Abstract – The paper describes possibilities and problems for penetration of renewable energy sources in liberalised markets. The analysis is based on recent development in EU with different models for supporting renewables. These include feed-in models with guaranteed minimum tariffs, tender models for different bands of technologies, and green certificate models with obligatory consumer quota. The paper describes the market situation in selected European countries, including Germany, the UK, Holland, Denmark, Austria and Greece. A critical evaluation is given of the different models with proposals for a balanced development between environmental and trading concerns. It is argued that too much emphasis is presently given to the side of free trade at the expense of long range planning for a sustainable energy development.

1. INTRODUCTION

The concept of “sustainable development” got world-wide attention after the publication of the so-called Brundtland Report (World Commission on Environment and Development 1987). The concept was formally introduced in international politics in the Framework Convention on Climate Change signed by 155 nations at the UN Conference in Rio de Janeiro in 1992. It was realised that the energy sector and its contribution to the greenhouse effect should play a major role in the policy for a sustainable environmental development.

The Climate Convention has been followed up by a number of conferences of parties charged with the purpose of finding operational procedures for stabilising the global climate. In Kyoto in December 1997 agreements were reached on targets for greenhouse gas reductions for industrial nations and regions. The reductions are relative to emissions in 1990 and refer to a basket of six greenhouse gases dominated by CO₂. The targets are 8 % for the EU, 7 % for the U.S., 6% for Japan and 5.2 % in average for the industrial world; the targets should be reached by 2012. The EU members have agreed how to distribute the targets between them. Denmark and Germany are to cut their emissions by 21 % while at the other end of the scale Greece can increase emissions by 27 % and Portugal by 25 %.

The Kyoto conference may be considered a moderate break-through for the international efforts of stabilising the global climate, but many barriers remain. One of them being that neither the US nor the EU has ratified the agreement. With the dominant political attitude in the US, the ratification in this country will remain uncertain for some time. In the EU the agreement has to be ratified both by the national parliaments and by EU as a “bubble”. It is expected that this complex procedure may also postpone the final ratification by the EU Member States.

It is interesting to note that although there has been a general scepticism in many industrial sectors in relation to the consequences of the greenhouse effect and the concern of global climate changes, then these problems are taken seriously by at least one commercial sector, namely the insurance companies. The actual insurance pay-outs due to natural disasters (accumulated per decade) has increased steadily from less than four billion US dollars in the 1960’ies to more than 70 billion dollars in the 1990’ies (Streiff 2000).

The main solutions for reaching the targets set by the Kyoto Protocol are energy conservation and the use of renewable energy sources. In this paper the focus will be on the potential and implementation of renewable sources in the production of electricity. This is not meant to imply that the potential of energy conservation is less important. On the contrary, energy conservation is more cost-effective in the short run, and the two solutions should be seen as complementary to each other.

It should be added, that renewables have another role in energy policy besides contributing to reduction of CO₂ emissions. Fossil fuels, especially oil and natural gas, will be exhausted before the end of this century at the present rate of consumption. At the same time, the world population is approaching 10 billion people who all will need energy supply. The known alternatives are renewables and nuclear energy. There are many reasons why nuclear energy is not considered a desirable energy solution. This leaves renewables as the only sustainable energy supply in the longer perspective.

A recent policy question in the climate negotiations has been the extent of the so-called flexible mechanisms, including trading of CO₂ quota and joint implementation projects. These mechanisms are promoted especially by the US while some European countries have warned that due to uncertainties of determining correct baselines, the mechanisms may be
exploited in ways which are counterproductive to the goal of reducing global greenhouse gas emissions. In order to obtain more practical experience with joint implementation, an EU project was accepted by the Commission in 1999 concerning joint implementation projects between industries in east and west Europe (JOINT 1999).

At present wind power and biomass are the most important “new” renewable sources of energy in electricity generation. Others include solar power, wave power and small-scale hydropower. Large hydroelectric installations are based on a mature and fully competitive technology, but their additional potential in Europe is limited for environmental reasons. Electricity production based on incineration of industrial and household waste and gas from refuse dumps is not usually considered to be a clean technology. Geothermal energy is environmentally friendly but not strictly speaking a renewable energy source.

