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DEVELOPMENT OF RENEWABLE ENERGIES: WHAT CONTRIBUTION FROM THE CARBON MARKET?

Cécile Bordier*

In the Climate Energy Package, the European Union pledged to achieve goals in reducing greenhouses gases and developing renewable energies. It has imposed objectives that are differentiated by country for the reduction of greenhouse gas emissions and the development of renewable energies. Some of the emissions reductions must be achieved thanks to a mechanism in which all the Member States participate. The European Union Exchange Trading Scheme (EU ETS) covers approximately 40% of the European greenhouse gas emissions produced by five major industrial sectors including electric power generation. The development of renewable energies has been left up to each Member State. To keep its commitments in terms of renewable energies, each Member State can employ a variety of economic incentive mechanisms: calls for tenders, feed-in tariffs or "green certificates".

This edition of *Climat Report* describes two national policies that utilise different instruments: price support mechanisms in France and definition of quantitative targets in the United Kingdom. This report evaluates these policies for the generation of electric power from renewable sources in terms of cost per metric ton of carbon avoided to compare them with the price of the carbon allowance under the EU ETS. The results demonstrate that the cost of national policies significantly differs from one country to another, but in each case, is above the price of the European carbon allowance.

It is difficult to draw definitive conclusions regarding the economic efficiency of the public policy instruments. The first phase of the EU ETS imposed only a relatively mild constraint, mainly weighing on the electric power generation sector. The allowances to this sector have been reduced in 2008 and they will be sailed at auction from 2013, up to a ceiling decreasing each year.

This increase in constraints on emissions is intended to play an essential role in the deployment of solutions to reduce CO_2 emissions by this sector, including the increased use of renewable energies. The role of the incentive mechanisms on the national level could complete the EU ETS impact, accelerating the commercial penetration of renewable energy sources which are not competitive enough.

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* **Cécile Bordier** is a research fellow at the Mission Climat of Caisse des Depots where she focuses on the study of economic instruments related to environmental policies.
cecile.bordier@caissedesdepots.fr – + 33 1 58 50 85 20

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SUMMARY

INTRODUCTION

European energy policy for the development of renewable energies and climate change is based on two fundamental texts. The first is the 2001 European directive with the objective to increase the share of electricity generated from renewable energy sources to 21% by 2010 in the EU-25. The second is the 2003 directive establishing the European Union Emissions Trading Scheme (EU ETS) that entered into effect in 2005 imposing a cap on carbon dioxide (CO_2) emissions for the high-emitting European sectors. The two directives have similar objectives. The renewable objective creates incentives for the production of renewable energies, potentially convincing power producers to retire base fossil fuel generation capacity, thereby facilitating compliance with the EU ETS. Likewise, a high CO_2 allowance price can equally push power producers to switch to less carbon-intensive fuels such as biomass, or even to invest in new power plants using renewable energies (wind, hydroelectric, geothermal etc.). However through both approaches, the cost of these new technologies is currently a major obstacle to their wider development.

Various incentive mechanisms exist to promote the growth of renewable energies in Europe. Numerous Member States have implemented policies that assist electricity producers who utilise renewable energy sources using calls for tenders, feed-in tariffs or green certificates. These national policies are in addition to the incentives offered by the EU ETS to electric power producers to reduce their CO_2 emissions.

How much do these national policies cost consumers and producers? This *Climate Report* compares the incentives offered by two national policies with those of the EU ETS by calculating the cost of these policies per metric ton of carbon avoided. This report analyses the case of France and the United Kingdom, two countries with very different energy profiles and subsidy policies: price mechanism in France and quantitative objectives in the United Kingdom. Finally, the current and future role of the EU ETS in the development of renewable energies is analysed, in particular as a result of the European Commission's January 2008 proposal to sell all of the allowances for the electric power generation sector at auction beginning in 2013.

I. CONTEXT AND CHALLENGES OF RENEWABLE ENERGIES IN EUROPE

A. Advantages of electric power generation based on renewable energy sources

Endless energy sources …

A renewable energy source is a source which is continuously replaced at a rate that is at least equal to the rate at which it is consumed. Renewable energy comes from natural sources found all over the planet: the sun, water, wind, geothermal heat and organic matter.

More precisely, this study takes the definition established by the 2001 European Directive: "'renewable energy sources' shall mean renewable non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases". Only the generation of electricity and heat from renewable energy sources will be considered in the analysis of the influence of the EU ETS on this sector. Biofuels will not be taken into consideration as the transportation sector is not subject to the EU ETS.

