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REDUCING CO_2 EMISSIONS AND DEREGULATING THE ELECTRICITY SECTOR IN EUROPE: A CONTRADICTORY DEVELOPMENT?

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ABSTRACT
Electricity generation is the single most important sector in which CO_2 reductions are achievable, with advanced generation technologies available and the existence of a centralised production structure, if compared to the transport or the industrial sector. It is a market undergoing a radical change in Europe, with competition rising as it is enforced by the deregulation of the markets, though to varying degrees on a national level. At the same time it is a sector characterised by efforts to support green energy systems and also by the increasing significance of international trade. It is therefore of interest to examine the impact of the technological and economic changes on the CO_2 emissions due to electricity generation, in order to try to assess the feasibility of the emissions' reduction policies as foreseen by a series of treaties and protocols. The points discussed in this paper focus on the interference of the recent market developments, the policies and economic tools applied in Europe and the state of the art conventional and renewable generation technologies, with respect to their contribution to the aim of reducing emissions.

KEY WORDS: Electricity market, deregulation, CO_2 emissions, environmental and economic policies, generation technologies.

INTRODUCTION
The traditional structures of the national electricity markets established in European countries after World War II are rapidly changing, due to the deregulation of the markets and the increased significance of international trade. This structural process can be monitored in its various stages in Europe, from the United Kingdom, where they were first introduced in the year 1990, to Greece and Ireland, where they began in 2001. Still, if one considers the European market as a whole, it has reached a state of maturity, with an annual production of 2.100 TWh in 1998 and an average annual growth rate of 1,9% for the time period between 1990 and 1998. The national markets of the 15 member states can be classified into three different groups, with respect to the increase rate of electricity consumption: There are eight high-growth countries, with average annual growth rates between 2,5 and 5% (Ireland, Portugal, Greece, Spain, Luxembourg, Belgium, the Netherlands and Finland). Then there are four

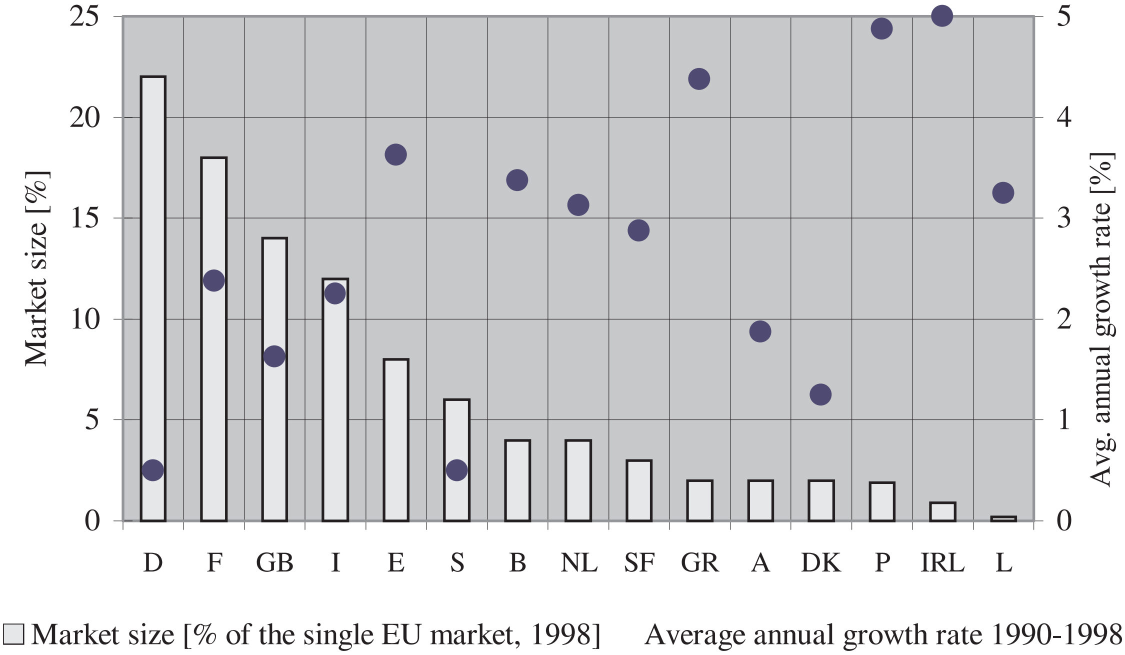

Figure 1. Development of the European electricity markets 1990-1998.

medium-growth countries, with annual rates of 1,5 to 2,5% (France, Italy, Austria, United Kingdom) and finally three low-growth countries with annual growth rates not exceeding 1,5%, namely Denmark, Sweden and Germany. Germany is, hence, the largest but slowest growing market (Eurostat, 1999). The size and growth rate of each country can be seen in Figure 1.

Electricity generation is probably the most important single sector to achieve reductions in CO_2 emissions. In 1997 it constituted almost 26% of the total CO_2 emissions in the European Union, 31% in the OECD countries and 36% in the USA. Coal fired power plants covered 27% of the total power generation in the EU in 1997, compared to 54% in the United States. At the same time they accounted for 73% of the electricity sector's total CO_2 emissions in the EU, the respective figure for the USA being 88%. Within the EU the situation is varying from close to zero emissions in countries where power generation is based on hydro and nuclear power plants, like France and Sweden, to countries where coal is the dominant fuel, responsible for more than half of national emissions, like Denmark and Greece. Coal-fired power generation contributed only 8% to Sweden's total CO_2 emissions, while in Denmark this share was almost 40% and in Greece 52% (IEA, 1999a).