Due to relatively high costs of production, wind power and other renewable sources of energy cannot compete in a free commercial market with mature technologies such as large hydro, combined cycle plants based on natural gas, efficient coal-fired combined heat and power plants or nuclear power plants. One should not overlook, however, that several of these technologies receive direct or indirect subsidies. In addition, externalities from fossil fuels and nuclear power are not fully included in the market price. Renewables are therefore not competing on a level playing field at present.

In EU there is a growing awareness that the use of renewable energy sources should be increased while keeping the growth of energy consumption at a low level or even aiming at demand reductions. In a recent White Paper of the EU Commission it was suggested that by the year 2010 the share of primary energy produced from renewables should be increased from the present level of 6 % to 12 % (EU Commission 1997). This indicative target has been confirmed by the EU Council in 1998 (Council Resolution 1998). The 12% target corresponds to about 22% coverage of electricity consumption by renewables.

So far no agreement on how this goal would be shared by the Member States has been negotiated within the EU. Individual countries have, however, published goals for increasing the use of renewable energy sources. In addition, the EU Commission has published an indicative distribution in connection with a recent draft directive for the promotion of electricity from renewables (EU Commission 2000).

In 1990 Denmark became the first EU country to make official commitments on targets for CO₂ reduction and the use of renewables (Danish Energy Ministry 1990). The present Danish target for renewables is that their use should reach 12 – 14 % of primary energy production by 2005 and 35 % by 2030 (Danish Ministry of Environment and Energy 1996). The realisation of these targets is an ambitious technical, organisational and political project which will involve radical changes in societal infrastructure.

Liberalisation of electricity markets in Europe was initiated by the UK (1989) and Norway (1991), followed by Sweden (1994) and Finland (1996). Agreement on the Directive specifying the rules for electricity liberalisation in the EU was reached in December 1996 by the Council of Ministers (European Communities 1997). The goal of the Directive is to achieve higher efficiency and lower consumer prices by introducing conditions of intensified commercial competition.

It may be noted that some EU Member States did not fully comply with the directive when it came into force on February 19, 1999, with France as an extreme example. Countries such as Denmark, Sweden, the UK, Germany and Holland have opened their national markets by more than required in the directive. However, for international trade of electricity a number of barriers such as special transmission duties remain (Skytte 1999 and Olsen 1998).

The directive does not give a high priority to energy conservation and renewable energy sources. On the contrary, there is an apparent conflict between the commercial goal of profit maximisation that is often based on a time horizon of five to ten years and the need for long-term energy conservation and implementation of supply systems based on renewable sources. As a compromise the directive gives national governments the option of introducing “public service obligations” (PSO’s) based on considerations of supply security, energy quality, price and environmental protection (article 3-2 in the Directive).

The following sections will describe and evaluate a number of different schemes that have been used in EU countries in order to promote renewables.

2. PROMOTING ELECTRICITY FROM RENEWABLE SOURCES

The EU Commission has been working for some time in order to formulate a directive on the trade of electricity produced from renewable sources. In April 1999 the Commission published Working Papers on the topic (EU Commission 1999a and 1999b). These papers evaluated existing subsidy schemes and systems for promoting the use of electricity from renewables in liberalised markets. In May 1999 the EU Council of Ministers requested the Commission to prepare a draft directive based on responses from the Member States. The Commission did not succeed in reaching internal agreement on a new draft directive before the Council...
In December 1999, the Council was only given a general orientation concerning different schemes for green markets. The main focus was on systems of green certificates trading. In early May of 2000, the EU Commission has finally published a draft directive on the promotion of electricity from renewables (EU Commission 2000). This draft proposes a five year period for further gathering of experience with the present national schemes for promotion of renewables. The draft directive also includes indicative figures for the percentages and amounts of electricity from renewables (RES-E) fulfilling the 22% target by 2010. These numbers (including large hydro) are indicated in Table 1.