Table 1 – Renewable energy sources and their uses

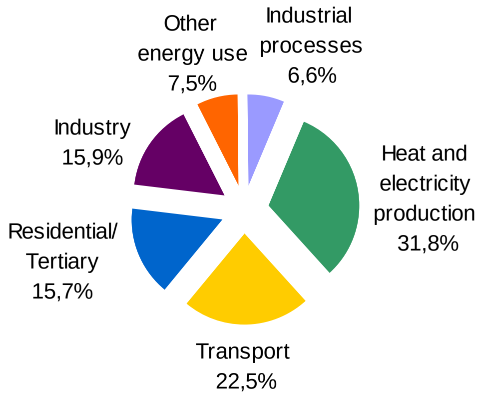
Wind	Wind turbines, which consist of blades in rotation around a hub, are driven by wind kinetic energy to generate electricity or mechanical energy which is used to pump water. There also exist offshore wind turbines.
Hydroelectric	Water drives a turbine that causes a generator to produce electricity. - The **large hydraulic** sector includes hydroelectric power generation plants with a capacity greater than 10 MW. - **Small hydraulic** installations are riverside plants with a capacity of less than 10 MW. - **Tidal** energy takes advantage of the potential energy of the vertical movement of a mass of water caused by the tides. **Wave** energy is generated by the movement of the surface of the sea under the action of waves.
Solar	Solar radiation can be used to generate heat and electricity. - **Thermal solar energy**: Glass-covered thermal collectors in which circulates a liquid heat exchange warmed by solar radiation. The liquid transmits the heat to a water heater or optionally to a low-temperature heated floor. - **Thermodynamics**: solar heat produces steam that drives a turbine, powering a generator to produce electricity. - **Photovoltaic solar energy**: combined into solar panels, photovoltaic cells are electronic components consisting of semi-conductors which generate electricity when exposed to light.
Biomass	General term used for energy sources originating from plants, trees, organic matter and waste. - **Wood energy** consists of extracting the energy from wood byproducts (branches, trimmings etc.) and industrial products (bark, sawdust, wood chips etc.). The carbon balance of this technology is neutral provided that the plantings are replaced. When wood is burned, it emits the CO_2 into the atmosphere that was absorbed during the growth of the trees. - **Waste** is utilised by direct combustion in incinerator units or turned into biogas produced by the fermentation in the absence of oxygen.
Geothermal	Consists of extracting the heat produced by the natural radioactivity of the rocks in the earth's crust and by thermal exchanges within the Earth. - **High-energy** (> 180°C) and **medium-energy** (between 100°C and 180°C) geothermal energy use geothermal resources to produce electricity and heat. **Low-energy** geothermal energy (between 30°C and 100°C) can be used to meet local heating requirements. - Geothermal heat pumps are **very low energy** applications that are used to heat and cool buildings. This technology captures the heat in soil and water or the ambient heat in the air. Geothermal heat pumps require electricity to operate (they generally consume 1 kWh of electricity for every 4 kWh of heat they produce). Only the thermal energy generated by geothermal heat pumps that have a minimum performance coefficient is considered as renewable energy.

Source: Mission Climat of Caisse des Dépôts, from Ademe.

…. that can be used to combat climate change

Reducing greenhouse gas emissions generated by energy consumption constitutes one of the principal tools in addressing climate change. The energy sector represents approximately 80% of the emissions from developed countries. In the European Union, the electricity production and heating sector generates the most emissions, accounting for approximately one-third of CO_2 emissions.

Figure 1 – The European Union's CO2 emissions by sector in 2005



Source: European Environment Agency, 2007.

The generation of electricity from renewable energy sources, like the electricity generated from nuclear energy, does not directly generate greenhouse gas emissions. The CO_2 emissions from these technologies are due solely to the construction of the infrastructure and its maintenance, which varies significantly from one site to another. For example, the carbon content of photovoltaic cells results from the manufacturing process, which in turn is a function of the energy source used as well as the manufacture of the battery that stores the electricity. The University of Louvain conducted a life-cycle analysis of the generation of electric power from renewable resources in terms of CO_2 emissions, which are compared in Table 2 to the emissions generated by the combustion of fossil energy as calculated by the International Energy Agency (IEA).

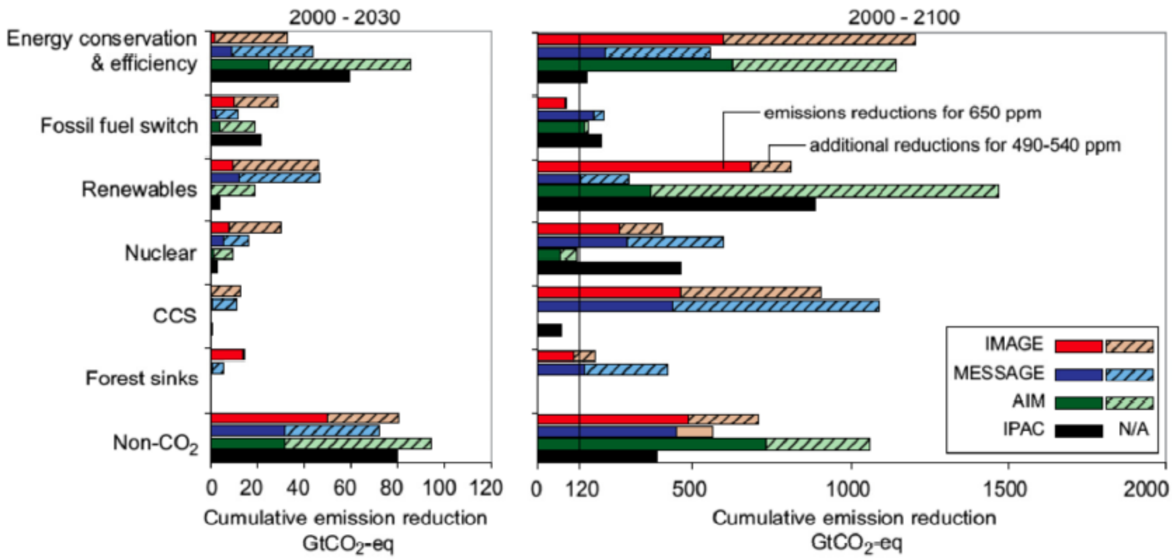
Table 2 – CO_2 emissions in metric tons per MWh generated

Indirect CO_2 emissions (life-cycle analysis) (tCO_2/MWh)	Solar	0,1 tCO_2/MWh
	Wind	0,008 tCO_2/MWh
	Nuclear	0,05 tCO_2/MWh
CO_2 emissions from fuel combustion (tCO_2/MWh)	Coal (thermal efficiency rate 40%)	0,87tCO_2/MWh
	Gas (thermal efficiency rate 55%)	0,36 tCO_2/MWh

Source: University of Louvain, AIE, 2005.