The first obvious impact of the structural changes in the European electricity markets was on the cost of electricity. Between 1990 and 1998, average domestic and industrial retail electricity prices fell by up to 25% in the United Kingdom and 30% in Germany, whilst during the same period, market liberalisation in countries like Hungary and Poland led to a doubling of electricity prices (Eurostat, 1999; Reichel, 1999).

The structural changes had also significant implications for the technologies and fuels used for electricity generation, and thus for the CO_2 emissions arising from the sector. Most of the new capacities built in Europe between 1990 and 1997 were based on natural gas: the capacity of gas fired plants almost tripled in this period. The decline in the use of coal thus led to keeping total emissions in the EU stable between 1990 and 1997. Emissions from power generation fell by 4% during the same period, while emissions from coal based generation alone decreased by more than 12%. The development in the United Kingdom is impressive; the share of coal in electricity generation fell from 65% in 1990 to 35% in 1997, while the share of natural gas increased from 1% to 26%. This helped reducing the total emissions in the United Kingdom by 5% and the power sector emissions by 23%. It is of interest to notice, that during the same period CO_2 emissions in the United States increased by 12%, despite the fact that gas fired generation capacities also increased (IEA, 1999a). It therefore becomes apparent, that developments in the electricity sector are rapid and complex. The following paragraphs discuss an assessment of the current options for emission reductions by using the available state of the art technologies and the policies that can bring these technologies into the market.

ELECTRICITY GENERATION AND CO_2 EMISSIONS IN A DEREGULATED MARKET STILL TO BE UNIFIED

The driving force behind market reforms is cost efficiency and price reductions for consumers or, in cases where prices do not reflect full cost, raising them to fully cover expenses. In non-competitive models miscalculations of future costs can be passed on to electricity consumers, directly through higher prices or indirectly through subsidies, followingly to be recovered by taxes. This has led in the past many utilities to develop more capacities than they would have done in a competitive market, capacities used only at partial load factors. Market deregulation or liberalisation has the effect of increasing risks borne by investors in the electricity supply industry. Utilities have therefore to consider more carefully capital costs versus running and other costs in dimensioning and evaluating the feasibility of new plants. The impact these changes have on carbon emissions will vary from country to country, as it will be discussed in the following sections.

CO_2 emissions and changes in the national markets

The aforementioned reductions in CO_2 emission in the United Kingdom between 1990 and 1997 were clearly led by market reforms, not only in the electricity sector but also in coal and gas supply. Coal subsidies were removed, creating a clear advantage primarily for gas and also for imported coal. These reforms, combined with the increased focus on cost reductions, led to the closure of older coal-fired plants and the introduction of combined cycle gas turbines. However, the opposite effect can be monitored in countries where the electricity systems are largely based on non-fossil fuels, like Norway, Sweden and Switzerland. Competition may well lead to an increased use of gas fired power plants, as they present for the investor the most attractive option, compared to the high initial costs of hydro power plants. The example of the Greek electricity sector, which is based on brown coal and was liberalised in February 2001, can prove very interesting. The state-owned utility (PPC) could take advantage of its access to the own brown coal pits and, given the sharp increase in seasonal electricity demand, place the new market players, who are likely to use gas fired plants, in a hard competition by increasing the annual production with weighted tariff schemes. The difference between the UK and Greece lies in two points: a) The rising energy demand, which cannot allow a short-termed substitution of brown coal by gas, as large capacities would be immediately needed. b) The economics of the brown coal plants are very attractive; they run on a cheap primary energy source and their generation capacities are almost completely amortised, as the average age of the main plants in operation is slightly exceeding 20 years (PPC, 1999). This combination leads to low production costs and provides the PPC with a solid argument to maintain these plants in operation, in order to remain competitive. It is therefore expectable, that new gas fired capacities will run in addition to the existing brown coal plants and not as their replacement. Such a development may be cost-effective and it will improve the average energy mixture, compared to the situation prior to gas introduction. Still, it will not lead to a reduction of emissions in absolute terms and hence make the aims set by the Kyoto protocol very difficult to achieve. If these aims are to be achieved, the brown coal plants will have to be taken out of production, requiring the rapid, large-scale construction of gas fired plants, which will lead to higher capital and, hence, production costs. These will inevitably be mirrored in the retail prices, putting the producer in a disadvantageous position in the competition.