<table>
<thead>
<tr>
<th>RES-E %</th>
<th>RES-E TWh</th>
</tr>
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<tbody>
<tr>
<td>Austria</td>
<td>78.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>6.0</td>
</tr>
<tr>
<td>Denmark</td>
<td>29.0</td>
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<tr>
<td>Finland</td>
<td>35.0</td>
</tr>
<tr>
<td>France</td>
<td>21.0</td>
</tr>
<tr>
<td>Germany</td>
<td>12.5</td>
</tr>
<tr>
<td>Greece</td>
<td>20.1</td>
</tr>
<tr>
<td>Ireland</td>
<td>13.2</td>
</tr>
<tr>
<td>Italy</td>
<td>25.0</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>5.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>12.0</td>
</tr>
<tr>
<td>Portugal</td>
<td>45.6</td>
</tr>
<tr>
<td>Spain</td>
<td>29.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>60.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10.0</td>
</tr>
<tr>
<td>EU total</td>
<td>22.1%</td>
</tr>
</tbody>
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Table 1. Indicative figures for EU Member State targets of RES-E in relation to gross electricity consumption by year 2010 (including large hydro).

In parallel to this work, DG IV in the Commission is drafting a directive that limits the state subsidies which are allowed for promoting renewables. There is a fundamental conflict between the goal of creating a sustainable energy development and the restrictions of state subsidies in their widest concept as desired by DG IV. This is part of the explanation why the EU Commission has had difficulties in reaching consensus on these questions. At the time of writing (May 2000), the EU Commissions seems to have postponed its decision on state subsidies for renewables by at least six months. It should be noticed that State Aid is a Single Market issue, so that the Commission has the final decision.

The main features of different promotional schemes are discussed in the following.

2.1 Feed-in systems

In a feed-in system a long-term minimum price is guaranteed for electricity obtained from renewable sources. In combination with standardised costs for grid connections and short lead times, this pricing system has made it possible for developers to obtain easily bank financing for investments in wind power stations.

In promoting wind power the feed-in system has been used with some variations in Denmark, Germany and Spain and has proved superior to other methods that have been tried in the EU. In the Spring of 2000, the installed wind power capacity is about 1800 MW in Denmark, 4600 MW in Germany and 1200 MW in Spain. The wind power capacities of these countries comprises around 80 % of the EU total. Countries which have used other approaches, including the UK - which has the best wind potential in Europe - have installed wind power capacities that are much lower. It may thus be concluded that the feed-in model has been superior to other applied models in Europe in promoting wind power.

The feed-in tariffs have typically varied between 7.7 and 9.3 Eurocents per kWh. One (political) problem with the system is that a fixed price level does not conform to traditional market principles. The Danish government has already taken notice of this and is preparing to replace the feed-in regime by a certificate system as described in a later section.

Another criticism against the feed-in model has been that the favourable tariffs have not been reduced in step with technological development. Windfall profits have been obtained by operators of the most modern wind turbines located at favourable sites. However, such problems could be overcome in several ways without abandoning the main elements of the feed-in model. The Danish Council for Sustainable Energy has proposed that tariffs should be linked to the level at which each individual turbine generates electricity. The tariff could be reduced after a designed production (and profitability) level has been reached.

An alternative solution would be to adjust the tariff for new installations at regular intervals taking into account the best technology on the market (benchmarking principle). This would also introduce an element of competition into the system.

As the market share of wind power increases, the burden of the feed-in system on government finances can become politically unacceptable. This can be avoided by financing the system from charges levied on electricity consumers.

It is also possible to design a feed-in system in a way that gives producers relying on renewable energy sources a fixed premium on top of the market price of conventional electricity. The fixed premium per kWh of electricity can be financed by means of a tax on all electricity consumption. Such a scheme has been used in Spain. The...
result is a flexible system that may include elements of market competition between traditional electricity and that based on renewables, if utilities are not obliged to accept all electricity that is produced from renewable sources. The model may also introduce competition between renewable electricity technologies at different development stages if premiums reflect differences in production costs. However, in order to make this a dynamic process, premium tariffs should be adjusted at frequent intervals to take technological development into account.