These low rates of emissions per unit of electric power generated make renewable energies a powerful tool in limiting atmospheric emissions of greenhouse gases from energy use. According to the most recent report by the Intergovernmental Panel on Climate Change (IPPC), the development of renewable energies is an essential element in the fight against climate change. Figure 2 presents the potential contributions of different actions or technologies such as an improvement in energy efficiency, carbon capture and storage (CCS) or renewable energies, to the reduction of greenhouse gas emissions by 2030 and 2100.

Figure 2 – Cumulative emissions reductions achieved by various reduction measures from 2000 to 2030 (left) and from 2000 to 2100 (right)



Four scenarios illustrate the means of achieving two objectives of stabilizing greenhouse gases in the atmosphere. The solid bars represent the emissions reductions that will achieve a concentration of 650 ppm CO_2eq; the striped bars show the additional reductions required to reach a target of 490 to 540 ppm CO_2eq. It should be noted that certain models do not take into consideration the potential reduction achieved by increasing forest carbon sinks (AIM and IPAC) or CCS (AIM).

Source: IPCC, evaluation report, 2007.

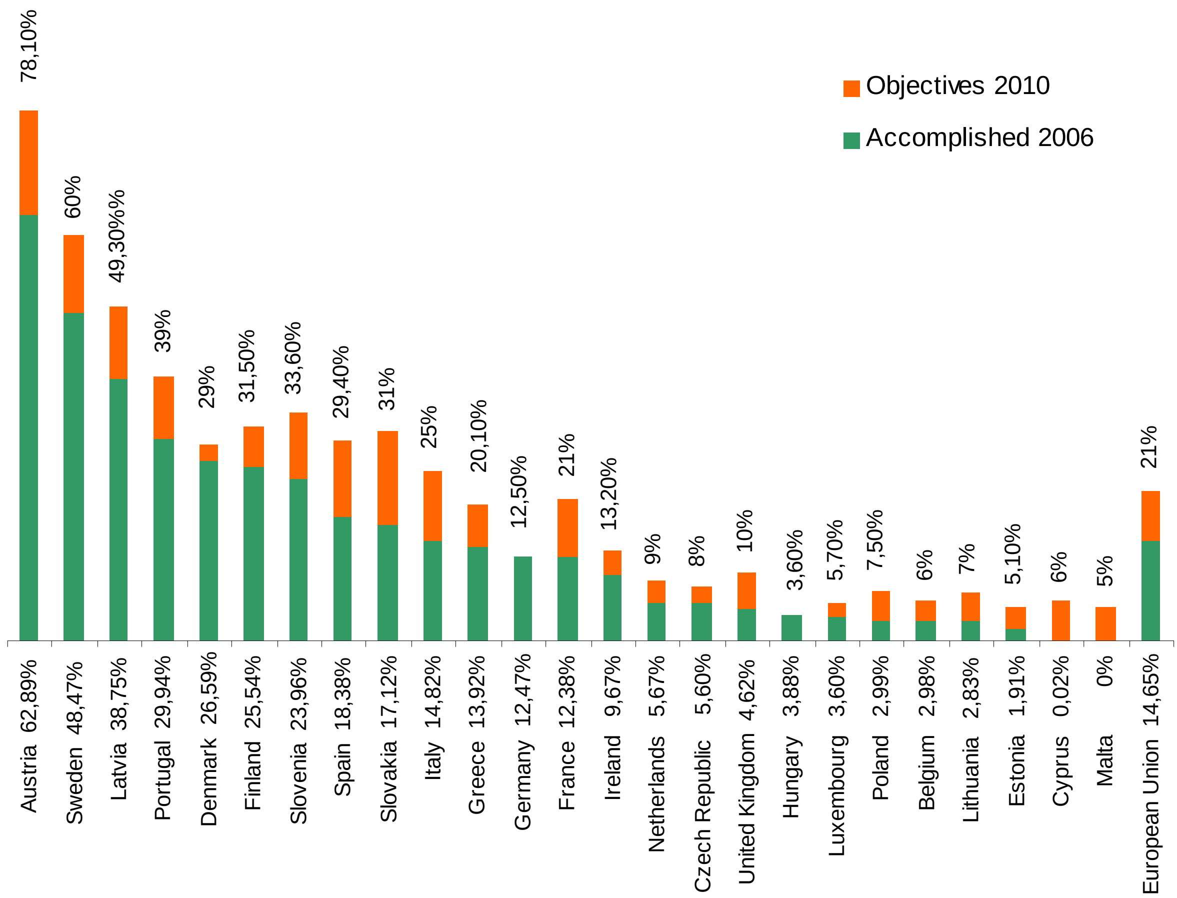
B. Deployment of renewable energies in Europe

Development objectives for 2010

European energy policy on renewable energy is based on different goals. Renewable energies respond to increasing energy demand while offering long-term solutions to ensure the security and independence of the energy supply. They also contribute to the economic growth of the European Union and the fight against climate change.

Beginning in 1997, the "White Paper" drawn up by the European Commission aims to increase the percentage of renewable energies in the gross domestic consumption of energy in the EU-15 to 12% by 2010. In 2001, the European Union subsequently approved a directive addressing the promotion of the use of renewable energy sources in the internal electricity market. The goal of this directive is to increase the percentage of renewable energy sources in the gross consumption of electric power in the EU-25 to 21% by 2010. Individual objectives were defined for each Member State as a function of potential and installed generating capacity. Figure 3 illustrates the objectives for electric power generation from renewable energy sources for each State, with their level of achievement in 2006.

Figure 3 – Percentage of renewable energies in gross electric power consumption in Europe in 2006, compared with the objectives of the Directive for 2010 (in %).



For each country, the percentage of renewable energies in its gross electric power consumption in 2006 is indicated after its name and its objective for 2010 above each bar.