The impact of international electricity trade on emissions

The examples, mentioned above, illustrate how important national and regional circumstances are when it comes to evaluating the effect market reforms can have on emissions. The differences in such circumstances become more important as

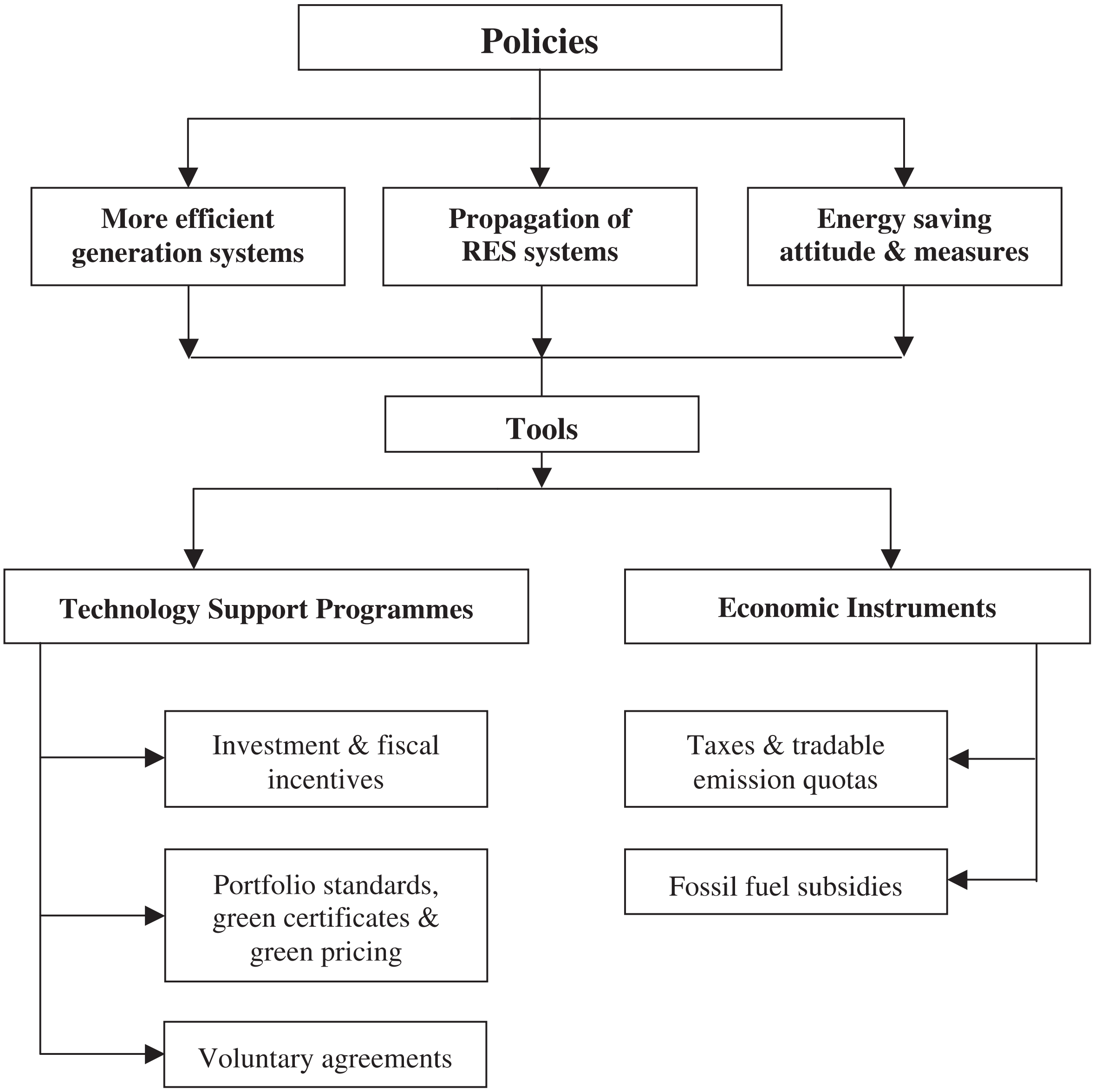

Figure 2. Structure and tools of policies to enhance the efficiency of electricity systems.

national electricity markets open up for international competition. Differences in marginal cost of production between neighbouring countries will have an important impact on the future development of national systems. Many studies pointed out, that the opening of markets across Europe, particularly Eastern Europe, reveal significant excess capacities (Reichel, 1999). In a truly liberalised market the abandonment of the less efficient capacities would be the inevitable consequence. The next step would be that producers in countries with excess capacities and low marginal operational cost will benefit, at least in the short run, while in the longer run, low capital cost and hence risks, will provide a critical advantage. This development may have significant impact on both the security of supply and on CO_2 emissions in many countries, given the fact that neither all the markets in Europe are liberalised, nor the emission policies are the same. The French market is a good example, as it remains fairly regulated, whilst the nuclear capacities enable exports at competitive prices to neighbouring markets, which are liberalised (DTI, 1998). One of the main difficulties of the Kyoto protocol is, hence, that it does not include any provisions on how emissions related to traded electricity should be dealt with.

POLICIES TOWARDS MORE EFFICIENT ELECTRICITY SYSTEMS

In most European countries the liberalisation of the market led to new scenery. In some countries consumers can choose their electricity provider, whilst in others the wholesale electricity market is being opened, to allow for new market players and promote competition. It is reasonable, that decisions on generating capacities no longer incorporate non-economic requirements, unless they are explicitly foreseen by regulations applicable to all potential competitors. It might seem ironic, but the deregulation of the markets makes governmental regulation more necessary than before, in order to overcome the market's natural unwillingness to effectively internalise the external costs of environmental protection. Such regulations should aim at being transparent and incentive-based, rather than attempting to establish a direct control, which is in any case difficult to achieve.