2.2 Tender system

Another approach to promote electricity from renewable sources is the tender system developed in the UK. In this system calls for tenders in relation to energy supply from renewables are made at intermittent intervals. Each renewable technology is given a quota, and the provider of the lowest asking price is given the contract. The British Non-Fossil Fuel Obligation (NFFO) dates from the early 1990s and so far there has been a succession of five competitive tenders.

Although the scheme has resulted in reduced prices, the quantitative results have not been impressive. Less than one third of the winning bids for wind power have been realised, and the installed capacity has not reached 400 MW. This seems to be mainly due to local opposition against wind farms in scenic areas combined with bureaucratic planning procedures. Local ownership of wind farms and improved planning principles could reduce these problems.

The intermittent nature of the NFFO procedure is not consistent with continued and predictable sales of energy production equipment. In addition, there is uncertainty about possible shifts in political support for renewable energy sources. These problems could be counteracted by guaranteed long-term calls for tenders. With the latest development in the UK, the tender system will be abandoned as described in a later section.

2.3 Green certificate markets

The aim of green certificate markets is to introduce conditions of market competition into the production of green electricity for technologies that are not fully competitive. So far there is no complete agreement in the EU concerning the definition of renewables technologies to be included in a special green market. According to the recent EU Commission draft directive (EU Commission 2000), the green market will include RES-E from wind, solar, geothermal, waves, tidal, small hydro (less than 10 MW) and biomass (including untreated wood waste and cork waste). Large hydro will, however, be included in the national accounting of RES-E, but the green certificates must distinguish between small and large hydro.

A green certificate market has operated in Holland since the beginning of 1998 and is supported by a voluntary consumer quota of green electricity. Electricity producers using renewable sources receive a total payment consisting of the market price of conventional electricity supplemented by the market price of the green certificate. A number of Dutch distribution companies have entered into a voluntary agreement to fulfil a green electricity quota for the year 2000. After that the parliament will decide whether or not to introduce an obligatory consumer quota. So far the system has not been able to accelerate the penetration of wind power in Holland to any noticeable extend. Nonetheless an adjusted version of the Dutch model has been adopted by the Danish government in its new electricity act as discussed in a later section. Italy is planning to initiate a certificate market by 2001 and the same is the case for the Flemish government in Belgium.

One of the problems of green certificate markets concerns the fairness of competition between renewable technologies at different stages of development. If an open market with free competition between different renewable technologies were created today, wind power would probably sweep most of the market. Solar electricity would not have a chance, while biomass and small hydro might be competitive in special cases. Such a market situation could not be considered optimal for the long-term promotion of the total renewable potential. One possible solution is to reserve the green market for the most mature renewable technologies and to promote other desired technologies through a quota tender model.

In a green certificate market where an obligatory consumer quota is applied, the price of green certificates can be expected to fluctuate wildly. When there is a shortage of electricity based on renewables, the price of green certificates will be very high. The price will fall to a very low value when there is a surplus. The uncertainty about the price increases the risks of investors and reduces investments in renewable technologies. The same problem in connection with swings in market prices has been encountered with the market rules used in California (Ford 1999).

In the new Danish system, minimum and maximum prices are defined for green certificates. It can be expected that the market price will land either at the minimum or maximum value, so that investors will still face an uncertain situation. The problem can be alleviated by long-term electricity supply contracts. Another approach is to take advantage of banking and futures mechanisms. Other unsolved problems are related to yearly climate fluctuations and the concern of consumers who wish to buy more green electricity than required by the specified quota (“green pricing”). One solution for the first problem would be to make the quota more
flexible, e.g. by allowing three months from the next year to be included in the accounting for the previous year. This could also contribute to reduction of fluctuations in the price of green certificates.

