission cars.

Carbon Tax

Several EU member states have applied taxes on CO_2 emissions with the double purpose of collecting revenues and try to influence the behaviour of the economic agents.

The objective of a carbon tax is to internalise the external cost of CO_2-pollution into the price of fossil fuels (Hanley et al., 1997). However, some practical difficulties are to be expected. First, the determination of the externality and therefore of the tax value is difficult. Second, tax neutrality shall be achieved, by compensating decreases somewhere else in the economy. Third, a pollution tax is not specific, i.e. its revenues are not allocated to any special purpose but go to the general State budget. Fourth, there would be significant variation in timing and size of the carbon taxes among countries and regions, given that the marginal cost of abating CO_2 emissions substantially differs across countries and over time. Fifth, the autonomous (i.e. non-price-induced) energy efficiency improvement, the possibilities for fuel substitution, and the availability of backstop technologies are essential elements in determining the evolution of the tax rate over time. Finally, the tax is part of the electricity price. The consumer, who is supposed to change his or her behaviour, will not be aware of it in a transparent way (Kunsch et al, 2004).

Table 2: A taxonomy of policy instruments to internalize externalities

Term	Definition
Technology-based command and control	The regulator specifies the methods and equipment that firms must use to meet the target.
Performance-based command and control	The regulator sets an overall target for each firm, or plant, and gives firms some discretion in how to meet the standard.
Accelerated depreciation	Any method of cost recovery of a fixed asset that is faster than charging an equal amount each period during the useful life of the asset after allowing for a salvage value. Traditional rationale supports higher maintenance and repair costs in later years. These costs are offset in the early years by the higher depreciation expense, resulting in a level effect on earnings throughout the useful life of the asset. Sometimes accelerated depreciation is used as a tax shelter because of large up-front write-offs with no reduction of cash flow.
Access fee	The fee charged for entrance to a protected area or biological reserve (e.g., national parks)
Administrative fee	Fees paid to authorities for such services as monitoring and enforcement of environmental regulations.
Deposit refund system	Involve a refundable charge which gives the user an incentive to return articles or materials.
Environmental funds	Programs which make available loans to finance environmental protection and resource conservation measures through public or private sector banks
Environmental performance bond	A deposit that polluters and violators of environmental standards must pay to a certain environmental fund. These bonds are aimed at providing a financial incentive to industry to adhere to environmental requirements.
Export taxes/subsidies	Any form of government levy or payment/benefit that is given to an exporter or producer contingent upon the export of goods.
Grants	Non-repayable forms of financial assistance
Import tariffs/subsidies	Fixed monetary tax/subsidy per physical unit of the good imported
Input taxes/subsidies	A levy or payment on an intermediary good used in the production of a final output
Investment tax credits	A government tax provision for reduction of tax liability as an incentive to encourage investment in a specific financial transaction. One such incentive for the small business is the reduction of tax liability when the business purchases new equipment.
Land reclamation bond	A binding agreement to make the land capable of more intensive use by changing its general character, as by drainage of excessively wet land; irrigation of arid or semiarid land; or recovery of submerged land from seas, lakes and rivers.
Land title	A register or survey of land, containing information on the surface of properties, tenants' names, commencing with the earliest owners through successive ownership and partitions.
Land use taxes	A program authorized by the state and adopted by localities at their option in which qualifying agricultural forest or open space land is taxed at its use value for its current use rather than its market value for possible development
Legal liability	The polluter or resource user is required by law to pay any damages to those affected. Damaged parties collect settlements through litigation and the court system.

Liability insurance	Entities using hazardous substances are required to take out liability insurance which ensures provisional compensation to victims of accidents without the need for a court hearing or proof of individual fault on the part of the entity
Location subsidies	A payment given to an entity for choosing to locate on a particular site.
Natural resource damage liability	Financial obligations for cleanup costs and preventive measures when an entity causes damage, injury or loss of natural resources.
Pollution charges	Charges to be paid on discharges into the environment, based in principles on the quantity and/or quality of pollutants.
Product taxes/subsidies	A positive charge on products that are polluting in the manufacturing or consumption phase or for which a disposal system has been organized; a negative charge on environmental friendly products
Resource use taxes	A levy placed on the use of a natural resource
Road toll	A fee paid for some liberty to pass a certain segment of a road link. This is one of the instruments commonly used to reduce road congestion.
Royalties	A payment made for the use of property such as a natural resource. The amount is usually a percentage of revenues obtained for its use.
Soft loans	Loans with interest rates below market rates
Tax differentiation	A positive charge levied on a polluting product and a negative charge, or subsidy, on a cleaner alternative. This instrument is used to promote consumption of products that are environmentally safe.
Tradable catch quota	Transferable property rights allocated to fishers in the form of a right to harvest any amount up to the limit equal to the quota over the course of a specified fishing period; Also called "Individual transferable quota" (ITQ) in fisheries management
Tradable emission permits	Tradable emissions permits are used in an environmental regulatory scheme where the sources of the pollutant to be regulated (most often an air pollutant) are given permits to release a specified number of tons of the pollutant. The government issues only a limited number of permits consistent with the desired level of emissions. The owners of the permits may keep them and release the pollutants, or reduce their emissions and sell the permits. The fact that the permits have value as an item to be sold gives the owner an incentive to reduce their emissions
Tradable land permits	An economic policy instrument under which rights to exploit land can be exchanged through either a free or controlled permit market.
Traditional management regimes	The traditional management regime is the existing state of management (eg. of a resource); or status quo. For instance, the traditional management regimes in open ocean fisheries are: "Open access regime" where property rights are non-exclusive.
Use right (licenses/concessions)	Any grant of rights, land or property by a government, local authority, corporation or individual
User charge -	Fee collected from only those persons who use a particular service, as compared to one collected from the public in general
Water right	A legal right to use surface water. This may be a right wherein a property owner is entitled to use of water which touches his/her property or may be an appropriative right granted by the government.
Voluntary agreements	Commitments made by individual companies or by trade and industry as a result of negotiations with public authorities.

Source: Markandya and Povh, forthcoming

Finally it is worth noting that if a tax is designed to fully internalize the external costs of electricity production, taxing the damaging fuels and technologies will result in a substantial increase of energy prices. For example, if the external cost of producing electricity from coal were to be factored into electricity bills, between 2 and 8 Euro cents per kWh would have to be added to the current price (this is true for the majority of the EU Member States). Politically, such increases would be impossible; hence full internalisation may never be achieved through a tax, or it may only be achieved over a very long period.

Carbon taxes have been introduced in the UK, Denmark, the Netherlands, Germany, Italy, Slovenia, Sweden, Norway, and Finland. The introduction of carbon taxes has not always been successful.

For example, Italy imposed a carbon tax in 1999 that was due to start at a relatively low level, and then to build over five years. However, during the late 1990s, Italy was required to meet several macroeconomic constraints, in order to be allowed to join the Euro currency at launch. One constraint was on the annual inflation rate. The carbon tax was suspended by Italy in order to reduce inflation. This suspension proved temporary, and the tax was re-instated. However, in late 2002 the Italian government notified its intention to repeal the carbon tax.

Other differences among EU Countries exist. For example, while Sweden is one of few countries that included coal in its carbon tax, major countries such as Germany are still subsidising coal production (Metroeconomica Limited, 2003).

In the present study we prefer not to stress the use of taxes as an instrument for the internalization of external costs of electricity production. The previous experience with the carbon tax has shown that some countries are not willing to increase or implement the use of a carbon tax adequate to the internalization of externalities. Moreover, the European Commission has highlighted that the use of subsidies, which has been stressed in the community guidelines on state aid for renewable energies, should be a preferred instrument to deal with externalities.

Emissions permits

Each permit represents a fixed quantity of allowed CO_2-emissions, typically 1 metric ton per permit (IEA, 2001). The number of permits in hands represents the total permitted emission quantity; a penalty is applied in case the actual emissions are in excess of this quantity.

Permits may be traded. Buyers will be those operators or countries, which lack permits for their emission needs (their marginal costs of reduction are high). Sellers will be those operators or countries, which have permits in excess (their marginal costs are low).

The emissions trading scheme for greenhouse gases is currently being introduced by the EU in order to achieve the Kyoto targets of emissions reductions. In the present report we want to keep distinct the EU Kyoto target that aims at reducing the emissions of greenhouse gases by 8% in 2008 compared to the 1990 emissions level and the broader goal of externalities internalization in the electricity market. We will therefore not emphasize the use of emissions trading as an option to internalize externality costs created by the emissions of the greenhouse gases, CO_2, CH_4, N_2O, N and S. However, emissions permits might be considered as a policy tool for the external costs in the electricity market generated by other pollutants, such as SO_2 and NO_x.

The allocation of permits among industries has been the subject of a debate. Permits could be allocated to companies on the basis of their historical output of emissions (grandfathering) or they could be auctioned.

The usual argument to support grandfathering is that while inefficient, is it provides greater political control over the distributional effects of regulation (Stavins 1997).

On the other hand, Cramton and Kerr (2002) argue that an auction is preferred to grandfathering because it reduces tax distortions and the need for politically contentious arguments over the allocation of rents, provides more flexibility in distribution of costs and greater incentives for technological innovation.

An important difference between permits that are auctioned by the government and permits that are issued for free is that with free permits the polluter pays only the abatement cost, but with auctioned permits the polluter must also pay the remaining damage at the new emission level, as pointed out by Desaigues and Rabl (2001). The difference in cost to the polluter is very large: a factor of three or more as can be seen from the results of Rabl et al. (2004).