Source: Observ'ER, 2007.

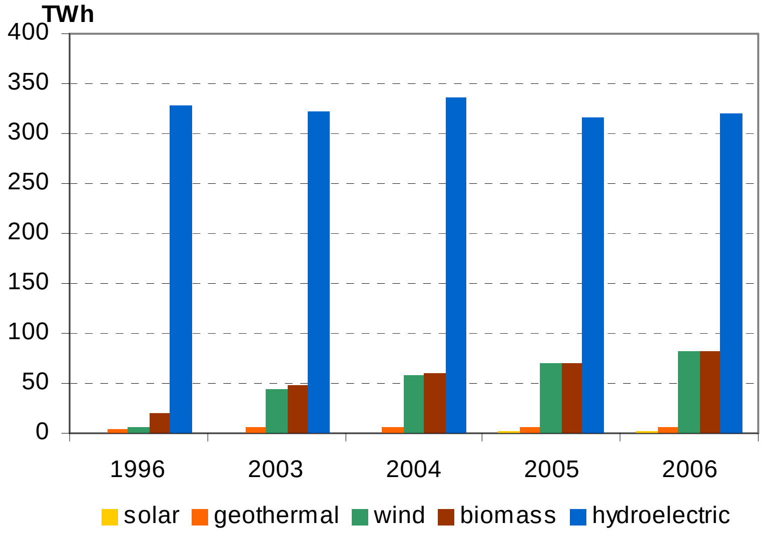
While Germany and Hungary have already met their objectives, the percentage of renewable energy sources in gross electric power consumption must be increased by approximately 6% overall in Europe to reach the objective of 21%. On the basis of the policies and efforts currently in place, the European Commission[1] estimated in January 2007 that the percentage of renewable sources in the generation of electric power will reach 19% in 2010. While results are positive thanks to major efforts by a small number of Member States, they are not satisfactory overall to reach the established target as many countries are still far from achieving their domestic objectives.

Increasing diversification of renewable energies

The generation of electricity from renewable energy sources is increasingly diversifying in Europe, as shown in Figure 4, illustrating the growth of electric power generation from renewable energy sources in 1996 and from 2003 to 2006 in Europe.

[1] COM(2006) 849 final, *Report on progress in the field of electricity from renewable sources*, 2007.

Figure 4 – Growth of electric power generation from renewable sources in the EU 27 (in TWh)



Source: Observ'ER, 2007.

Hydroelectric power is without question the most exploited renewable energy resource in Europe. Wind and biomass sources have increased by 77.8 and 62 TWh respectively since 1996, and in 2006 each produced 82.9 TWh of power. Although solar power generation is still on a very low level in Europe, it grew at an annual rate of 44% from 1996 to 2006. The variety of the European landscape offers great potential which can be achieved by exploiting a number of different renewable sources[2].

Growth prospects after 2010

At the meeting of the European Council on March 16, 2007, Europe was given a new objective for the year 2020: to increase the percentage of renewable energies in the final energy consumption of the European Union to 20%. This proposal, which is still under discussion in Brussels[3], is part of the "Climate Energy Package" presented by the European Commission in January 2008.

This directive covers the three sectors concerned by renewable energies: electricity, heating/cooling and transportation. The overall approach selected consists of leaving Member States free to determine the distribution of efforts among these sectors to achieve their national objective[4]. The objective for the share of renewable energies will be restrictive and will be specified for each individual Member State. Table 3 presents these objectives, in increasing order of the relative increase that must be accomplished.

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[2] See Annex 1 for additional details on the growth of the European market..

[3] If this new directive is adopted, the provisions of the older directive 2001/77/EC which deal with the objectives and relationships for 2010 will remain in force until December 31, 2011.

[4] Except for the transport sector, for which the climate energy package calls for a 10% share of renewable energy in total vehicle fuel consumption by 2020.

Table 3 – Objectives of the Member States concerning the percentage of renewable energy in the final energy consumption in 2020

	Percentage of renewable energy in final energy consumption in 2005	Objective for 2020
United Kingdom	1,3%	15%
Denmark	17%	30%
Ireland	3,1%	16%
France	10,3%	23%
Germany	5,8%	18%
Italy	5,2%	17%
Netherlands	2,4%	14%
Spain	8,7%	20%
Greece	6,9%	18%
Belgium	2,2%	13%
Austria	23,3%	34%
Portugal	20,5%	31%
Cyprus	2,9%	13%
Luxembourg	0,9%	11%
Malta	0%	10%
Finland	28,5%	38%
Sweden	39,8%	49%
Slovenia	16%	25%
Hungary	4,3%	13%
Lithuania	15%	23%
Poland	7,2%	15%
Slovakia	6,7%	14%
Latvia	34,9%	42%
Estonia	18%	25%
Czech Republic	6,1%	13%
Bulgaria	9,4%	16%
Romania	17,8%	24%

Source: European Commission, 2008.

C. Constraints on the growth of renewable energies

Constraints in terms of popular acceptance

According to a pan-European survey on energy consumption, Europeans are overwhelmingly in favour of the increase and development of renewable energies[5]. However, this finding must be qualified as renewable energy projects frequently encounter fierce local opposition, as evidenced by the "NIMBY" ("Not In My Back Yard") syndrome.

A large majority of rejected wind power construction permits are the result of concerns about the landscape and the protection of animal and plant species. According to one study of the investigation of applications for construction permits in France[6], the rejection rate increased from 2006 to achieve 33% in 2007. On the other hand, the rate of appeals against administrative decisions declined by 13% during the same period, reaching the low rate of 14%.