Green pricing may be included in the general green certificate model with obligatory consumer quota if the supplementary green electricity is documented by special certificates that are not counting in fulfilment of the quota. Otherwise, consumers who are not taking part in the green pricing scheme would be released of part of their obligation at the expense of the “idealistic” green pricing consumers. This “free rider” opportunity might severely reduce the wave of idealism.

2.4 International trade of green certificates

There is an increasing interest in setting up international markets for green certificates. They could help to stabilise certificate prices, while national markets are likely to remain too small for the creation of price stability. A precondition for an international market is that national rules are harmonised to such an extent that unfair competition is avoided. Complicated negotiations have to be carried out before a fair international market can be established. Some recent EU projects are analysing these problems (RECerT 2000).

Negotiations have taken place between a group of utilities from Austria, Belgium, Denmark, Germany, Holland, Italy, Norway and the UK. The goal has been to set up a pilot project on international trade of green certificates (RECS 1999). It would be useful to obtain practical experience on a limited scale related to international trading of certificates with real money, before such a market is established on a larger scale. However, different market principles in different countries complicate even the establishment of such a pilot project. The outcome may be to start with a realistic simulation game.

It has been suggested that trade of green certificates for RES-E should be coupled to trading of quota for greenhouse gas (ghg) emission and to joint implementation (JI). The argument is that all mechanisms are related to reduction of ghg emission. This is, however, a complex issue both technically and due to differences in supplementary aspects of the mechanisms. Thus, renewables are replacing exhaustible energy sources (fossil fuels), while JI projects may have important local effects for employment and development of new technologies. On this background it may be preferable to decouple the three mechanisms during the first development phase of the mechanisms.

3. DEVELOPMENTS IN INDIVIDUAL EUROPEAN COUNTRIES

Liberalisation of electricity markets and adoption of supply systems based on renewable energy sources are progressing with widely different speeds among European countries. In this section we shall summarise the main developments in six representative countries. More details can be found in reports from recent EU projects (REALM Project 1999, EWEA Project 2000).

3.1 Germany

The previous Feed Law on Electricity from Renewables (Stromeinspeisungsgesetz) has in March 2000 been replaced by a new law: “Act on Granting Priority to Renewable Energy Sources” (Gesetz zur Förderung der Stromerzeugung aus erneuerbaren Energien) or in short: Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EGG). The new act was confirmed in the Bundestag in late February 2000 and by the Bundesrat in early March 2000. It is formally operational by April 1, 2000.

EGG continues the basic principles from the previous Feed Law but includes a number of adjustments aimed at promoting the penetration of renewables and at creating equal burden sharing between German utilities in relation to the extra costs in connection with electricity from renewables.

The main purpose of EGG is to facilitate a sustainable development of German energy supply in the interest of managing global warming. A concrete target is at least to double the share of renewable energy sources in total energy consumption by the year 2010. At present about 6% of German electricity is produced by renewable energy sources (RES) as compared to an average in EU of about 12%. Large hydro is not included in these numbers.

In the past, German utilities have not favoured renewable energy sources. In fact they have actively opposed the previous Electricity Feed-In Law, and the new act (EGG) may be contested in court by German utilities.

In the following we shall list some of the important new features of EGG:

- The feed-in tariffs are not dependent on the market price of energy but are defined in the law.
- The feed-in tariffs are different for wind, biomass, photo voltaics etc.
- The feed-in tariffs are decreased over the years in order to take into account the technological learning curves.
- German utilities investing in renewables will receive the same premium tariffs for electricity from renewables (RES-E) as other investors.
- The costs associated with connecting installations to the grid shall be borne by the installation operators.
The costs associated with upgrading the grid in order to connect new RES installations shall be borne by the grid operators.

Transmission grid operators shall be obliged to equalize differences in compensation payments to RES-E amongst themselves.

The following quantitative specifications are given in the new law:

Small hydro, gas from landfills, mines and sewage treatment plants up to 500 kW:
Premium tariff of at least 15 pf/kWh.