There are three major groups of measures that can be taken to control CO_2 emissions, as they are presented in Figure 2: technology support programmes, economic instruments and enhanced propagation of energy saving attitude. The difference between technology support programmes and economic instruments is methodological: The former refers to actions launched to promote or discourage the use of specific technologies. The latter refers to measures taken to influence the effects of using certain technologies. In that sense, a favourable buy-back rate for wind-generated electricity is a technology support programme, whilst a CO_2 tax generally applicable on diesel is an economic instrument.

Technology support policies

In a competitive market, utilities are not willing to invest in technologies, which increase the electricity production cost. To promote environmental conscious technologies governments can introduce specific measures: R&D financing, investment subsidies, fiscal incentives, subsidised prices and/or guaranteed markets, portfolio standards, green certificate markets, green pricing, voluntary agreements and information programmes. The major aspects of these measures are presented in the following sections.

Investment, revenues and fiscal incentives

Investment subsidies have been and are still used both on a national and on a European Union level, in order to promote both the development and the installation of energy efficient systems as well as renewable energy projects. However, since the mid nineties they are steadily being replaced by revenue incentives, like guaranteed buy-back tariff schemes securing the revenues of private investors. An overview of the regulations governing non-utility power purchases in European countries shows significant differences in the way and the extent to which support is given to the generation of electricity from renewable energy sources.

However, the way European governments deal with this issue is quite different and a uniform trend, a presupposition for a unified deregulated market, is not in sight. Conversely, there are significant contradicting points: In some countries the present regulations will hardly encourage a strong deployment of ‘green' power production (Wirths, 1998). Other countries, in turn, have adapted ambitious plans in order to achieve the European Union's energy aims, as described in the White Paper, doubling the renewable sources' contribution within the next decade. The range of models covers subsidies on feed-in tariffs, which are to be paid exclusively or largely by the electricity utilities, as well as models where the government directly or indirectly pays virtually the entire grant, putting hardly any burden on the utilities. Accordingly, there are enormous differences within the EU regarding feed-in tariffs to be paid to the RES electricity producers. These differences can be seen in Figure 3, which depicts not only the differences between countries, but also within the countries themselves.

Fiscal incentives have been introduced, in forms of environmental taxes, in countries like Germany and the Netherlands (Okosteuer and Ecotax respectively, where the names Okosteuer and Ecotax stand for ecological taxation). The objective of these incentives is to stimulate the use of renewable energy through exempting renewable energy sources and final energy generated from renewable energy sources from taxes. A propor-