[5] The acceptance rate among French citizens is identical: 86% of the French are in favour of solar energy, 70% are in favour of wind energy and 65% in favour of hydroelectric energy, according to a TNS Sofres study conducted in 2007.

[6] *2007 survey on the investigation of applications for construction permits,* DGEMP-DIDEME, November 2007

Wind turbines are therefore situated where there is wind and where they are accepted by the public; these conditions do not necessarily correspond with areas of high electricity consumption. Delivering electricity to high-consumption areas requires the electric network to be strengthened through the construction of high voltage lines. In France, installing such lines requires public approval and three separate consultation procedures. Because of this, the construction of a new high voltage line takes at least 8 years.

Administrative constraints

The application necessary to obtain a wind power construction permit requires extensive and expensive studies. In addition of the probability that the application will be rejected, long lead times are required to obtain permits. The average time required for the investigation of an application for a construction permit is 13 months in France and can reach 24 months depending on the total investigative resources of the prefectures. France is seeking to simplify the administrative formalities by offering local governments the option of designating Wind Energy Development Zones. This procedure makes it possible to examine potential obstacles stemming from impacts on the landscape, the profitability of the installation and to plan the necessary grid upgrades to absorb new capacities at an early stage of the proceedings.

In general, according to the consulting firm Ernst & Young[7], Germany is the most attractive country in Europe for investments in renewable energies. The German legislation in place and the country's development targets have helped to clearly shape the market. In Spain, which ranks second in attractiveness in Europe and fourth in the world, recent legislation concerning the procedures for the installation of offshore wind farms has made the Iberian peninsula a very attractive area.

Technical constraints

Renewable technologies face a number of operational limitations, notably intermittent power collection capacity.

In contrast to wood and biomass, which can be stockpiled and represent relatively reliable sources in terms of security of supply, wind energy embodies many of the technical obstacles of a difficult-to-control renewable energy source. The risk of intermittency on the grid is a limitation on the development of this energy source, such as in Spain where the government's objectives have been thwarted. To guarantee an equilibrium between supply and demand, the Spanish electric power transmission grid limits the portion of wind power to 30% of demand to protect the grid from sudden decreases in production.

Advances in modelling and weather forecasting can help anticipate hazards and adjust supply. It is also possible to use the surplus electricity produced by wind turbines to pump water from a hydrological reservoir downstream to another upstream. This reserve could then be used to generate hydroelectric power if the wind weakens. Also, a wide distribution of wind turbines across a territory can assure a minimum level of production. France, which has different climactic zones (oceanic, continental and Mediterranean), benefits from this type of distribution and thus has some the most productive wind power in Europe.

The development of interconnections with other Member States will also render the electric power grid less vulnerable to fluctuations. In January 2008, France and Spain entered into an agreement aimed at increasing electric power trading capabilities and pool their generating capacity. The construction of this new interconnection will play a key role in the growth of the renewable energy market in Spain and its integration into the larger European electric power market.

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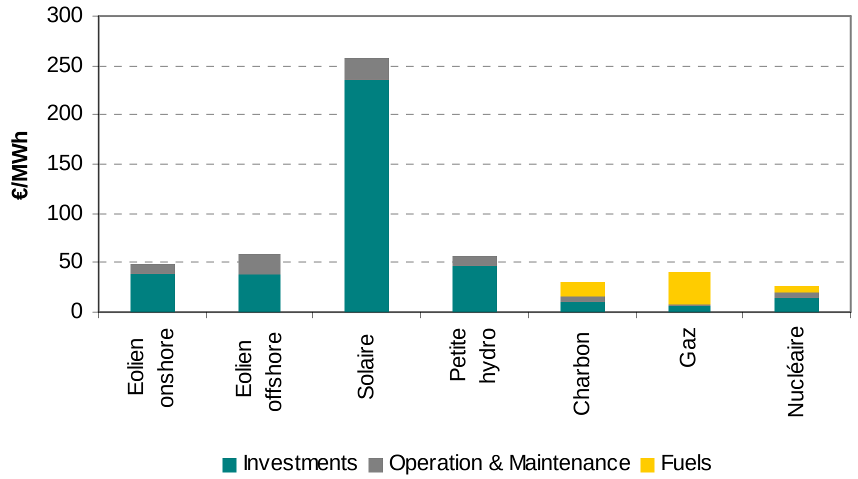
[7] *Renewable Energy Country Attractiveness Indices*, 2008.

Cost constraints

One of the major obstacles to investments in renewable energies is the price differential between the cost of generating electricity from renewable sources and other modes. The high investment costs must be paid back over a shorter period of operation of the equipment. The cost differential tends to decrease, especially for mature energy sources such as wind energy, but a relatively large difference remains for other sources, as illustrated in Figure 5. These numbers, compiled from an IEA study[8], should be taken with grain of salt: costs can vary significantly as a function of the capacities of the different installations and the price of raw materials. Moreover, the sample is not always representative (for example, only 4 installations are included for offshore wind energy).

Figure 5 – Long-term marginal cost of different energy sources (€/MWh)



The costs indicated above are the generation costs (capital investments, operation & maintenance and fuels) and do not include transportation costs. The prices are expressed in €/MWh, based on the exchange rate used by the IEA (1 EUR = 1.144 USD).