Biomass installations:
Premium tariff of at least 20 pf/kWh for plants up to 500 kW, 18 pf/kWh up to 5 MW, and 17 pf/kWh for plants above 5 MW. After January 1, 2002 these tariffs shall be reduced by one per cent annually for new installations as of this date.

Wind power:
Premium tariff of at least 17.8 pf/kWh for five years from the date of commissioning. For existing wind turbines, the date of commissioning is defined as April 1, 2000. The number of years with the high premium tariff may be extended above the five years depending on the wind potential at the specific siting. The law specifies an algorithm for this extension which favours sitings with less wind resources in relation to a reference siting (mean annual wind speed of 5.5 m/s at 30 m above ground, a logarithmic wind shear profile and a roughness length of 0.1 m). A service life of 20 years is assumed for all turbines.

For very good sites (wind potential larger than 150% of reference site), the above algorithm leads to an average premium tariff of 13.5 pf/kWh over the 20 years. For an average site this number is increased to 16.4 pf/kWh and for inland sites to 17.3 pf/kWh.

For off-shore wind farms commissioned before 2007, the period with the high tariff of 17.8 pf/kWh is increased to nine years.

From January 1, 2002 the tariffs specified above shall be reduced by 1.5% annually for new installations commissioned after this date.

Solar radiation energy:
The premium tariff shall be at least 99 pf/kWh in the beginning. From January 1, 2002 this tariff shall be reduced by 5% annually for new installations commissioned after this date.

3.2 The United Kingdom
The UK was the first European country to pursue wholesale liberalisation. The 1989 Electricity Act privatised and restructured the electricity industry, leading to a complete opening of the market by the end of 1998. As a result power prices are in real terms lower than before privatisation - and the size of the workforce in the electricity industry has been decimated. There has been a great deal of takeover and merger activity in the British electricity sector, including takeovers by American and European utilities. The new vertically-integrated electricity companies seek economies of scale in their nationwide competition for customers. Renewable energy sources have been supported mainly by the Non-Fossil Fuel Obligation (NFFO) scheme. It awards fixed price contracts to producers who are selected on the basis of price competition in each category of renewable electricity production technology. The system is administered by a central agency, and the cost is recovered by a levy on electricity consumers. The mechanism has supported about 85% of all renewable electricity generation in the UK, but the total capacity achieved amounts only to about 3% of the UK electricity supply. The quantity is low in comparison to other EU countries. The potential interest of British consumers in renewable or “green” electricity tariffs is still unproven. Some new entrants to the green supply market have ambitious plans to expand, but the overall level of uptake is still low.

A new Utilities Bill was introduced in the House of Commons on 20th January 2000 (Bill 49). The Utilities Bill has been prepared by the Department of Trade and Industry (DTI) and the Department of the Environment, Transport and the Regions (DETR). The Bill covers the gas, electricity, telecommunications and water sectors. The Bill is expected to be finally confirmed by July 2000 and implemented around April to June 2001.

For the electricity sector, the Bill establishes a new regulatory authority called the Electricity Markets Authority and a new consumer council called the Electricity Consumer Council. It is planned that trading of electricity in the UK shall no longer be handled by a pool, but from 31th of October 2000 a New Electricity Trading Arrangement (NETA) shall be based on bilateral contracts between producers and suppliers with a systems operator, probably National Grid Company (NGC), taking care of the balance between supply and demand. However, this time schedule may be too ambitious and the start could well be postponed to June 2001 (after an expected national election in early 2001). The policy for renewables has been prepared mainly by DTI that issued a report outlining the principles in March 1999 (DTI 1999). In the introduction to this
The British government is working towards a target of renewable energy providing 10% of UK electricity by 2010. An intermediate goal is that 5% of UK electricity should be provided by renewables by 2003, compared to the current figure of 2%. It is expected that the first obligation for the year starting March 2001 will be around 3% green electricity (where large hydro will not be included).