Subsidies

The same environmental goal reached by taxing the most damaging fuels and technologies can be reached by subsidizing greener technologies and renewable energies. Since taxation on a EU level is very difficult to achieve, the Commission has opted to encourage the second solution. In February 2001, it published the Community guidelines on state aid for environmental protection, which explicitly foresee that “Member States may grant operating aid to new plants producing renewable energy that will be calculated on the basis of the external costs avoided.” At any rate, the amount of the aid thus granted to the renewable energy producer must not exceed 5 Euro cents per kWh. More details of limits to subsidies under EU law are discussed below.

Subsidies range from tax credits given to companies that produce green electricity, or low-interest loans for the purchase of renewable energy equipment, to sales tax exemptions for the cost of renewable energy equipment.

Subsidies: Feed-in tariffs

The feed-in tariff scheme involves an obligation on the part of electric utilities to purchase the electricity produced by renewable energy producers in their service area at a tariff determined by the public authorities and guaranteed for a specified period of time (generally about 15 years).

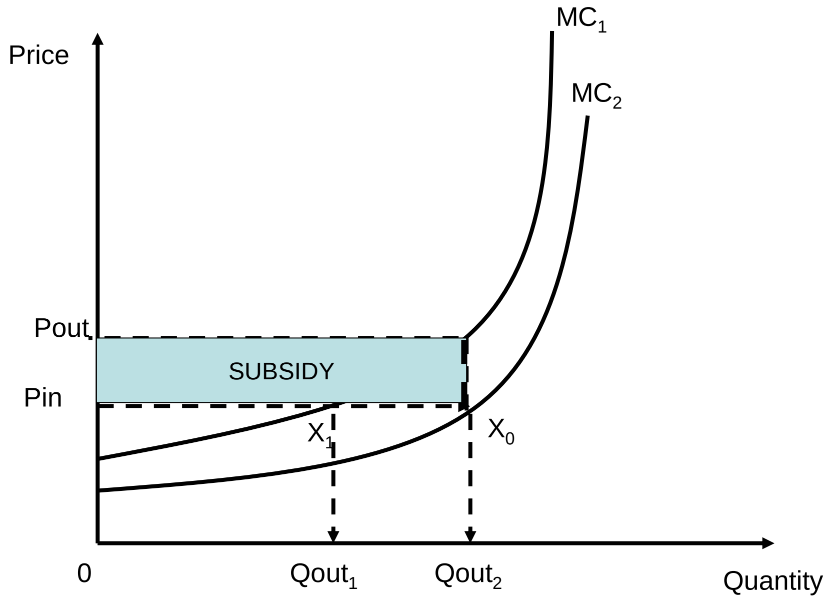
The feed-in tariff system operates as a subsidy allocated to producers of renewable electricity. It works in the same way as a pollution tax does for firms that pollute: producers of green electricity are encouraged to exploit all available generating sites until the marginal cost of producing green electricity equalises the proposed feed-in tariff price P_{in}. The amount generated then corresponds to $Qout_2$, representing an increase in renewable energy of $Qout_2$ - $Qout_1$ depends on the position of the marginal cost curve (Figure 3).

The cost of subsidising producers of renewable energy is covered either through cross-subsidies among all electricity consumers (Spain, Italy) or simply by those customers of the utility obliged to buy green electricity (Germany),[4] or by the

[4] According to the old German Electricity Feed-In Law it was the utility who had the exclusive right to serve in the area where the renewable energy power plant was erected that was obliged to purchase the renewable energy produced. This led to a situation where utilities and their customers in northern

taxpayer, or a combination of both systems (Denmark).[5] Calling simply on customers of local companies to finance green power generation is considered unfair and mechanisms are therefore often adopted to share the burden more equitably (Menanteau et al., 2003).

Figure 3. Feed-in tariffs



MC_1 = Marginal Costs for Renewables W/out Subsidy. MC_2 = Marginal Costs for Renewables With Subsidy

$Qout_2$ - $Qout_1$ = Increase in renewable energy supplied with the subsidy

Subsidies: Competitive bidding processes

In the case of competitive bidding processes, the regulator defines a reserved market for a given amount of renewable energy and organises a competition between renewable producers to allocate this amount. Electric utilities are then obliged to purchase the electricity from the selected power producers.

Competition focuses on the price per kWh proposed during the bidding process. Proposals are classified in increasing order of cost until the amount to be contracted is reached. Each of the renewable energy generators selected is awarded a long term contract to supply electricity at the pay-as-bid price. The marginal cost P_{out} is the price paid for the last project selected which enables the quantity Q_{in} to be reached (Figure 4). The price in this case is determined by the position of the marginal

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Germany with the majority of wind power installations under the Law had to pay a considerable higher share of the costs than the southern companies and their customers. The introduction of amount caps tried to solve this problem: if the green electricity fed-in exceeded 10% of the total sales of the utility, the obligation for the specific utility to purchase the green electricity would end. However, this solution threatened the further deployment of wind energy in certain areas and addressed the unbalanced burden insufficiently. The Renewable Energy Act of 2000 solves this problem in a different way by requiring electricity supplier to have the same share of green electricity in its fuel mix. Thus, not only the costs but also the benefits in form of the generated electricity are shared equally among all electricity suppliers, thus electricity customers (see SEPCO website: www.ises.org/sepco/).

[5] In Germany, the new tariffs for wind energy are 0.091 Euros/kWh during 5 years, after which the rate decreases depending on the site; in Denmark, the tariff is fixed at 85% of the domestic tariff supplemented by the reimbursement of the carbon tax.

cost curve. The implicit subsidies attributed to each generator correspond to the difference between the bid price and the wholesale market price.

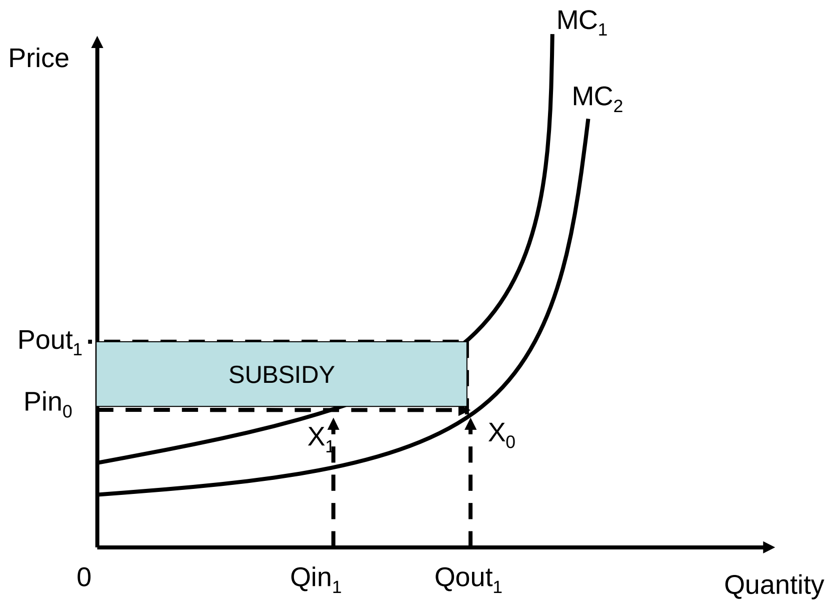
The competitive bidding procedure enables the marginal production costs of all the producers to be identified (ex post.) The overall cost of reaching the target is then given by the area situated under the marginal cost curve.

Competitive bidding systems have been used in the United Kingdom under the Non-Fossil Fuel Obligation (NFFO) set up in 1991 and which concerned different renewable energy technologies. Similar schemes existed in France with the Eole 2005 programme set up in 1996 to promote wind energy.

A difference between competitive bidding and feed-in tariffs is that the exact amount of renewable electricity covered by the bids is known a priori in the competitive bidding system. On the other hand, since the precise shape of the cost curve is not known (ex ante), the marginal cost and the overall cost of reaching the target cannot be determined.

Finally, the extra cost is financed in much the same way as in the previous case. It is either added to electricity bills in the form of a special levy (England), or the cost is covered through cross-subsidisation among all electricity consumers (France).

Figure 4. Competitive bidding system



MC_1 = Marginal Costs for Renewables W/out Subsidy. MC_2 = Marginal Costs for Renewables With Subsidy

$Qout_1$ - Qin_1 = Increase in renewable energy supplied with the subsidy

Subsidies: Green renewable certificates

Green certificates have been introduced by several governments to support the development of renewable energies (IEA, 2001; Odgaard, 2000; van den Berg and van Biert, 1998). The regulator imposes a quota as a percentage of the total electricity production, which has to come from those renewable sources. Wholesalers, distributors or retailers of electricity are liable to respect the quota. To give them more flexibility and compensate for missing green kWh, they can purchase green certificates from the green electricity producers. The price of green certificates will be close to the difference in price between renewable electricity and classical electricity. The additional revenues for the producers will compensate them for this difference in price. Distributors, which do not achieve the quota imposed by the regulator, will have to pay penalties. No certificates can be produced without actual electricity production (Kunsch et al, 2004).

The flexibility of this instrument allows the regulator to induce the demand for green certificates by transferring the national target for renewable energy to either the consumers or the distribution companies.[6] Consumers or distributors will be required to prove that they consume at least the specified amount of renewable energy.

There are also some practical difficulties, however. First, the start up of the green certificate market is difficult in countries with small initial renewable capacities. Second, although the renewable quota is respected, or even exceeded, the emission-reduction objective might not be achieved. Renewable electricity could be used mainly to compensate the increase in demand and not to substitute “dirtier” emission sources. However, this is an issue that would remain with any similar subsidy or with a carbon tax.