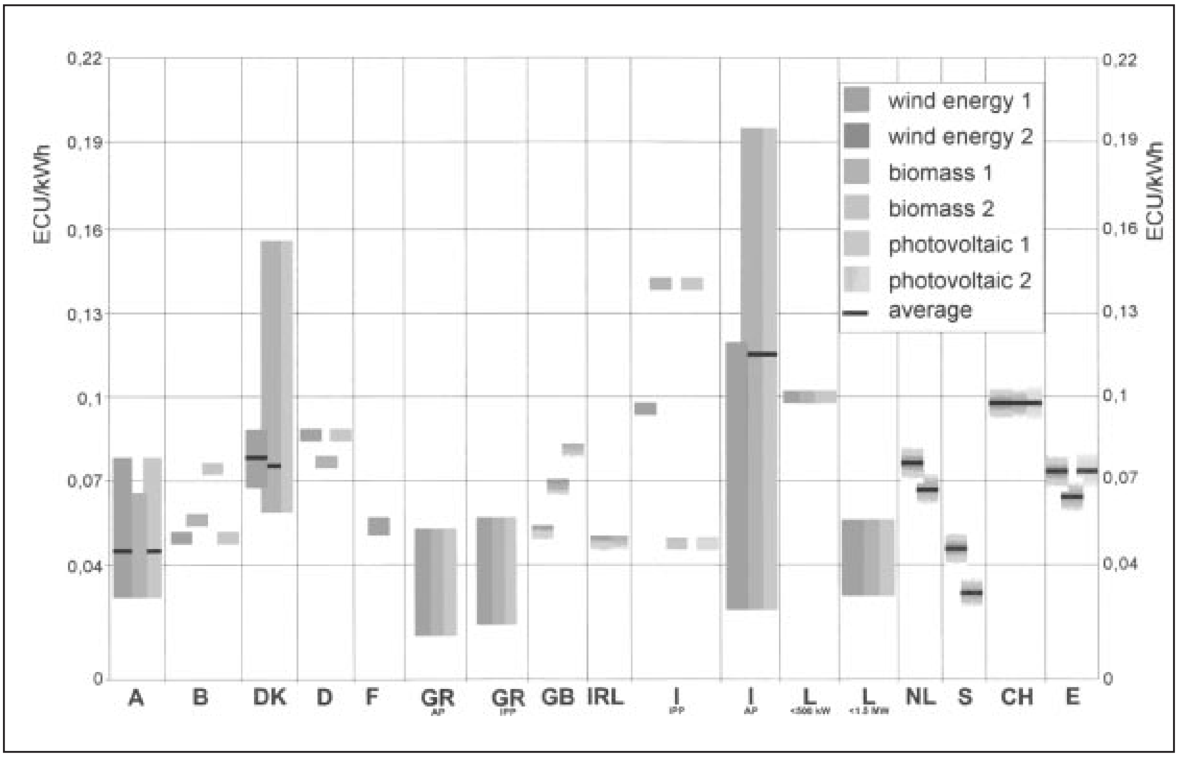

Figure 3. Buy-back rates for RES electricity in Europe. [Cerveny and Resch, 1998]. In GR, I and L, there are different rates for Autonomous Producers (AP) and Independent Power Producers (IPP). The indices 1 and 2 in the legend refer to the investment carries legal form (private carrier, public and local community etc.).

tion of the energy taxes revenues is transferred back as a support to renewable sources.

Portfolio standards, green certificates and green pricing

Renewable portfolio standards are set to require electricity sellers to have a certain percentage of electricity from renewable sources in their portfolio. The best known example of a renewable portfolio standard is the proposal under the US Comprehensive Electricity Competition Plan which requires that 7.5% of retail sales should be based on renewables by 2010 (Terry, 1999). Portfolio standards can be combined with a green certificate market. These certificates are issued to generators based on their amount of produced electricity from renewables. The certificates can be traded and may also be banked for use in later periods and hence provide an extra financial impulse for developing renewable energy sources. Similar schemes are considered in the Netherlands and Denmark. Green pricing is another instrument, which aims at creating a separate market for electricity from renewable sources. In this case producers offer, often at a premium price, green electricity to consumers and businesses that are willing to pay for it. In the United Kingdom there are now 13 companies offering green tariffs (Unander, 2000; Correlje, 2000).

Voluntary Agreements

Voluntary agreements between governments and utilities may be important for the process of consensus building, fostering an understanding of the climate issue and of possible responses. An example is the limitation on investment in new coal-fired power plants in Denmark. Such agreements may include target setting for the share of renewables or combined heat and power plans, or even a target for reducing CO_2 emissions to a certain level.

Economic instruments

The most important economic instrument involve setting taxes on emissions, introducing tradable emission quotas and removing the subsidies granted to fossil fuels.

Taxes and tradable emission quotas

The aim of these instruments is to internalise the cost factors of the targeted environmental externality, by making the emitters accountable for the occurring cost. In the case of a taxation system, a single tax rate is applied to all emissions of a certain pollutant by all sources in the system. In the case of a tradable emission quota system, each source is allocated an emission objective or quota. Any source that emits less than its quota can sell its extra emission 'right' to another source that needs it to cover its own above-quota emissions. With enough participants in the system, a market for tradable quotas emerges: each source can choose to reduce emissions, buy emission permits from others, or reduce emission beyond their objective and sell the unused emission permits. Both types of instruments assure that all emission sources face the same cost for the emission of the targeted pollutant. All sources have therefore a similar incentive to reduce emissions up to the point where the marginal cost of reduction is equal to the marginal gain expected from such a reduction. The effect of such a mechanism is that pollution is reduced at minimum cost. In spite of the efficiency of taxes and tradable permits, at least in theory, they have found little resonance in the electricity sector. Although some countries in Europe (e.g. Denmark, Finland, the Netherlands, Norway and Sweden) have introduced carbon taxes aiming to cut CO_2 emissions from a wide range of activities, few of these have chosen to tax CO_2 emissions from fossil fuel use in electricity generation due to concerns of competition distortions. No country has applied a single tax rate across all other emission sources. A number of countries have shown considerable interest in domestic greenhouse gas trading systems as a response to their Kyoto emission objectives. Denmark introduced in the year 1999 a tradable CO_2 quota system in the power sector and the United Kingdom is considering a pilot domestic trading system (IEA, 2000).

Fossil fuel subsidies

A true market-oriented measure for large reductions in CO_2 emissions is the removal of subsidies in fossil fuel sources, since the interaction between production cost and prices is direct. Grants and other forms of budgetary and price support for coal production, especially when these are combined with support for electricity industry investments, are clearly the types of subsidies that have the most negative impact on CO_2 emissions. A typical example is Germany after its unification, when the inefficiency of the old brown coal plants in former Eastern Germany led to their closure. Still, Germany retains subsidies for its remaining hard coal mines. On the whole, most EU countries have already removed subsidies, power generators pay international prices and the potential for CO_2 reductions is, in that sense, by and large already used up.

TECHNOLOGICAL OPRTIONS FOR REDUCTIONS OF CO_2 EMISSIONS

There are two groups of technology options to reduce CO_2 emissions from power production:

* Shifting fuel mix towards fuels with lower CO_2 emissions per kWh
* Improvement of generation efficiency

Both options are constrained by factors that influence technological developments, like efficiency of the technology, cost and the rate of renewal of power plants. A schematic description of the problem is depicted in Figure 4.