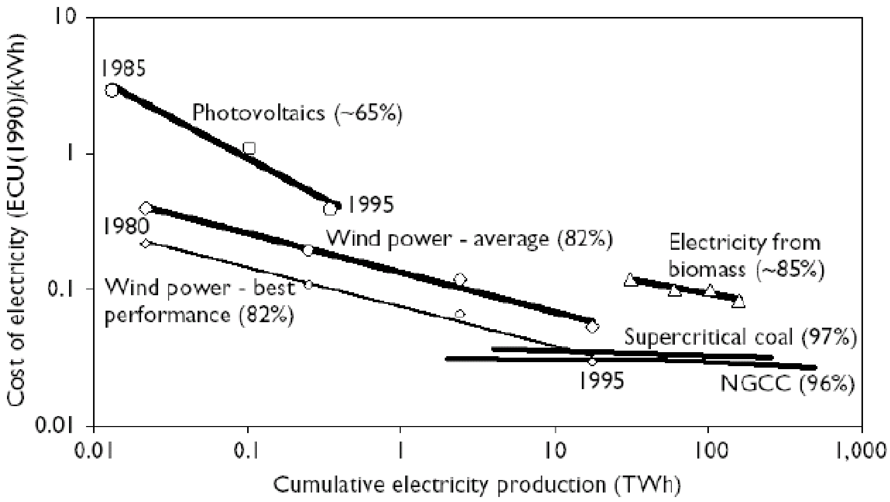
Source: AIE, 2005, author's calculations.

The cost of generating electricity from natural gas and coal depends to a very large extent on the price of the raw materials: in the case of natural gas, this can represent up to 78% of the total cost of generating one MWh. Contrarily, the operation cost of renewable installations is solely a function of the capital investments and maintenance operations.

Further, the cost of electricity generation from renewable sources is being reduced by a combination of learning effects and economies of scale. Figure 6 shows the learning curves for different modes of power generation. The costs of new modes of electric power generation such as solar and wind energy are decreasing rapidly as industrial capacities increase and the technology continues to improve. Nevertheless, in spite of this decrease in cost, renewable energies are still more expensive than conventional sources and require direct assistance to ensure their growth.

[8] *Projected Costs of Generating Electricity*, 2005.

Figure 6 – Growth of costs as a function of the learning effect



The number in parentheses indicates the speed of the learning effect. It describes the relative cost of one KWh after a doubling of production capacity. 65% means that the doubling of capacity resulted in a 35% decrease in the cost of the KWh generated (65% of the cost prior to the doubling of capacity).

Source: Stern Report, from AIE.

II. National renewable energy incentive policies: the case of France and the United Kingdom

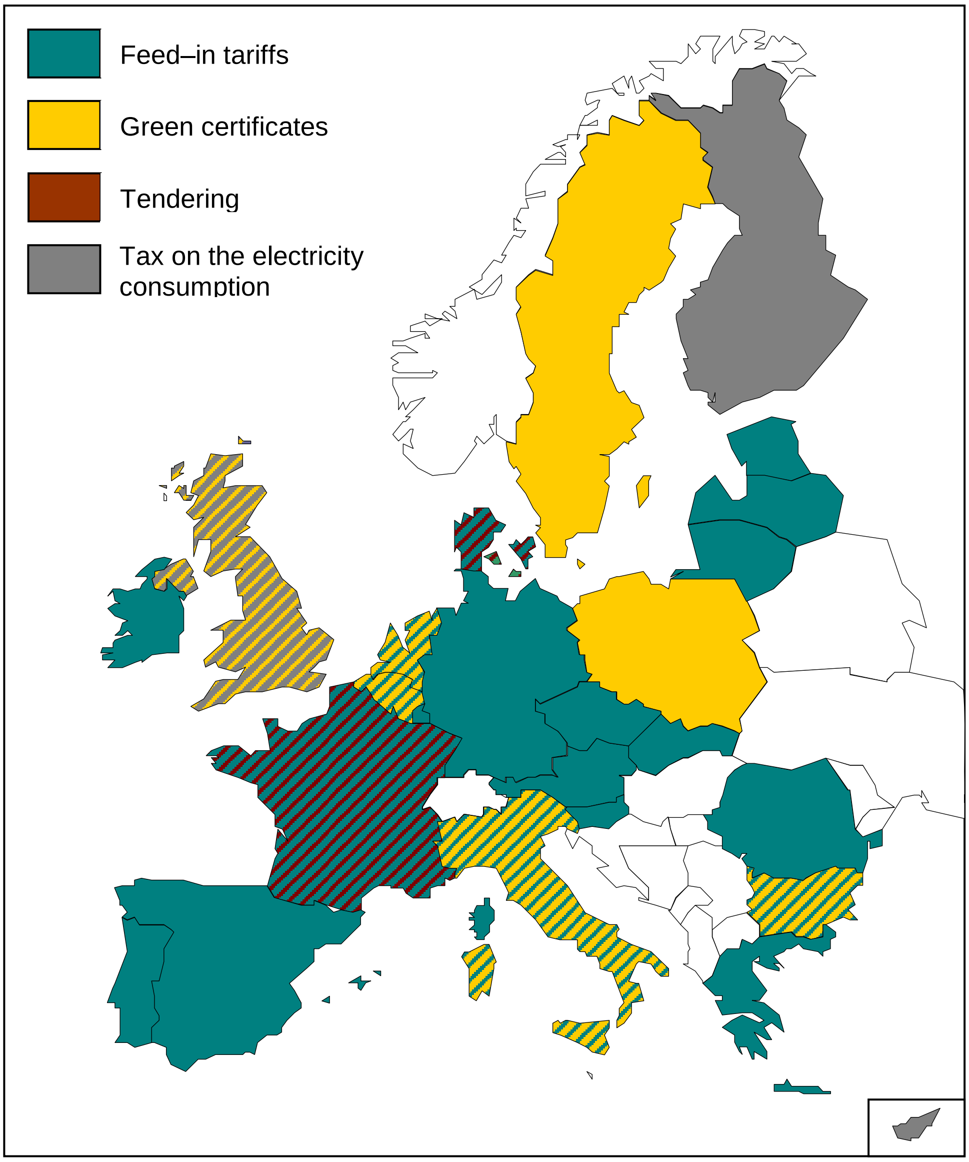
A. Overview of renewable energy incentive policies in the Member States

The European 2001 directive has set its target: 21% of European Union electricity is to be generated from renewable energy sources by 2010. In order to reach this objective, Member Sates were authorized the use of public subsidies to promote the commercial penetration of electricity generated from renewable resources. EU member states remain free to use any type of mechanism they like in order to achieve their goal. The following 4 assistance mechanisms can be highlighted: feed-in tariffs, green certificates, calls for tenders and tax incentives.