Green renewable certificates have been recently introduced in Italy, Denmark, Belgium (the Flanders region), Germany, UK, Australia and the US.[7]

Voluntary agreements in the electricity market

Voluntary agreements in the energy market involve commitments by the industry to decrease the level of emissions in exchange, for example, of a training programme for energy-efficient purchasing and an audit provided by the authority. Voluntary agreements are the results of co-operation and negotiation between two partners, an authority and an industry, and are intended to be followed by some form of contract. From the voluntary basis of cooperation there also follows a variation in content between agreements aimed to fulfil the same purpose. Failures in fulfilment cannot be brought to court. Handling failures thus have to be dealt with by partners in a way agreed upon.

It is often argued that voluntary approaches do not result in significant effects on the environment. Voluntary commitments may hide a low ambition of the objective itself: in a voluntary agreement firms may have declared an easy target to reach. Critics argue that voluntary approaches only contain a pollution program which follows a natural trend, a business as usual trend. As technology evolves and

[6] This obligation could also be imposed on the supplier. In Italy every supplier of energy, except renewable energy producers or importers, are required to ensure that 2% of the energy that is put on the grid is renewable energy. This can be done by installing renewable energy capacity or buying certificates (Nielsen and Jeppesen, 2003).

[7] Nineteen US States (Arizona, California, Colorado, Connecticut, Florida, Hawaii, Illinois, Iowa, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, Rhode Island, Texas and Wisconsin) have introduced the Renewable Portfolio Standards (DSIRE, 2004). This is a policy that requires those who sell electricity to have a certain percentage of “renewable” power in their mix. These policies often start around 1-5% in the first year and require an increasing percentage of renewables in each energy supplier’s mix, often aiming for a goal of 4-20% in about 10 years. Renewable Portfolio Standards policies typically involve a credit trading mechanism so that companies with extra renewable power can sell the extra credits to suppliers who have not met their Renewable Portfolio Standards requirement. Renewable Portfolio Standards policies vary in many ways. Some allow only new renewables while others allow existing renewables to qualify. Most Renewable Portfolio Standards policies do not have strong requirements for clean renewables. Some have more consumer protections than others.

improves, it "automatically" increases the efficiency with which natural resources are used, and therefore reduces the emissions per unit of resource used.

A second concern with voluntary agreements is that once an agreement has been signed, the initial pressure may dissipate and firms may have the opportunity not to comply with their commitments. Even though voluntary agreements have been initiated in association with a regulatory threat, most have not included a monitoring and sanction for non-compliance mechanisms.

Another criticism that has recently emerged is that voluntary measures are often suspected to promote collusive practices between participating firms. The potential danger of industry collusion is greater when the voluntary approach concerns a contracted sector where a relatively small number of firms dominates the market (Carraro and Lévêque, 1999).

These limitations imply that agreements can never replace legislated regulations or other more conventional policy instruments.

The appropriate contexts for using environmental agreements indicate that they are best suited to industries with well-organised management that has a good understanding of the environmental problem in question (Lindén and Carlsson-Kanyama, 2002). Past experience with voluntary agreements in the energy market has shown that they can play a useful role. However, this requires proper preparation and negotiation of demanding targets as well as a combination with substantial incentives for compliance by other policy instruments. Moreover, regular monitoring and evaluation have to be explicitly utilized for policy learning. By this, effective agreement schemes impose significant institutional demands, i.e. implementation costs. Moreover, a sound preparation of voluntary agreements takes time, so that they are not necessarily a suitable means for accelerating the energy policy process (Krarup and Ramesohl, 2000).

In Switzerland, voluntary agreements are an integral part of the federal law to reduce CO_2 emissions which was passed in 1999. Voluntary agreements in the energy market have been applied also in Sweden, France, Denmark and the Netherlands.

Green Electricity Purchasers

The main advantage of renewable energies over conventional energy generation is that they contribute to the preservation of public goods, namely clean air and climate stability. Because of the non-excludable and non-rival characteristics of these public goods, however, private actors are not prepared to invest in something which everyone can acquire free of charge. In such conditions, the diffusion of renewable energies cannot be assured spontaneously by the market (Menanteau et al., 2003), unless it is cost effective. This has been the position of economists for a long time, but there is now some evidence that certain groups may, in fact, buy some goods that are more expensive, because they have some public good benefits. The arrangements under a liberalised electricity market which enables consumers who want to pay for this environmental good to purchase green electricity directly from a supplier, is one response to this demand. This solution, already tested in a number of countries (Germany, United States, Netherlands, etc.), can provide insight into the preferences of consumers and their willingness to pay for renewables.

Although green electricity seems to attract a small and increasing number of supporters in certain countries, most consumers are not prepared to pay a higher price for a public good which everyone will be able to benefit from; the problem of free-riding remains a very real one (Batley et al., 2001; Wiser and Pickle, 1997; Mirabel et al., 2001). Experience has shown that the proportion of green electricity purchasers is low, around 2–3%, except in cases where there are strong incentives in the form of tax exemptions for electricity consumers (Jegen and Wustenhagen, 2001). In the Netherlands in 2001, 8% of consumers opted to buy green electricity, but with a tax incentive of 0.06 euros/kWh. This percentage may, however, be increased by information campaigns, education, formation and training can help to increase the acceptance of renewable energies. Additionally, special support programmes can provide grants or low-interest loans for investments in renewable plants for own use of electricity, which can be used voluntarily by beneficiaries (Espey, 2001).

Generation Disclosure Rules

"Disclosure" typically refers to the requirement that utilities provide their customers with additional information about the energy they are supplying. This information often includes fuel mix percentages and emissions statistics. Fuel mix information, for example, can be presented as a pie chart on customers' monthly bills.

"Certification" is a related issue which refers to the assessment of green power offerings to assure that they are indeed utilizing the type and amount of renewable energy as advertised.

Both disclosure and certification are designed to help consumers make informed decisions about the energy and supplier they choose. Indeed, disclosure is often thought of as a good policy to help educate customers about electricity and thereby to prepare markets in advance of retail competition.

In the US, twenty-four states are using generation disclosure rules in energy policy (DSIRE, 2004).[8]

6. Which instruments to use for the internalization of externalities in the electricity market?

The choice of the instruments to internalize the external costs of electricity production has to carefully consider the consequences that such instruments will have on the economy. The optimal instrument will be one that internalizes the externalities and creates no distortions in the market. Ideally such an instrument should be efficient, fair, minimize costs and uncertainty, have low administrative costs, stimulate technological innovation, have a positive effect on the job market, and guarantee the security of the supply of energy. This is not an easy task. It is likely that the solution will emerge as a compromise for the instrument, or the mix of instruments, that will guarantee the best acceptable outcome to consumers, producers, policy-makers and stakeholders in general. Another problematic element to keep in mind when looking for the best instrument is that one of the crucial results of the

[8] For example, as a result of Senate Bill 1305 (1997), California's energy suppliers must disclose to all customers the energy resource mix used in generation. Providers must use a standard label created by the California Energy Commission (CEC), and this information must be provided to end-use customers at least four times per year.
On the certification side of the issue, the Green-e Renewable Branding Program is being used by suppliers in the state. Designed by the Center for Resource Solutions, this voluntary certification and verification program designates energy offerings whose renewable energy content is at least 50%. For the non-renewable portion of energy with the Green-e label, if fossil fuels are used, those resources must have their air emissions per/kWh for SOx and NOx less than or equal to California System Power. The program is governed by the Green Power Board, an independent oversight board.

ExternE research is that external costs are site dependent and may widely vary by regions.

The European experience with the carbon tax has not given a straightforward indication. While some countries have a long experience with such a tax (Finland) others are still experiencing problems with its implementation (Italy). Differences among countries, different taxation rates, the low rates implemented by countries so far make this instrument less attractive as an effective one for the externalities internalization in the electricity market.

The recent orientation of the European Commission toward the increase use of renewable energy has emphasized the role that subsidies might play in stimulating the adoption of green technologies. In February 2001, the Commission published the Community guidelines on state aid for environmental protection, which explicitly foresee that “Member States may grant operating aid to new plants producing renewable energy that will be calculated on the basis of the external costs avoided.”

A problem to be considered with the introduction of subsidies and tradable green certificates is whether these instruments should be regarded as state aids following the EU legislation. The basic rule for environmental regulation is the Polluter Pays Principle, under which the polluter is meant to cover the costs of measures. Since the fifth environmental program, adopted in 1992 (EAP, 1992), it is an important principle that environmental protection requirements must be integrated into other general community policies. Moreover, environmental policies should be based on the Polluter Pays Principle (see Box).

As the details in the box indicate, Community Guidelines on state aid for environmental protection (CEC, 1994), open up the possibility of granting this kind of state aid under certain conditions. These guidelines aim to strike a balance between the requirements of competition and those of environmental policy. The general rule is that state aid is justified when adverse effects on competition are outweighed by the benefits to the environment. There are two further circumstances under which the Commission may accept the granting of state aid (CEC, 1994): (i) if it is impossible for producers in certain sectors to fully internalise external costs, state aid may give producers an incentive to adjust production to comply with the standards. This is called a “temporary second-best solution”; and (ii) if state aid can give producers an incentive to either go further than that prescribed by the standards, or invest in technology that would make production less polluting.

Table 4 summarizes the instruments considered in the present study for the internalization of external costs in the electricity market. The list spans from subsidies given to either producers or consumers of renewable energy, to price or quantity based measures, to voluntary agreements and other voluntary measures, such as generation disclosure rules. The latter are to be considered as supplemental instruments useful to educate consumers, but should not be considered as a sufficient instrument.