The balance of capital costs and fuel costs determines generation efficiency: efficiency increases as fuel cost increases, and efficiency increases as capital cost decreases. Hence policy approaches could work along both these axes: economic instruments to increase fuel costs or costs of emitting CO_2; technology support programmes to reduce the capital cost of more efficient technologies. Competition in the electricity supply contributes to both aims, as minimising fuel cost and other operating costs through efficiency improvements is essential in a competitive environment. Competition, furthermore, promotes a search for new technologies in order to gain a cost advantage. In the following sections are presented the key groups of technologies, which can play a role in reducing emissions.

Nuclear power

Nuclear power is attractive from a CO_2 emissions perspective, as it is virtually carbon-free. However, the prospects of nuclear power in a competitive environment are uncertain, as a num-

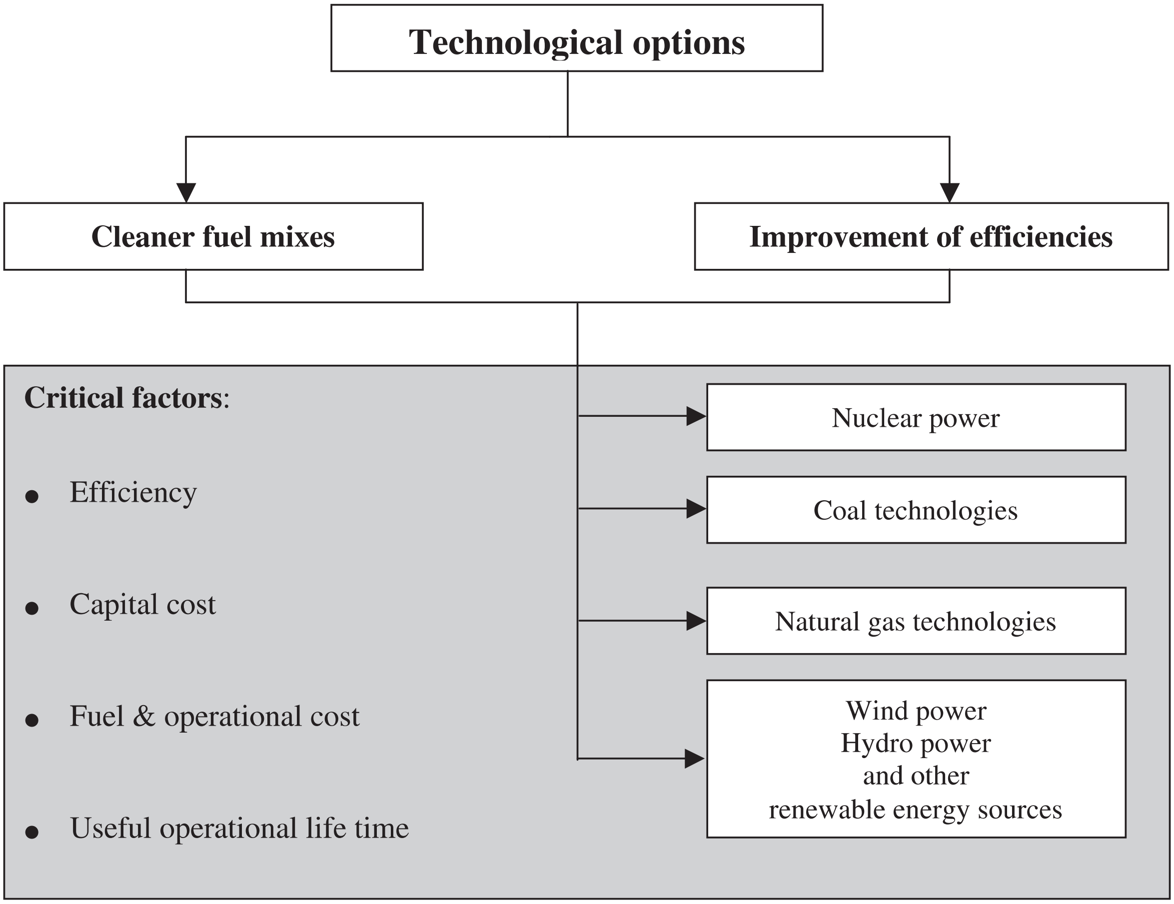

Figure 4. Technological options and factors for reducing CO_2 emissions.

ber of economic and public support obstacles arise. Key problems are the long lead times and high capital costs for construction and decommissioning of plants, the disposal of radioactive wastes and public opposition. While low operating and fuel costs can make nuclear attractive in countries with less liberalised markets, its costly capital structure, long lead times, inflexibility in operation and uncertain back-end costs are unattractive to investors operating in a competitive market. If there is not a monopoly or quasi monopoly system, like the French market dominated by the Electricité de France (EDF), the investment risk increases, requiring correspondingly higher rates of returns to make the investment attractive. This can only be achieved by raising the retail price of electricity. The agreement reached between the German federal government and the power corporations in the year 2000, for phasing the nuclear plants out of operation progressively within the next 20 years, indicates that future nuclear development is determined by a combination of economic and environmental-political reasons.