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The suppliers may buy themselves out of the obligatory green quota by paying a penalty. The penalty is expected to be set at 2 p/kWh from the beginning, which will correspond to the maximum price of the green certificates. However, the Minister can increase this penalty if investments in green electricity (mainly wind power) are lacking behind the targets. There is no lower limit for the price of certificates specified in the Bill. A special scheme with higher tariffs is foreseen for offshore wind farms and energy crops until their production cost is reduced sufficiently.

The Utility Bill is coupled to the Climate Change Levy (CCL), which is a major new policy initiative that applies to energy used in industry, commerce and the public sector (but not to domestic consumers). The CCL amounts to 0.3-0.4 p/kWh for non-domestic consumers. The British government has announced that electricity and heat generated from RES will be exempt from the levy (except large hydro). This will provide an incentive for business to opt for electricity from RES and thus form an important element of the new RES policy.

3.4 Austria
The legal framework for the Austrian electricity market liberalisation is defined in a law according to which 27% of the market were opened to competition by 1999 and 50% will be opened by the year 2003. By the year 2005 three per cent of electricity sold by Austrian utilities should originate from new renewables such as wind, solar power and biomass (excluding waste). Electricity distribution companies have to accept all renewable power (except hydroelectricity) produced by independent power producers at a specified feed-in tariff. Moreover, the independent producers are allowed to sell power from renewables directly to all final consumers. All power producers shall have access to the grid on equal terms. These rules were implemented in 1999 and have brought dramatic changes to the Austrian electricity sector as utilities from France, Germany and Switzerland are attempting to penetrate the Austrian market. Electricity prices for eligible customers can be expected to converge towards the cheapest offers on the market, and it is possible that only the most efficient Austrian producers with the highest amount of financial reserves will survive.

3.3 The Netherlands
In the Netherlands an electricity bill enacted in 1998 liberalised the electricity market in stages. In 1998 customers with an annual average power consumption of more than 2 MW were given a free choice of suppliers. The share of these customers corresponded
the next five years (REALM Project 1999). As a consequence, Austrian utilities seek strategic alliances with national and international partners. Another consequence is that Austrian utilities have been forced to reduce electricity tariffs to captive customers by about 10%.

### 3.5 Denmark

The regulations for the Danish electricity sector are laid down by a new electricity act from June 1999. It provides for a faster opening of the electricity market than the EU Directive. By January 2001 the market is to be opened for all electricity customers, who consume over 1 GW a year, and by January 2003 liberalisation will extend to all consumers. The act breaks with the traditional Danish non-profit principle as power plants are to be operated as ordinary commercial enterprises in the future. Users of district heating are to be protected against unfair price increases. The profits of grid companies will be regulated and majorities of their boards will be elected by customers.

A special certificate market will be introduced for green electricity with obligatory consumer quota. The Danish government has specified that 20% of the electricity with obligatory consumer quota. The Danish government has specified that 20% of the electricity consumed shall be covered by RES by 2003. The law also specifies that the annual CO₂ demand shall be confirmed by June 2000.

During 1999 a number of problems have turned up in connection with the transition to a more liberalised market. The problems include financing of the power plants and distribution companies during their transition from non-profit utilities to competitive free-market enterprises. Special schemes were agreed by the government and the utilities in order to avoid serious economic problems. It is too early to say whether these schemes are sufficient to secure the competitiveness of the Danish electricity sector.

Other problems have been related to the operational details of the green market where trading of certificates were originally planned to start in January 2000. The Danish government has now postponed this trading to 2002. A complicated set of transitional rules is expected to be confirmed by June 2000.

### 3.6 Greece

The legislation for promotion of RES is mainly defined by the Law for regulation of electricity generation from RES from 1994. This law establishes the framework for electricity generation by players other than the Greek Public Power Corporation (PPC), such as independent power producers (IPPs) and auto-producers (APs).