Box: The PPP and the Use of Subsidies in the EU and OECD

The perverse effects of subsidies were important considerations that triggered adoption of polluter pays principle (PPP) as a hallmark of environmental policies in OECD countries since 1972. The PPP constitutes for OECD member countries a fundamental principle for allocating costs of pollution prevention and control measures required by public authorities. Initially the PPP established a general "no subsidy" objective – the costs of complying with existing and new environmental regulations should be borne by those who cause the pollution (PPP in a "strict sense" or "standard PPP"). Along time the PPP broadened its scope to comprise paying for all pollution-related externalities including the environmental risks caused by accidental pollution and also pollution taxes and charges ("extended PPP").

The OECD Members have advocated limiting the use of subsidies to pollution control ("standard PPP") mainly in order to avoid "environmental dumping", which might affect competitiveness of national firms and pose obstacles to trade. Therefore harmonization (comparability) of environmental policies is an important policy objective for OECD member countries.

The PPP "in a strict sense" (non-subsidisation of pollution prevention and control) is widely incorporated into the legal systems of most OECD countries. This notwithstanding OECD countries have been, and are providing subsidies to domestic pollution control in a variety of forms, through the government budgets or via specialized (sometimes extra-budgetary) agencies, such as public environmental funds, water or environmental agencies. For example in the fifteen "old" EU member states total state aid to environment amounted to 4.6 Billion Euro and accounted for 0.052% of EU Gross Domestic Product (GDP) in 2002.

As frequent as it may have been, the government aid to pollution abatement in industry in OECD countries has been generally subject to agreed rules, mutual peer pressures and information disclosure standards. OECD Council adopted documents that specify the circumstances in which government assistance would be considered compatible with the PPP and specific conditions, under which government assistance in bearing the costs of pollution could be granted. Cases where environmental aid to domestic industry was granted not in line with Polluter Pays Principle are exceptions rather than a rule. Rarely environmental aid was pervasive and/or permanent. The general trend has been to decrease aid intensity along time.

Members of the European Union are subject to a specific legal regime of the PPP, which is embodied into the EU law on competition. It restricts provision of State Aid by the member States if it could distort or threaten to distort competition and affect trade between Member States. European Commission has a degree of discretion in considering individual cases of state aid and deciding where state aid is compatible with the common market and where it should be forbidden. In order to make its judgments on environmental aid more predictable the European Commission is using "The Community Guidelines on State Aid for Environmental Protection"

Initially (in 1994 Guidelines) environmental aid was bounded to firms that could not afford the costs of adapting to new environmental requirements introduced by the Member States and by the Commission. The early concern was to justify aid when only State intervention could prevent significant social or economic difficulties from arising in certain industries or regions. Since 2001 state aid should no longer be used to make up for the absence of cost internalization. State aid to help firms adapt to mandatory standards introduced in the European Union is no longer allowed in the member states. Exceptions and special provisions are aimed at encouraging firms to apply environmental controls going beyond Community standards or in the absence of mandatory standards. There is limited allowance, however, for environmental state aid aim at supporting certain environmentally friendly economic activities deemed particularly important for the Community as a whole (energy saving, in the combined production of heat and power and in promotion of renewable source of energy). Firms located in the poorer regions of the Union (eligible for national regional aid) and small and medium size enterprises (SMEs) can still receive aid in order to adapt to new Community standards. Special provisions allow aid for rehabilitation of polluted sites and for EU firms investing outside of the European Community.

Commission allows state aid as a "cushion" to protect competitive position of the countries that innovate with higher levels of environmental protection. This approach encourages individual member states to innovate and introduce more ambitious environmental controls than in the rest of the Union. Once a new innovative pollution control regime becomes state of art in one or few countries the Commission works towards turning unilateral innovations into a state of art (standard) in the entire European Community.

Tabe 4. Policy instruments for the internalization of the external costs of electricity production

Type of Policy Instrument	Policy Instruments
Command and Control Instruments	Technology-based command and control
	Performance-based command and control
Economic Instruments	Tradable emissions permits
	Feed-in-tariffs
	Competitive bidding processes
	Green renewable certificates
	Subsidies given to consumers who purchase renewable energy equipment
	Subsidies given to consumers who purchase renewable energy
Voluntary Instruments	Voluntary agreements
	Generation disclosure rules

In what follows we provide some considerations of the performance of the instruments described in Table 4 with respect of a series of criteria that should be considered in choosing the instruments. The criteria considered are: efficiency, cost minimization, administrative costs, equity, flexibility, impact on the job market, uncertainty of the result in terms of internalization of the externalities, technological innovation, security of energy supply and site location of the externality.

Efficiency

A preliminary investigation of the performance of policy instruments and previous experience has shown that economic instruments, such as subsidies given to producers and tradable green certificates, should guarantee the best outcome in terms of efficiency and flexibility. The emissions trading system is also an efficient instrument, because it combines the advantage of the emission limits (certainty of the result) with the flexibility and efficiency of the free market.

Price and quantity measures, such as competitive bidding design and feed-in tariffs should also guarantee that those firms with the lower marginal costs will be those that produce the higher amount of green electricity. In the competitive bidding system a firm with low marginal costs should outbid a firm with higher marginal costs, and therefore should be allocated a greater share of green electricity production. In the feed-in tariff system producers of green electricity are encouraged to exploit all available generating sites until the marginal cost of producing green electricity equalises the proposed feed-in tariff price. Also in this system, producers with lower marginal costs are stimulated to produce more green electricity.

According to Menanteau et al. (2003), green certificate trading provides the best opportunity for distributing an overall objective in the most efficient way among several technologies and for organising renewable energy development on the scale of several countries. However, the price of adopting green certificate trading is the limited experience we have with such markets, and as long as uncertainties persist concerning market operation and the creation of a framework that is considered stable by investors, its real efficiency has still to be proven.

Command and control measures have long been designated as inefficient instruments, given that they do not stimulate nor allow firms with lower marginal costs to exploit their advantage. In the same way firms with higher marginal costs are forced to reach the same target that firms with lower marginal costs have to, causing an overall greater cost to the economy in reaching the target.

The efficiency of voluntary agreements depends on the decisions taken within the agreement. A voluntary approach can simply be a tool helpful in reaching an agreement for the adoption of an economic instrument, such as green certificates, subsidies, feed-in tariffs schemes, or competitive bidding programs. However, if agreements are based on command and control approaches they will not guarantee an efficient outcome. Moreover, when voluntary agreements hide an easy target for firms, then this instrument may not guarantee an efficient outcome. For example, if firms are able to bargain a low level of production of green electricity, there will be a limited incentive for firms to engage in any production of green electricity, even for those with low marginal costs if these advantages are negligible.

Cost minimization

Command and control usually impose high costs to the society in terms of monitoring and enforcing of the regulation. Given that these instruments do not provide incentives to economic agents to modify their behaviour, the regulator is forced to monitor the market and take actions in case of non-compliance. Free rider problems are frequent in such situations if the government fails to effectively monitor and enforce the regulation. Only in a market where players' reputation in terms of 'green behaviour' is valuable, will firms comply with rules and diminish the need for tough controls by the regulator. However, these situations are very rare and costly for the government: the regulator can try to influence firms' behaviour and try to make reputation a valuable asset through awakening the public opinion to environmental problems.

Among the economic instruments, tradable green certificates and emissions trading appear to require only a minimum of state involvement, compared to subsidies; at least as far as government expenditures are concerned. Costs would be minimized for the government if tradable emission permits will be auctioned.

With tradable green certificates, the main task for governments is to fix the quota and to provide sufficient long-term perspectives for the future development of the renewables requirements (Espey, 2001). However, this may entail quite substantial administrative costs for the measurement and certification of certificates and for the trade of certificates.[9]

Feed-in tariffs and competitive bidding processes result in a cost minimising solution but they do entail subsidies, which can have a fiscal and welfare cost of their own. They may also require substantial administrative costs for the certification of the specified amounts of renewable energy that have been effectively produced. The incentive to reduce costs is much stronger in the competitive bidding system, since competing producers must reflect lower costs in prices in order to win subsidies. In a system of feed-in tariffs, there is less incentive to lower costs, since drops in production costs have not systematically been reflected in the feed-in tariffs (e.g. the Germany until 2000). However, it is possible, as demonstrated by the new incentive policy in France, to provide for a gradual reduction in feed-in tariffs to take into account the progress made in renewable technologies.

Voluntary agreements, whether they are based on economic instruments or on command and control measures, may be an expensive instrument for both the regulator and the firms. Agreements are usually reached after time consuming

[9] Policy makers should also be careful in designing a market for tradable green certificates if it coexists with a market for tradable emissions permits to avoid double counting of permits (Morthorst, 2001).

bargaining. These costs can be quite substantial when parties have difficulties in reaching an agreement.

Equity

Economists have long debated over the equity-efficiency trade-off. Not always the most efficient mechanism is the one that fairly distributes the costs of the externality. The relevant question is: who should pay the cost of the internalization of the externality? The Polluter Pays Principle requires that who generates the externality, i.e. electricity producers, should be responsible for its internalization.

However, it is also worth analyzing whose benefits are increased by the internalization of the externalities of electricity production. If we look at the damages of electricity production in Table 1 we can see that all society will benefit from the internalization of externalities. Not only current generations, but also future generations will benefit, for example through reduction in risks of cancer and of the adverse effects of global warming. If we look at the problem from this perspective, then those who receive the benefits should pay for the costs of the externality.

The policy for the internalization of the costs of electricity production should carefully consider who will finally pay for the externality. An increase in production costs is likely to be transferred to consumers through an increase in sale prices. In this way, final users will be the ones that will bear the burden of the externality. An increase in consumer prices may be seen also as a stimulus to influence consumers' behaviour. Higher energy costs should make consumers more responsible in the use of energy and opt for domestic energy efficiency measures as well (low energy consumption household electrical appliances, housing retrofitting, etc.) However, a policy that imposes the same cost to all consumers, independently of their income, may be regarded as unfair. The issue is related to the use of the PPP, which is discussed in greater detail in the Box above.