Coal technologies

Coal-based generation has by far the highest carbon emissions, whilst it also has high environmental control costs for SO_2, NO_x, particulates and solid wastes. In addition, coal technologies present the same economic problems as nuclear power, namely long lead times and high capital costs. Hence, coal-fired generation is becoming very unattractive in a competitive market, which also places value on environmental aims. On the other hand, liberalising coal markets can be expected to lead to lower fuel costs for generators, by enabling the use of cheaper imported coal. This can be achieved by expansion in low-cost production areas, investment in modem mining technology, improvements in transport and transfer infrastructure and squeezing of margins throughout the chain. A lot of high quality, low-cost coal can therefore be expected in the world markets. The development of coal-firing technologies (e.g., integrated coal gasification combined cycle (IGCC), atmospheric fluidised bed combustion, pressurised fluidised bed combustion) and construction of conventional coal-fired plants by independent generators around the world demonstrates that coal remains still an attractive technology, though it is currently not favoured in Europe.

Natural gas technologies

Natural gas is being considered as the most attractive generating fuel choice over the last decade, for a series of reasons. Major technological advances have increased efficiencies to more than 50% in gas turbines and to almost 60% in combined-cycle gas turbines (CCGT). These efficiency improvements combined with the low carbon content of gas, relative to coal, result in the CCGT turbines' ability to produce electricity with less than half of the carbon emissions of coal-fired plants. Uncertainty of future environmental control requirements such as for the greenhouse gases consequently makes gas-based technologies low risk investments, compared to other fossil fuel fired plants. CCGT plants are modular, fairly fast to build and install and can therefore be scheduled to meet demand growth, resulting in a very flexible investment budgeting. Moreover, their relatively small space requirements help address the problem of siting power facilities, whilst their environmental friendliness leaves little space for local objections. Finally gas-fired plants have relatively low capital costs, making them very attractive in competitive market niches, as risks on invested capital have become an important issue when deciding on which type of new capacity to build.

The developments in international gas markets provide further reasons for the increased attractiveness of natural gas fired plants. Norway and Russia, the two major suppliers of Europe, are considered to be reliable partners, with gas supplies sufficient to cover the demand over many decades. Within the EU the liberalisation of national gas markets has, so far, reduced the cost of gas for end-users. Given the current price and availability of natural gas and the relative efficiency of gas technology, it is understandable that these units are considered to be competitive for base-load generation.

However, CCGT technologies are sensitive to changes in prices. According to an IEA study, fuel costs account for 60% to 75% of total generation cost compared to 0% in renewable energy systems and up to 40% in nuclear and coal fired systems (IEA, 1999c). Hence, a respective increase in fuel price would potentially have a more serious impact on the economics of a CCGT plant, than for other technologies. One could also expect, that the rapid increase in the use of CCGTs, combined with the propagation of gas in the domestic and tertiary sector, could also lead to higher prices for natural gas, and in some countries, to concerns over energy security and diversification as gas consumption grows substantially.

Decentralised power generation may increase in deregulated markets, as it is better suited to respond to site-specific load peaks whilst it can also better utilise energy sources available locally, e.g. biomass. Especially combined heat and power plants (CHP) can be expected to have a large potential for decentralised power generation. These plants can provide a secure and highly efficient method of generating electricity and heat for local use. Such a method can significantly reduce final energy use and therefore emissions. In current installations savings can be of the magnitude of 30% compared to coal plants and 10% compared to CCGT. For new installations, total efficiencies of about 70% are common, and 80% or more are achievable. However, they do require a respectable heat demand and are thus most relevant for industrial applications, or in urban areas where district heating networks are in use.

Wind power, hydro power and other renewable energy sources

The use of wind power has developed faster than any other renewable-based power sources in the last twenty years. From less than 20 MW in 1979, the total installed capacity of wind electricity systems grew to 1.750 MW by 1989, and has since grown to more than 5.000 MW in IEA countries in 1999. The European country with the largest wind contribution to its energy balance is Denmark, whilst the highest growth rate has been monitored in Germany. This development is based on the fact that wind generators have become a cost effective, mature technology, achieving high reliability and availability values over the years. Although wind power is intermittent, with annual load factors of typically 30 to 35%, up to at least 20% of the total capacity on a large-scale regional grid could be based on wind power, without jeopardising the system's stability and reliability (Hau, 1996). The latter figure is indicative, as it can vary according to a series of factors, like the amount and type of spinning reserve of the conventional generation, the load shedding policies, the distribution of generation etc. Considering the cost development of wind generators one can notice a significant price decline. The ex-factory average cost of a typical 300 kW generator dropped from 2.680 Euro/kW in 1981 to 715 Euro/kW in 1998. The additional cost factors (transport, installation, connection to grid) are summing up to approximately one third of the initial cost of the generator's ex-factory price, with respect to site-specific features. At the same time wind generators have grown bigger, with typical capacities increasing from 100 to 300 kW and 500 kW in the beginning and the middle of the nineties and reaching up to 1.500 kW and even more in the last years. It is characteristic, that, in Germany, the average installed capacity per generator increased from 140 kW in 1991 to over 400 kW in 1998 (Kaltschmitt *et al.*, 1998). As far as the environmental impact of wind generators is concerned, it is limited to rather small visual and noise problems. Wind technology is a good example of how the technology support policies, as mentioned in the relevant section, were effectively used to accelerate the propagation of wind energy in most European countries.