- **Feed-in tariffs** are prices set by the State for a specified period of time at which the electric power distribution companies are required to purchase the energy generated from renewable sources. This system, used in most European Union Member States, offers a high level of security for capital investments and fosters the promotion of technologies that are not yet fully mature.
- **Green certificates** encourage the generation of renewable energy by setting a quantitative objective. The distributors (or the power producers, depending on the applicable regulations) are required to offer a certain proportion of renewable energy as part of the electricity they sell (or generate). To document their compliance, they are required to purchase green certificates from the producers of renewable resource generated electricity. One green certificate generally corresponds to 1 MWh of renewable energy. Green certificates are therefore a market mechanism where the price is set according to the law of supply and demand. When the supply of green certificates is tight, the high prices of the certificates stimulate capital investments in renewable energies. The play of competition among renewable energy producers to generate certificates at the lowest possible cost promotes the technological development of renewable energies. This system is in use in United Kingdom, Poland, Italy, Sweden, Belgium, Bulgaria and in the Netherlands.
- In the context of a **call for tenders**, the State promotes competition among producers in the generation of renewable energies and signs a contract with one producer. This allows the State to ensure a substantial demand in renewable energies in order to launch the market. In 1996, France launched the Eole 2005 program to develop wind energy and in 2007 issued a new call for tenders to develop biomass. Denmark uses this system for the deployment of offshore wind energy generating capacity.

- **Tax incentives** such as a tax on the consumption of electricity generated from fossil fuels or tax reductions can also be used, most often in combination with a principal support policy.

Figure 7 – Principal policies supporting renewable energy in Europe in 2008



Source: European Commission, 2008.

B. *The French price policy support for renewable energies*

Feed-in tariffs

To guarantee capital investments in the generation of electric power from renewable energies, France has had feed-in tariffs in place since 2000. Article 10 of Act No. 2000-108 (February 10, 2000) relative to the modernisation and growth of the electric power public utility stipulates that installations that generate electric power from renewable energy sources benefit from an obligation on the part of EDF or the non-nationalised distributors to purchase the electric power they generate.

The feed-in tariffs for each energy source are defined by a tariff order issued by the Ministers of the Economy and Energy. The initial feed-in tariffs were set in 2001, followed by a redefinition of the purchase terms for energy from renewable sources in 2006 and 2007. Table 4 summarises the current tariff conditions.

Table 4 – Tariff decrees by renewable energy power generation technologies

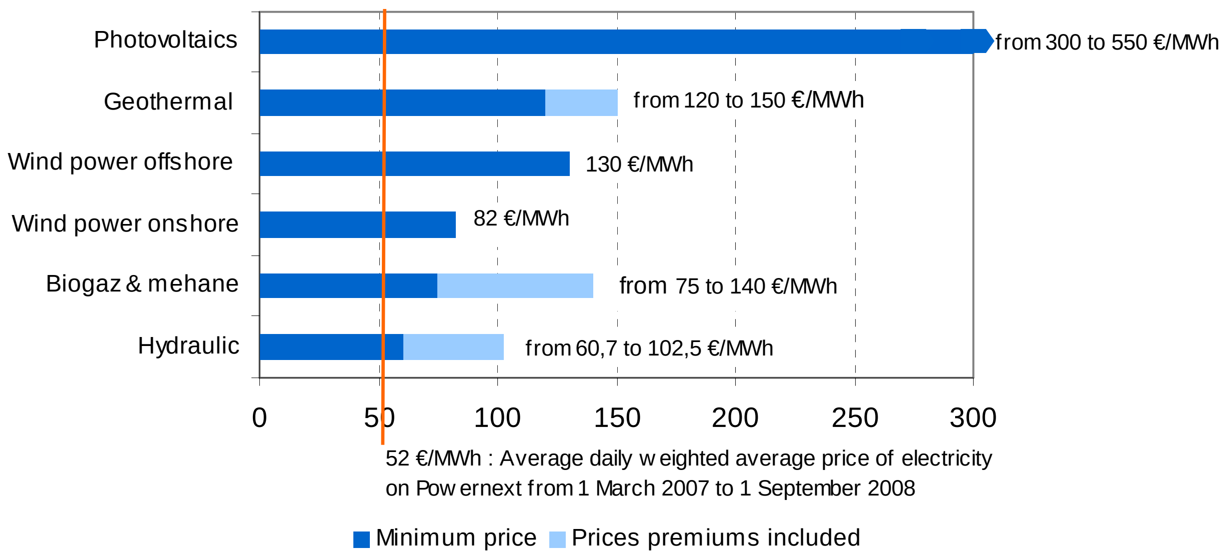
Sector	Decree	Length of contracts	Tariffs for new facilities
Hydraulic	1 Mach 2007	20 years	60.7 €/MWh + premium between 5 and 25 €/MWh for small facilities + premium between 0 and 16.8 €/MWh in winter according to the regularity of production.
Biogaz and méthane	10 July 2006	15 years	between 75 and 90 €/MWh depending on the power, + energy efficiency premium between 0 and 30 €/MWh + methanisation premium 20 €/MWh.
Wind power	10 July 2006	15 years (terrestre)	82 €/MWh for 10 years, then between 28 and 82 €/MWh for 5 years depending on the sites.
		20 years (en mer)	130 €/MWh for 10 years, then between 30 et 130 €/MWh during 10 years depending on the sites.
Photovoltaics	10 July 2006	20 years	Mainland : 300 €/MWh + built integration premium of 250 €/MWh.
			Corsica, overseas territories, Mayotte : 400 €/MWh + built integration premium of 150 €/MWh.
Geothermal	10 July 2006	15 years	Mainland : 120 €/MWh + premium energy efficiency between 0 and 30 €/MWh.
			Overseas territories : 100 €/MWh + premium energy efficiency between 0 and 30 €/MWh.