The cost of subsidies given to producers of green electricity may be spread through all the population through an increase in income taxes. However taxes increases are never welcome. The cost of green certificates may be allocated to either producers or consumers. The regulator has to decide who at the end of the year will be asked to posses the certificates.

Finally, the costs of direct regulations are likely to be fully transferred to final consumers through increase in prices.

Technological innovation

When compiling the portfolio of policy instruments to achieve innovations, specific attention should be given to instruments removing imperfections in the (national) systems of innovation. In many countries system oriented instruments are heavily under-represented in the portfolio to date. Instead, supporting R&D in individual companies is often the major objective of innovation policies. More attention should be given to policies and instruments dealing with the building and organization of sustainable energy innovation systems and the management of interfaces between potential partners in the innovation process. Instruments are also needed to create conditions for various forms of learning and experimenting with innovative energy technologies and to provide an infrastructure for strategic information production on the technologies tailored to the needs of actors involved. In addition more attention is needed for policy instruments that can be applied to stimulate demand articulation and to facilitate the search for possible applications of new technologies (Turkenburg, 2002).

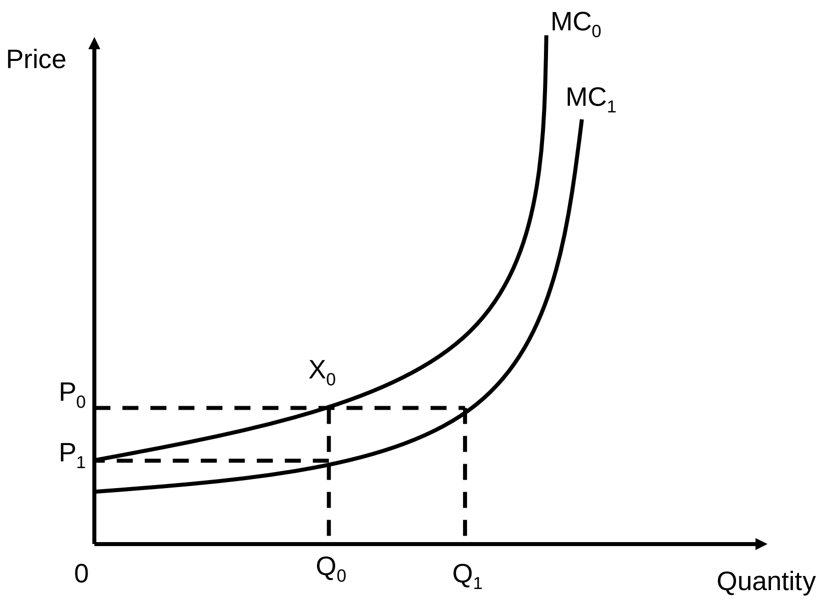
It is often argued that economic instruments will generate a dynamically efficient pattern of incentives on corporate and consumer behaviour. The incentive structure operates to continually reward successful environmentally friendly innovation. In a market-based scheme, every unit of emissions reductions is rewarded by a tax saving. The key issue here is the incentives firms are facing to develop green energy production technology.

The other common argument is that command and control instruments generate weak incentives for innovation. The binary nature of many such instruments creates a discrete switch in behaviour: once a required target is met there is no longer any incentive to go further.

Finally there are some researchers that consider command and control measures in a rather positive way. If the regulator is able to identify a best-practice environmentally friendly technology and imposes this as a requirement on firms through minimum acceptable technology regulations, this will have a first direct effect on spreading technology diffusion. Second, barriers due to lack of information, frictions and other market imperfections that may lead firms to be overcautious or unable to act voluntarily no longer bite in the face of imposed requirements (Perman et al., 2003).

It is worth to consider the effects on the quantity and on the price of green electricity derived from a technological innovation. When we focus our attention on economic instruments we have to distinguish between price-based and quantity-based instruments. In the case of subsidies or feed-in tariffs, when there is a technological innovation, the marginal cost curve shifts downwards allowing a greater quantity of green electricity to be produced (from Q_0 to Q_1 in Figure 5). With a quantity based instrument (tradable green permits and competitive bidding design) when the marginal cost curve shifts downwards through a technological shock, the quantity of green electricity produced remains constant, while its price decreases from P_0 to P_1.

Figure 5. The effect of a technological change on quantity and price of green electricity production



It is finally worth noting that the experience with feed-in tariffs has shown that this instrument has obtained good results in diffusing technologies (e.g., wind turbines and photovoltaic systems in Germany).

Feasibility

It is important that the instrument(s) chosen for the internalization of the costs of producing electricity be feasible. This is one of the reasons that drove us to disregard the adoption of taxes among the instruments available to policy makers. The experience with the carbon tax has not always been successful, and other instruments may be better accepted by economic agents. All other instruments that have been considered in this study appear to be measures that may be implemented (or have already been implemented) by some states.

Impact on the job market

It is in general hard to estimate the effect of the instruments on the job market. Subsidies given to stimulate companies to invest on renewable energy should have a positive effect on employment. Similar positive results should emerge by introducing tradable green certificates that should stimulate the growth of renewable energy producers. More uncertain might be the outcome on the job market for other instruments. Voluntary agreements might have a positive effect on the job market, given that a bargaining process between the regulator and firms generally consider jobs as an important priority, but they do run the danger of achieving lower environmental targets.[10]

Uncertainty

When choosing the instrument for the internalization of the externalities, the policy maker has to consider which instrument gives the most certain result in terms of internalization of externalities.

If the regulator has perfect information on the marginal cost functions of individual firms, command and control instruments lead to an efficient policy. However, it is very difficult that the regulator knows these functions. Indeed, economic instruments are often preferred because they are able to reach targets at least costs even when the regulator has no information about individual firms' marginal costs.

If the regulator is not certain about the position of the aggregate cost functions, price-based instruments (subsidies, feed-in tariffs) and quantity-based instruments (tradable green certificates, competitive bidding design) will differ in internalizing the externalities. In general, uncertainty about marginal costs translates into uncertainty about the quantity of green electricity produced with a price-based instrument. In translates into uncertainties about prices or costs under a quantity-control system.

The trade-off in this case is a quantity-price one. The regulator may decide that it is more important to adopt an instrument that fixes the quantity of green electricity that will be produced in the market, or it may prefer to fix its price. The choice of the regulator may be guided by looking at the elasticity of the marginal cost curve. A quantity based approach is preferable when the slope of the marginal cost curve is gentle. In fact, a price-based approach would, if the cost curve were

[10] For example, a voluntary agreement between the city of Venice and the companies operating in the industrial harbour of Porto Marghera has guaranteed the security of jobs and the creation of opportunities to stimulate investments in new environmental technologies in exchange for the cleanup of the site (Accordo di Programma per la Chimica di Porto Marghera, October 21, 1998).

incorrectly estimated, give a quantity result that would be well off target. Inversely, when the cost curve is steep, a price-based approach should be adopted since the effect on the volume of electricity generated is relatively small and the result closer to the target. This is one of the reasons why feed-in tariffs schemes have been criticised for their overall high cost. If it is assumed that the wind energy cost curves are, at present stage, relatively flat it can be seen that a slight variation in the feed-in tariff proposed leads to substantial increase in the quantity produced, and consequently on the subsidies, whether financed by the electricity consumers, or the general public.

Energy security

Policy makers should also consider how instruments affect the security of energy supply and how the liberalization of markets will influence the applicability of each instrument. These concerns should especially take into consideration the rising level the demand for energy. This means that it might be important to focus more on instruments that can stimulate the increase in the production of green electricity, rather than instruments that affect the price of green electricity.

In terms of overall dependence on foreign supplies of fossil fuels, the move to renewable sources has a positive impact (i.e. it reduced dependence). In terms of overall reliability of supply of the electricity system, however, the position may be more complex and more work is needed on that.

Site location

Finally, the policy maker should not forget that the externalities in the production of electricity are site specific and it is possible that one instrument will be more practical to target a specific firm rather than another in specific geographical areas.

The identification of the optimal instrument(s) to internalize the externalities in the electricity sector needs further investigation. In this section we described the criteria that need to be considered when choosing an instrument. In the next section we describe how we can use the conjoint choice analysis to better understand the relative importance of some of these criteria when policy makers are asked to select the optimal instrument(s).

7. The use of conjoint choice analysis in the selection of the instruments for the internalization of externalities in the electricity market

When policy-makers and stakeholders are asked to choose the instrument(s) to internalize the externalities in the electricity production, they have to find a solution that gives the best outcome in terms of the criteria described in the previous section. However, it is difficult to identify one single instrument that outperforms the others in terms of efficiency, cost minimization, impact on the job market, security of energy supply, equity, technological innovation, certainty, feasibility. The choice of the instrument will require some trade-offs among these criteria.

Conjoint choice analysis can help investigating how policy-makers and stakeholders trade-off the criteria when designing a policy for the internalization of the externalities. In this section we first describe the conjoint choice methodology and then show how it can be applied in the energy market to highlight the criteria that are considered more important in the choice of the instruments for the internalization if the external costs of electricity production.