Hydropower is probably the most established renewable energy source, being the oldest and, from an investment's point of view, a traditional field for long term investors. However, this feature is becoming critical within the competitive market emerging: Large-scale plants mean for the investor high construction costs and long lead times, resulting in high production costs if the plants are not used for base load demand, a situation likely to occur in a demand and price driven market. While hydropower has a very low CO_2 impact, resulting from the initial civil engineering works, it raises other environmental concerns; like the impact of the dams to the biosphere. Still, most suitable locations in Europe are already being exploited, presenting a small potential for further expansion. Small-scale plants, with capacities of less than 10 MW, reduce the financial exposure and have shorter lead times, whilst there is still significant exploitable potential. They therefore present an interesting opportunity for investors. Furthermore, their decentralised concept enables their proximity to regional demand, ensuring sales and a stability of the grid. On the other hand operational factors, such as limited hydraulic potential in dry years and a frequently occurring conflict of interests with agricultural users, may increase investment risks (Papadopoulos *et al.*, 1996). The trend is therefore, that the utilisation of hydropower over the next years in Europe is expected to focus on small-scale plants to cover local demands, in the energy, irrigation and watering sectors.

Other renewable sources are not expected to make a progress similar to the one of wind and hydropower, and are therefore not expected to make a major contribution to electricity supply systems in the foreseeable future (Capros *et al.*, 1998). For some systems like the photovoltaics production costs remain relatively high and the energy yield small. Other sources and systems such as biomass, geothermal and high temperature solar systems have a better perspective if combined with natural gas fired systems. Such applications have been successful, technically and financially, and can supply power usually combined with heat consistently at high capacity factors, but on a rather limited, local scale, rarely exceeding 5 to 10 MW. From an environmental perspective, these renewables have varying impacts. For example, combustion of landfill gas is considered environmentally beneficial since it converts methane to CO_2, which has a weaker greenhouse effect. Solar technologies have relatively few CO_2 emissions, but the production of photovoltaics has two important pollutants as by-products, cadmium and arsenic, whilst their energy analysis remains questionable, as the electricity generated during their useful lifetime does not always offset the one consumed for their production (Kaltschmitt, 1997). The biggest barrier for investing in these renewables is that their capital cost is in most cases not yet competitive with other systems. In addition, renewable technologies tend to be capital intensive investments, though they offer low running costs, which makes them rather unattractive to the power producer, particularly in periods when oil, gas and conventionally generated electricity prices are low and stable. However, increased production will on the long run make renewables more competitive, due to economies of scale. Furthermore, as renewable energy systems are small in absolute terms, the initial investment required makes them suitable for small and medium investors, whilst, depending on the technology, they can be sited closer to load centres, enhancing regional development in remote areas. As a whole, the most important expectations of renewable energy sources contributing to electricity production are focused on wind energy. The impact of other RES technologies is either of local scale and limited size, like in the case of geothermal energy, small hydro plants and biomass, or depending on support policies for research, development and installation, like in the case of photovoltaics.

CONCLUSIONS

It is difficult to predict the exact effects of deregulation of the electricity markets on CO_2 emissions in Europe, as most effects are country-specific. It can lead to higher efficiencies, as it promotes generation at lower prices, but this is not always favourable in terms of emissions. For example, in cases like Greece, introducing high efficiency gas fired plants in a so far brown coal based system may reduce emissions, though at a higher cost for the end user. On the other hand, expanding the capacities through gas-fired plants in a hydro- or nuclear-based power system, in order to minimize capital costs, will increase emissions. The opening up of markets across national borders makes the issue even more complex. Market deregulation contributes to increased electricity trade as a means of improving the economic efficiency when meeting rising demand. But increased trade also results in higher emissions for exporters of fossil-based electricity. In many cases there may be a conflict between an open, deregulated market and the national commitments for the reduction of greenhouse gases. If electricity trade is combined with international trading of emissions permits, however, trading of electricity can provide greater flexibility for the power sector to contribute to overall emission reductions and hence reduce the cost of meeting greenhouse gases targets.

It thus becomes evident, that market reforms set new challenges to the regulatory system of complying with environmental targets valid until now. A large number of investors, producers and brokers become active in an expanding, more competitive market, utilising new technologies and a more competitive primary resources potential. When addressing externalities like CO_2 emissions on a European level, one has the difficult task of respecting national political and macroeconomic constrains, not distorting the competition, suppressing inefficiencies and also sensing the limits of public acceptance for certain measures. The success story of wind power utilisation, is a good example for such a balance act, but wind energy still accounts for no more than 0,4% of the European energy demand. It also enhances the argument that it remains doubtful if climate change policies can be effective when solely based on economic instruments and technological advances. In that sense, the deregulation of the European electricity markets can lead to reduction in CO_2 emissions, provided the necessary emission reduction policies are implemented. Such policies will have to take into account the points mentioned in this paper, and probably some more. In cases like Greece, they will also lead to higher prices for consumers, compared to the level of prices known so far, making therefore a broader social consensus a presupposition. It may sound contradictory, but the deregulation of the European electricity market can lead to reductions in CO_2 emissions, provided the latter will be regulated.

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