The main provisions of the 1994-law are the following:

- Electricity production is allowed for IPPs, provided they use RES.
- PPC is obliged to buy all electricity produced by IPPs, with some reservations in relation to technical constraints of the system.
- Long term (10 year) contracts are offered to IPPs, thus establishing a stable market environment.
- Attractive feed-in tariffs are offered to IPPs, typically in the range from 70-90% of consumer retail price, with the highest tariffs applying for isolated island systems.
- The cost for grid connections and/or for "shallow" reinforcements required in the transmission network is born by the IPPs.
- The total installed capacity of intermittent RES in isolated island grids is limited to 30% of peak load in the previous year.

Under the current Greek legislation, IPPs applying for development of wind farms are served on first-come first-served basis in relation to licences within the PPC grid capacity.

In addition to the promotional measures for RES in the 1994-law, market incentives in terms of investment subsidies are provided by the Development Law from 1990 and by the Operational Programme for Energy covering the period from 1999 to 2006. These subsidies range from 40% to 50% of capital cost, depending on the type of RES. However, there has been introduced some features of benchmarking in the system, because the investment subsidy for wind farms can only be allotted for projects with an investment cost lower than 350,000 Drachmers per kW. The present Greek scheme for renewables may thus be characterized as a favourable feed-in system with high tariffs for electricity from RES, supplemented by high investment subsidies.

Greece has large wind resources, estimated as at least 2,400 MW. On this background it is surprising that the total installed capacity of wind power in Greece at present is no larger than about 115 MW, including 37 MW belonging to PPC.

In December 1999 the Greek parliament confirmed a new electricity law that outlines the framework for a liberalised energy market in Greece (Law No 2773: "Liberalization of the Electricity Market – Regulation of Energy Policy Issues and Other Provisions"). The last four pages of this law (articles 35 to 41) are concerned with CHP and RES. The new law is not considered a "complete" law according to the Ministry of Development, and it is expected to be supplemented during year 2000, e.g. in order to enforce the upgrading of the grid in windy areas.

The Minister of Development has in his power to regulate the tariffs for electricity from RES in consultation with a new Regulatory Commission, e.g.
in order to avoid wind-fall profits for wind farms at favourable sitings.

4. CONCLUSIONS

The extent to which electricity markets have been liberalised varies between European countries. Many countries have opened their markets at a faster pace than required by the EU directive. The result is that consumer prices have been declining in accordance with the goal of the EU Commission. In addition mergers and alliances between European utilities have been accelerated. As a consequence it is expected that strong business concentrations will emerge in the electricity sector and may even lead to the creation of private monopolies.

In promoting the use of electricity produced from renewable energy sources the greatest successes have been obtained by the application of the feed-in system in Denmark, Germany and Spain. Thus, if the highest priority is given to fulfilling ambitious goals for the penetration of renewable energy source, the natural conclusion would be to rely on the feed-in model. The burden on the government budget can be reduced by sharing the premium tariff between electricity consumers, and competitive features may be introduced by using bench-marking principles. However, the feed-in system does not fully conform to the principles of market competition.

Several EU Member States are supporting a green certificate system with specified consumer quotas for electricity from renewable sources. The discussion in this paper has illustrated that there are a number of uncertainties for investors in this system. These have to be considered in depth in order to avoid disruptions in the market. Moreover, transaction costs can be high in competitive market schemes.

The creation of green markets is a very complex process. Throwing renewable technologies into an uncertain commercial market may cause serious setbacks in extending the use of clean energy sources. The problems related to market competition between technologies at different stages of development may be reduced by combining the certificate model with a centralised tender model.

The present political trend favours the use of commercial market as a driving force for technical change. This political preference presents a dilemma for the long-term development of clean energy sources. It is the judgement of this author and others (Illum and Möller 1998) that a cost-effective and sustainable energy solution requires comprehensive planning – including the transport sector - with time horizons of 30 to 50 years. This is in conflict with the characteristics of a commercial market.

The planning of an energy supply system that includes a large contribution from fluctuating energy sources is a much more complex project than planning traditional energy systems based on fossil fuels. Decisions based on short term profits may well block the least-cost long-term sustainable solutions. The challenge for the proponents of market principles is to demonstrate that this dilemma can be solved in a satisfactory fashion.

References


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