A useful tool to compare the policy instruments we described is provided by the conjoint choice analysis techniques (or conjoint choice experiments, or choice experiments).[11] In a typical conjoint choice survey, respondents are shown various alternative representations of a good, which are described by a set of attributes, and are asked to choose the most preferred (Hanley et al., 2001). The alternatives differ from one another in the *levels* taken by two or more of the *attributes*. This approach has the advantage of simulating real market situations, where consumers face two or more goods characterized by similar attributes, but different levels of these attributes, and are asked to choose whether to buy one of the goods or none of them.[12]

To motivate the statistical analysis of the responses to conjoint choice experiment questions, it is assumed that the choice between the alternatives is driven by the respondent's underlying utility. The respondent's indirect utility is broken down into two components. The first component is deterministic, and is a function of the attributes of alternatives, characteristics of the individuals, and a set of unknown parameters, while the second component is an error term. Formally (see Alberini et al, forthcoming),

$$(1) \qquad V_{ij} = \overline{V}(\mathbf{x}_{ij}, \boldsymbol{\beta}) + \varepsilon_{ij}$$

where the subscript i denotes the respondent, the subscript j denotes the alternative, **x** is the vector of attributes that vary across alternatives (or across alternatives *and* individuals), and ε is an error term that captures individual- and alternative-specific

[11] Conjoint analysis and other stated-preference (SP) techniques have recently emerged as a complement to revealed-preference (RP) techniques. While RP evaluate economic agents' behaviours in real markets, SP involve choice responses evoked in hypothetical markets. The interest in hypothetical behaviours in economics arises from different reasons, such as the necessity to investigate economic agents' preferences for new policies that might be implemented, for the development of a new product or good, or for evaluating goods that are not traded in real economic markets. All these examples make it clear that it is not possible to estimate agents' preferences using revealed preferences. Choice experiments analysis allows a great deal of flexibility because researchers can explore how a change in the hypothetical scenario influences people's responses, and compare the current scenario with many hypothetical alternatives. This is particular helpful for informing policy decisions before the policy itself has been decided upon.

Usually revealed preference data from regular marketplaces (such as the labour and the housing market) contain information about actual market equilibria for the behaviour of interest, and can be used to infer short-term departures from the current equilibria. In contrast, stated-preference data like responses to choice experiments questions are especially rich in attribute trade-off information. Therefore, stated-preference data are useful in estimating future changes in agents' behaviour (Louviere et al., 2000).

In a single choice experiment exercise researchers learn only which alternative is the most preferred, but the result of the exercise does not tell anything about the preferences for the options that have not been chosen. A single choice experiment exercise does not offer a complete preference ordering. Therefore, if researchers want to know a complete ordering of preferences it is necessary either to ask a respondent to do many choice exercises, or to survey more respondents varying the levels of the attributes.

[12]A simple example of the application of the conjoint choice methodology can be described by studying the choice of a 'car'. When we choose to buy a car we compare the 'levels' taken by the 'attributes' that describe them. In fact, a car can be described by several attributes: make, number of doors, price, engine, etc. The levels for the attribute 'make' can be: Ford, FIAT, Renault, etc. The levels for the attributes 'number of doors' can be: 3 or 5. And so on for the other attributes.

factors that influence utility, but are not observable to the researcher. Equation (1) describes the random utility model (RUM).

Respondents are shown two or more representations of the good. The alternative they select is the one that gives them the highest utility. Because the observed outcome of each choice task is the selection of one out of K alternatives, the appropriate econometric model is a discrete choice model expressing the probability that alternative k is chosen. Formally, the probability that respondent *i* chooses alternative *k* is given by:

$$(2) \qquad \Pr(k \text{ is chosen}) = \Pr(V_k > V_1, V_k > V_2, ..., V_k > V_K) = \Pr(V_k > V_j) \quad \forall j \neq k \ ,$$

If the error terms ε in (1) are independent and identically distributed and follow a standard type I extreme value distribution, it can be shown (Train, 2003) that the probability that respondent i picks alternative k out of K alternatives is:

$$(3) \qquad \Pr(k) = \frac{\exp(\mathbf{w}_{ik}\boldsymbol{\beta})}{\sum_{j=1}^{K} \exp(\mathbf{w}_{ij}\boldsymbol{\beta})}$$

Where w_{ij} is the vector of all attributes of alternative j. Equation (3) is the contribution to the likelihood in a conditional logit model. The full log likelihood function of the conditional logit model is

$$(4) \qquad \log L = \sum_{i=1}^{n} \sum_{k=1}^{K} y_{ik} \cdot \log \Pr(i \text{ chooses } k),$$

where y_{ik} is a binary indicator that takes on a value of 1 if the respondent selects alternative k, and 0 otherwise, and Pr(*i* chooses *k*) is equal to Pr(*k*) in equation (3).

For large samples and assuming that the model is correctly specified, the maximum likelihood estimates $\hat{\beta}$ are normally distributed around the true vector of parameters **β**, and the asymptotic variance-covariance matrix, Ω, is the inverse of the Fisher information matrix.

Once model (4) is estimated, the rate of trade-off between any two attributes is the ratio of their respective β coefficients. The **marginal value** of attribute *l* is computed as the negative of the coefficient on that attribute, divided by the coefficient on the price or cost variable:

$$(5) \qquad MP_l = -\frac{\hat{\beta}_l}{\hat{\beta}_2}.$$

The **willingness to pay** for a commodity is computed as:

$$(6) \qquad WTP_i = -\frac{\mathbf{x}_i\hat{\boldsymbol{\beta}}}{\hat{\beta}_2},$$

where **x** is the vector of attributes describing the commodity assigned to individual i. It should be kept in mind that a proper WTP can only be computed if the choice set for at least some of the choice sets faced by the individuals contains the "status quo" (in which no commodity is acquired, and the cost is zero).

8. Conjoint choice analysis and the policy instruments for the energy sector

In our case, the object of the analysis is a policy for the internalization of the externalities in the energy production. The policy is identified by the instrument (such as feed-in tariffs, competitive bidding designs, or tradable green certificates, taxes, emission permits) used for the internalization of the externalities. The choice of the instrument depends on how the instrument performs in terms of criteria (equity, efficiency, impact on the job market, uncertainty in terms of internalization of the externalities, technological innovation, cost minimization, feasibility of the instrument, energy security) and on the relative importance of these criteria.

The application of the conjoint choice technique may shed light on the relative importance of the criteria in order to suggest the choice of the optimal policy instrument. We decided to apply the methodology within the MAXIMA Co-ordination Action, a project funded by the European Commission, whose aim is to involve policy-makers and stakeholders in the debate on the external costs of electricity production. A first draft of the questionnaire was administered at the MAXIMA Workshop in Krakow, on February 28th and March 1st, 2005. In this section we report the results of this preliminary investigation.

A. Selection of the attributes

The first step in our investigation was to select the attributes for the choice tasks. Choosing the number of attributes and their levels is a difficult task because the researcher has to identify the attributes that best describe the good or the program to be evaluated. Researchers usually need to limit the number of attributes and levels for two reasons. The number of possible hypothetical scenarios depends on the number of attributes and levels. In order to identify the preferences of respondents for a high number of hypothetical scenarios it will be necessary to survey a large number of respondents. Therefore, researchers need to consider the number of interviews they plan to carry out. The second motivation for limiting the number of attributes and levels is to keep the choice exercise relatively simple and minimize the cognitive burden the respondent has to bear. The higher the number of attributes and levels, the more difficult and complex the choice exercise becomes.

Given that in our Workshop we could only survey a very limited number of respondents, we decide to limit the number of attributes to four: (i) the cost of the policy expressed in terms of the increase in energy prices due to the internalization of the external costs, (ii) the percentage of the external costs to be paid by electricity producers, (iii) the effects on the job market and (iv) the security of electricity supply. Table 5 describes the attributes and the levels chosen for our attributes.

Table 5. Attributes and levels for the conjoint choice exercise carried out at the MAXIMA workshop in Krakow.

Attribute	Level 1	Level 2	Level 3
The cost of the policy	3 €cent/kWh for coal and oil 1 €cent/kWh for gas 0 €cent/kWh for hydro	5 €cent/kWh for coal and oil 2 €cent/kWh for gas 0.1 €cent/kWh for hydro	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	35%	50%	65%
Change in the employment in the electricity industry in Europe	- 10,000 jobs	+ 10,000 jobs	--
Frequency of moderate events of energy disruptions in Europe	1 black-out every 8 years	2 black-outs every 8 years	--

The choice of the attributes was driven by the desire to understand how much of the external costs stakeholders and policy makers are willing to internalize and to see whether respondents would pay more attention to the job market or to the security of the supply of electricity in designing a policy for the electricity market.

The attribute of the cost of the policy is described by an increase in the price of electricity. We decided to link the price increase to specific fuels. The levels chosen for this attribute indicate a higher increase in the prices of electricity produced when using more polluting fuels (oil and coal) and a smaller increase for less damaging fuels (gas and hydro).

The second attribute, the share of the cost of the internalization that producers bear is aimed at identifying how much stakeholders feel they should contribute in the internalization of the externalities. A rational respondent should prefer a policy that passes onto consumers the full cost of the instrument. However, it is possible that altruistic behaviours might drive respondents to consider electricity utilities as responsible for the damages to human health and the environment caused by the production of electricity and might therefore like a policy that imposes a higher share of the costs to stakeholders than to consumers.

The third attribute considers the effect on the job market of the policy. This effect is expressed as an increase or a decrease in the number of workers in the electricity market in Europe. The levels we consider for this attribute are: an increase in the number of jobs of 10,000 and a decrease of 10,000 in the whole European Community.[13]

The last attribute describes the effects of the policy on the supply of electricity. After having defined the frequency of a *moderate* event of energy disruption in Europe as a black-out that affects about 100,000 people and lasts for

[13] A variation of 10,000 jobs in the electricity sector is equal to a variation of 0.6% in the number of jobs in the electricity, gas, water sector in the EU-25 measured in second quarter of 2003 (EUROSTAT).

about 2 hours, we considered two levels for this attribute: one moderate black-out every eight years and two moderate black-outs every eight years.

The choice and the selection of the attributes and of their levels were discussed among the researchers that organized the MAXIMA workshop.

B. Questionnaire description

The first two pages of the questionnaire prepare respondents to the choice questions by describing a hypothetical policy and its attributes for the internalization of the external costs of electricity production.

The questionnaire is then divided into three parts. The first part of the questionnaire comprises six choice questions. Each choice question presents respondents with two hypothetical policies (Policy A and Policy B). Each policy is described by the above mentioned four attributes. In each choice exercise, Policy A differs from Policy B in the level of two or more attributes. For each pair, respondents are first asked to choose the policy they find more attractive and then to choose among the two policies and the option of not implementing any policy. Clearly, answering the conjoint choice questions requires trading off the attributes of the alternatives under consideration.

The second part of the questionnaire asks debriefing questions in order to flag those respondents that did not fully understand the choice exercises. Respondents are further asked to rank the importance of the attributes presented in the choice exercises in order to compare the results from the choice exercises.

The last part of the survey instrument asks respondents to state which policy instruments they would prefer to be used for the internalization of the externalities in the electricity market. Finally, the questionnaire ends by asking respondents their main sector of interest and the number of years of experience in the energy market. A copy of the questionnaire is attached in Appendix A.

To stimulate participants to fill in the questionnaire we assured them that we would have shown some preliminary results from the analysis of the data on the second day of the workshop.

C. Results

Unfortunately we were able to interview only ten respondents. The results we present here should be interpreted as a pretest of the survey instrument and will be used to implement a larger survey that will be carried out in the next months.

As expected, our respondents have a long experience in the electricity market. The average respondent has worked for 15 years in the energy market. The sample of respondents is quite balanced among people that are interested in fossil fuels and renewable energies.

When asked on the policy instruments to adopt for the internalization of the external costs of electricity production, each respondent generally suggested more than one instrument. Eight people recommended the use of taxes; five respondents proposed the use of tradable emission permits. Command and control instruments and subsidies given to producers of renewable energy were each chosen by three participants.

All of our respondents found the choice exercises clear and had no problems in filling in the questionnaire. Three persons however, judged the choice questions difficult because it was hard for them to consider a policy for the electricity market based only on the four attributes we considered.

Table 6 reports the results of four specifications of the conditional logit model we used for the analysis of the answers to the conjoint choice questions. Each specification has 120 observations because each respondent answered 6 pairs of 'forced choices' (choose between A and B) and 6 pairs of choices that also entail the 'status quo' (choose between A, B and the do nothing option). The reader should however be careful in drawing robust conclusions from our analysis, given the limited sample size of our experiment. The results shown here should be considered as indicative for further research.

The independent variables used in the four specifications of the conditional logit model are the attributes used in the choice questions. We tried two different specifications for the first attribute of table 5, the increase in price of electricity. A first specification uses three dummy variables to take into account the three levels of the attribute, as described in table 6. COST1 is a dummy variable that takes on a value of one if a respondent was shown a policy that considered an increase in the prices of 3 €cent/kWh for electricity produced from coal and oil, 1 €cent/kWh for electricity produced from gas and 0 €cent/kWh for electricity produced from hydro. COST2 is a dummy variable that takes on a value of one if a respondent was shown a policy that considered an increase in the prices of 5 €cent/kWh for electricity produced from coal and oil, 2 €cent/kWh for electricity produced from gas and 0.1 €cent/kWh for electricity produced from hydro. COST3 is a dummy variable that takes on a value of one if a respondent was shown a policy that considered an increase in the prices of 7 €cent/kWh for electricity produced from coal and oil, 3 €cent/kWh for electricity produced from gas and 0.2 €cent/kWh for electricity produced from hydro.

In a second specification we used two continuous variables, TAXCOAL and TAXGAS, that take into account the increase in the level of prices for oil and coal, and for gas.

We decided to use these two specifications because we wanted to check whether respondents only looked at the price increase of a specific fuel, rather than of all fuels we considered.

Table 6. Conditional logit model

Dependent variable is the probability of selecting a policy for the internalization of the externalities in the production of electricity. 120 observations.								
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
COST1	-0.0176	-0.02			1.2935	2.59		
COST2	-0.2587	-0.35			0.7957	1.50		
COST3	-0.6822	-0.92			0.4969	1.06		
TAXCOAL			0.3758	0.44			1.6820	2.80
TAXGAS			-1.0867	-0.59			-3.7633	-2.83
JOBS	0.0361	2.60	0.0344	2.81	0.0334	2.43	0.0354	2.92
BLACK	-0.3571	-1.42	-0.3472	-1.40	-0.3728	-1.49	-0.3878	-1.58
PROD_COS	2.3767	2.05	2.2937	2.06				
Log likelihood function	-97.8890		-97.9236		-100.0461		-100.0926	

Model (1) shows the specification with the dummy variables for the cost attribute. All the coefficients for the cost attribute are negative, but not significantly different from zero. The coefficient of JOBS[14] is positive and statistically significant at the 1% level, suggesting that, as we could expect, a policy that increases the number of jobs in the electricity market is preferred by our respondents. The coefficient of BLACK, the number of moderate black-outs in the next eight years, is negative but not statistically significant. Finally, the coefficient of PROD_COS, a variable the takes into account of the share of the cost of the internalization that producers bear, is positive and statistically significant at the 5% level, suggesting that our respondents prefer policies that require producers to bear the cost of the internalization. This seems a quite surprising result, because it suggests an altruistic behaviour from electricity stakeholders that recognize their responsibility in the production of externalities and express their willingness to pay for the cost.

Model (2) uses a specification with continuous variables for the cost of the internalization of the externalities. The results do not change from specification (1). It seems that respondents prefer a policy that imposes a higher cost on the most damaging fuels like coal and oil, however the coefficient of TAXCOAL, even if positive, is not statistically different from zero.

D. The internalization of external costs

Models (1) and (2) show that electricity stakeholders consider themselves willing to pay for the externality caused by the production of electricity, a result that contrasts with free riding behavioural assumptions.

One of the possible explanations for this result is that our respondents did not consider the variable that describes the share of the cost of the internalization that producers bear. In fact, as pointed out by Rabl and Friedrich (personal communication), stakeholders may consider that every increase in energy prices will be completely transferred to consumers. If this hypothesis is true, our respondents may have omitted to consider the share of the cost of the internalization that producers bear when they were doing the choice exercises. Therefore, in specifications (3) and (4) we re-ran our models omitting the variable PROD_CONS. The results highlight that the increase in the price of electricity affects the choices of our respondents.

Model (3) shows that respondents prefer a policy with the lowest increase in prices. The sign of the coefficient of COST1 is positive and significant, while they are indifferent between policies with much higher costs, COST2 and COST3, and not implementing any policy. This suggests that our respondents believe that a policy for the internalization of the external costs of electricity should consider a low increase in the level of the prices for electricity and that such a policy should be preferred to not implementing any policy at all. Finally, we can see that the coefficients of JOBS and BLACK do not change considerably from specification (1).

Model (4) shows that both coefficients of TAXCOAL and TAXGAS are now statistically significant, with the first one positive and the second one negative. This result suggests that our respondents appreciate a policy that targets more heavily the production of electricity from most damaging fuels, such as coal and oil, but contrast a policy that would increase the price of gas, a fuel that has less external costs than

[14] The variable JOBS takes on a value of 10 when the choice questions showed a policy that considered an increase of 10,000 jobs, and a value of -10 when the choice questions showed a policy that considered a decrease of 10,000 jobs.

coal or oil. Also for this specification, the sign and the level of significance of JOBS and BLACK do not change considerably from specification (2).

The conclusions we draw from this preliminary analysis are that in the future set of interviews we should omit the attribute that considers the share of the cost of the internalization that producers bear because respondents are unlikely to deem it a credible attribute.

9. Conclusions

In this paper we have reviewed the external costs in the production of electricity. Fifteen years of ExternE research have assessed the external costs to human health and the environment of electricity production. The next step is to internalize these external costs. Several policy instruments exist, from subsidies given to renewable energy producers, to taxes, tradable permits, command and control instruments and voluntary agreements. The choice of the optimal instrument should consider the effects that the instrument would have on the electricity market in terms of efficiency, cost minimization, equity of the policy, effects on the job market, security of energy supply, feasibility of the instrument, technological innovation.

We prepared a questionnaire that employs the conjoint choice methodology to investigate the preferences of electricity stakeholders for a policy for the internalization of the external costs in electricity production.

We found that stakeholders pay attention to both the employment in the electricity market and the security of energy supply. They also prefer a policy that internalizes a low percentage of the total damage caused by external costs from electricity production. However, they do prefer a policy that internalizes some external costs than no policy at all.

The results reported in this paper are very preliminary and should be considered with great caution by the reader. They will be used to refine the survey instrument for a more thorough survey to be carried out among energy stakeholders in the next months.

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Appendix A

MAXIMA Workshop Questionnaire

Welcome to the MAXIMA Workshop in Krakow!

During this Workshop we will present and discuss the external costs of electricity production and the policies for the internalization of such costs.

From the beginning of the 1990s, the ExternE (External Costs of Energy) European Research Network has looked at the determination of the external costs – the monetary valuation of the environmental damages and human health effects – caused by energy production and consumption.

The research conducted case studies throughout Europe using a common methodology and succeeded in comparing damages caused by different fuels and technologies.

On the basis of the external costs calculated to adjust to the relative price of energy, policy actions could therefore be derived to tax the most damaging fuels and technologies (like oil and coal) or encourage those with lower socio-environmental costs (such as wind). Policies might also encourage the emergence of clean technologies and new sectors of activity for research-intensive and high added value enterprises (European Commission, 2003).

Goal of the questionnaire

This questionnaire aims at identifying the preferences of stakeholders, policymakers and other interested persons in relation to the effects of policies for the internalization of the costs of electricity production.

In the next pages you will face six exercises where you will be asked to look at *hypothetical* policies for the internalization of the external costs of electricity production. Each policy is described by four characteristics. Policies differ in the magnitude that some of the characteristics may take on.

For each exercise, you will be asked to choose the policy you prefer on balance.

Please, try to choose the policies as a representative of your organization, and not as a private individual

It will take you about 10 minutes to fill in the questionnaire.

We kindly ask you to fill in this questionnaire **TODAY** and to hand it back to Alberto Longo or to the registration desk.

Tomorrow we would like to present some preliminary results emerging from the analysis of the answers, so please do fill this in today.

PART 1 Hypothetical policies for the internalization of the external costs of electricity

An energy policy for the internalization of the damages to human health and environment may be characterized by the following elements:

1) The **cost** of the policy: the internalization of the external costs of electricity production
The internalization of the external costs could impact on producers to different degrees, according to the fuel used in production and to the target level of internalization. For example, three different policies may be described in the following way:

Policy 1 =>	3 €cent per kWh for coal and oil	1 €cent per kWh for gas	0 €cent per kWh for hydro
Policy 2 =>	5 €cent per kWh for coal and oil	2 €cent per kWh for gas	0.1 €cent per kWh for hydro
Policy 3 =>	7 €cent per kWh for coal and oil	3 €cent per kWh for gas	0.2 €cent per kWh for hydro

The figures in the above table give the additional costs of delivery of electricity per kWh that are the result of environmental regulation policies

2) **Who pays for the cost** of the policy
At the end energy producers and/or consumers will pay the cost of the policy. The policy may be designed to impose higher costs on one group than the other.

3) Effects on **employment** in the electricity industry
The policy might negatively affect employment in industries that produce electricity using the most damaging fuels (like oil and coal) and technologies, but might positively affect employment in industries that produce electricity causing lower socio-environmental cost (such as wind). In sum, the policy might have positive or negative effects on aggregate employment levels.

4) The **security of supply of electricity**
Today the frequency of a *moderate* event of energy disruption in Europe, that is a black-out that affects about 100,000 people and lasts for about 2 hours, occurs on average once every 8 years. One of the consequences of a policy for the internalization of the costs of electricity might be an increase in the frequency of a moderate event of energy disruption, increasing the number of moderate black-outs to 2 every 8 years.

Choice between hypothetical policies

The following 6 tables compare hypothetical policies. For each table, we would like you to choose between two hypothetical policies. Please compare only the two policies presented in each table. **Do not compare policies among different tables.**

Choice 1. Compare Policy A with Policy B

Characteristics	Policy A	Policy B
Cost of the policy: the internalization of the external costs	3 €cent/kWh for coal and oil 1 €cent/kWh for gas 0 €cent/kWh for hydro	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	65%	50%
Share of the cost of the internalization that consumes bear	35%	50%
Change in the employment in the electricity industry in Europe	+ 10,000 jobs	- 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	2 black-outs every 8 years	1 black-out every 8 years

1. Which policy do you find more attractive? ☐ **A** ☐ **B**
2. If you were to choose between A, B and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **A** ☐ **B** ☐ **NO POLICY** (no cost internalization)

Choice 2. Compare Policy C with Policy D. Do not compare the policies in this Choice 2 with the policies in Choice 1

Characteristics	Policy C	Policy D
Cost of the policy: the internalization of the external costs	5 €cent/kWh for coal and oil 2 €cent/kWh for gas 0.1 €cent/kWh for hydro	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	35%	35%
Share of the cost of the internalization that consumers bear	65%	65%
Change in the employment in the electricity industry in Europe	- 10,000 jobs	+ 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	1 black-out every 8 years	1 black-out every 8 years

1. Which policy do you find more attractive? ☐ **C** ☐ **D**
2. If you were to choose between C, D and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **C** ☐ **D** ☐ **NO POLICY** (no cost internalization)

Choice 3. Compare Policy E with Policy F. Do not compare the policies in this Choice 3 with the policies in Choice 1 or 2

Characteristics	Policy E	Policy F
Cost of the policy: the internalization of the external costs	5 €cent/kWh for coal and oil 2 €cent/kWh for gas 0.1 €cent/kWh for hydro	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	50%	50%
Share of the cost of the internalization that consumers bear	50%	50%
Change in the employment in the electricity industry in Europe	- 10,000 jobs	- 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	1 black-out every 8 years	2 black-outs every 8 years

1. Which policy do you find more attractive? ☐ **E** ☐ **F**
2. If you were to choose between E, F and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **E** ☐ **F** ☐ **NO POLICY** (no cost internalization)

Choice 4. Compare Policy G with Policy H. Do not compare the policies in this Choice 4 with the policies in previous Choices

Characteristics	Policy G	Policy H
Cost of the policy: the internalization of the external costs	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro	3 €cent/kWh for coal and oil 1 €cent/kWh for gas 0 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	65%	35%
Share of the cost of the internalization that consumers bear	35%	65%
Change in the employment in the electricity industry in Europe	+ 10,000 jobs	- 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	2 black-outs every 8 years	1 black-out every 8 years

1. Which policy do you find more attractive? ☐ **G** ☐ **H**
2. If you were to choose between G, H and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **G** ☐ **H** ☐ **NO POLICY** (no cost internalization)

Choice 5. Compare Policy I with Policy J. Do not compare the policies in this Choice 5 with the policies in previous Choices

Characteristics	Policy I	Policy J
Cost of the policy: the internalization of the external costs	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro	7 €cent/kWh for coal and oil 3 €cent/kWh for gas 0.2 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	35%	65%
Share of the cost of the internalization that consumers bear	65%	35%
Change in the employment in the electricity industry in Europe	+ 10,000 jobs	- 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	1 black-out every 8 years	2 black-outs every 8 years

1. Which policy do you find more attractive? ☐ **I** ☐ **J**
2. If you were to choose between I, J and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **I** ☐ **J** ☐ **NO POLICY** (no cost internalization)

Choice 6. Compare Policy K with Policy L. Do not compare the policies in this Choice 6 with the policies in previous Choices

Characteristics	Policy K	Policy L
Cost of the policy: the internalization of the external costs	3 €cent/kWh for coal and oil 1 €cent/kWh for gas 0 €cent/kWh for hydro	5 €cent/kWh for coal and oil 2 €cent/kWh for gas 0.1 €cent/kWh for hydro
Share of the cost of the internalization that producers bear	65%	35%
Share of the cost of the internalization that consumers bear	35%	65%
Change in the employment in the electricity industry in Europe	+ 10,000 jobs	+ 10,000 jobs
Frequency of moderate events of energy disruptions in Europe	1 black-out every 8 years	2 black-outs every 8 years

1. Which policy do you find more attractive? ☐ **K** ☐ **L**
2. If you were to choose between K, L and the option of not implementing any policy and therefore not internalizing any external cost, what would you choose? ☐ **K** ☐ **L** ☐ **NO POLICY** (no cost internalization)

PART 2 Choice motivations

1. Do you think the choice questions in the previous pages were clear? ☐ Yes ☐ No

2. Did you find the choice questions in the previous pages difficult to answer?
   ☐ No
   ☐ Yes → What were the main difficulties you found while comparing the hypothetical policies?
   ____
   ____

3. Did you consider all the characteristics of the policies when you were comparing each group of two policies, or have you paid attention only to one characteristic?
   ☐ I considered all the characteristics
   ☐ I only considered one characteristic → Which one?
   - ☐ The cost of the policy
   - ☐ Who pays for the cost internalization
   - ☐ The effects on the employment
   - ☐ The possible increase in energy disruptions

4. On a 1 to 4 ranking, where 1 means the most important element and 4 the least important element, please rank the importance of the following elements for a policy for the internalization of the external costs of electricity production:
   _______ Effects on the **employment** in the electricity industry
   _______ Identify a **fair distribution of the costs** among producers and consumers
   _______ Guaranteeing the **security of supply of electricity**
   _______ Maximize the level of the **costs** that are internalized

5. Can you explain the motivations for your ranking of the characteristics?
   ____
   ____

PART 3 Final Questions

6. Which of the following policy instruments would you prefer to see used for the internalization of the external costs of electricity? Choose one or more instrument.
   ☐ Traditional command and control
   ☐ Tradable emission permits
   ☐ Pollution taxes
   ☐ Subsidies given to producers of renewable energy (Feed in tariffs, Competitive Bidding Design, Green renewable certificates / Renewable Portfolio Standards)
   ☐ Subsidies given to consumers who purchase renewable energy equipment
   ☐ Subsidies given to consumers who purchase renewable energy
   ☐ Other: ____

7. Do you think the ExternE methodology and results should be used in designing policies for environmental regulation of the electricity sector and if so how should they be used?
   ____
   ____

8. Are you working on an ExternE project? ☐ Yes ☐ No

9. Are you a representative of:
   ☐ University ☐ Government / Policy ☐ Electricity utility ☐ Other Industry
   ☐ NGO ☐ Research institute ☐ Consultant ☐ Other, please explain __________

10. Which is your main sector of interest? (tick one or more)
    ☐ Oil ☐ Coal ☐ Gas ☐ Hydro ☐ Wind ☐ Photovoltaic
    ☐ Nuclear ☐ Other, please explain ____

11. How many years of experience do you have in energy markets? ______Years

12. Which Country are you from? ____________________

13. Did you fill in the questionnaire as a representative of your organization or as a private individual?
    ☐ Representative of your organization ☐ Private individual

Thank you for having completed the questionnaire!

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(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

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