Source: French Ministry of economy and finances, 2007.

The system of feed-in tariffs provides great security for investments by guaranteeing long-term support; the prices are fixed for periods of up to 20 years. Moreover, the tariffs take into consideration the investment and operating costs of the different modes of power generation and are therefore higher or lower, depending on the degree of maturity of the technologies. This approach by sectors makes it possible to encourage investments in technologies that are still relatively uncompetitive compared to conventional sources of electricity.

The difference between the feed-in tariffs in France and the market price of electricity varies for each mode of generation. Since March 1, 2007 - the date the most recent feed-in tariffs were set - the average selling price of electricity on the Powernext market has been 52 € per MWh. Therefore, the difference between the feed-in tariffs was a minimum of 8.2 € for hydroelectric power and a maximum of ten times the market price for solar energy.

Figure 8 – Comparison of prices on the electricity market and feed-in tariffs in France



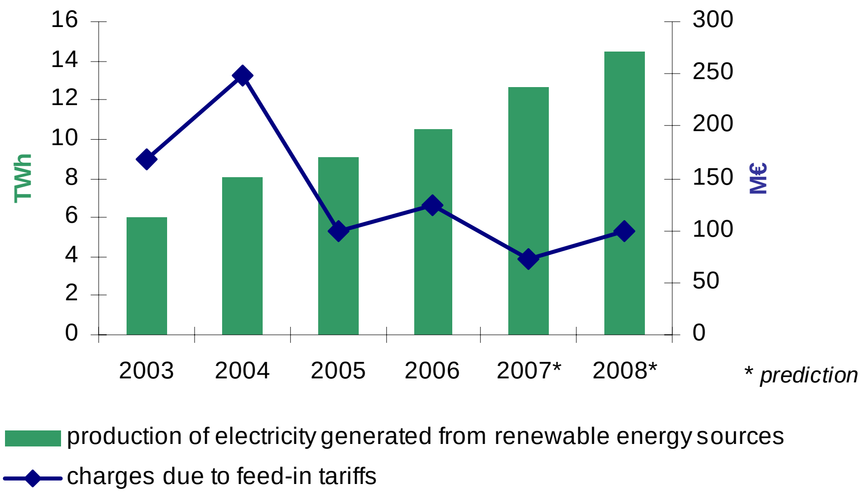
Source: Powernext, Ministry of Economy and finances, author's calculations.

Incentive effect and financing of the public policy of feed-in tariffs

The extra cost due to the feed-in tariffs compared to the market price is shifted to consumers in the form of a tax, the "Contribution to the Public Electricity Service" (CSPE), a portion of which finances costs related to the development of renewable energies[9]. The Energy Regulation Commission (CRE) is the French organisation in charge of the implementation of the feed-in tariffs and their financing. It evaluates the amount of charges corresponding to this support mechanism for the historical operator EDF and the other electric power distributors based on the difference between the purchase price paid to the producers of electric power from renewable energy sources and the market price of electricity. The electric power distributors are then reimbursed for the extra cost incurred as a result of the feed-in tariffs from the funds collected in the form of the CSPE.

Figure 9 highlights electricity generated from renewable energy sources with the charges due to the reimbursement of electricity suppliers[10]. The percentage of energy from renewable sources which is eligible for feed-in tariffs in the French energy supply has increased significantly, almost doubling between 2003 and 2007. Simultaneously, the costs linked to the feed-in tariff decreased significantly in 2005 on account of the increase in the price of electricity, which reduced the differential from the feed-in tariffs. The average of daily market prices on the German exchange (EEX) and the French exchange (Powernext) was 28.6 €/MWh in 2004 and reached 49.3 €/MWh in 2005, i.e. an increase of almost 42%.

Figure 9 – Amount of energy from renewable sources and costs linked to the feed-in tariffs



Source: Energy Regulation Commission, 2008, author's calculations.

Calculation of the cost of one metric ton of CO_2 avoided by the French subsidy policy

The objective of the increased utilisation of renewable energies must be balanced against the costs imposed on producers and consumers. This section discusses the cost of these stimulus measures in terms of the quantity of carbon dioxide avoided.

First, we must calculate the extra cost linked to the feed-in tariffs in Metropolitan France in 2006. EDF purchased approximately 10 TWh of electricity from renewable sources in 2006[11], for a total of 644.2 M€, feed-in tariffs included. At the market price of electricity, this amount of electricity would have cost

[9] The CSPE first finances the additional costs of electricity production in areas not connected to the metropolitan grid.

[10] See annex 2 for further details on CSPE budget

[11] Not taken into account are the minimum expenses borne by local distribution companies because the Energy Regulation Commission does not specify the nature of the production resources (cogeneration or renewable energies).

520.1 M€. The extra cost generated by the feed-in tariffs for renewable energies was therefore 124.1 M€ in 2006.

This cost can then be related to the volume of CO_2 emissions reduced by the use of renewable energies. The situation in France is unique on account of the utilisation of nuclear energy, which emits very little CO_2, during "base"[12] periods and the use of fossil fuels or hydroelectric power to meet peak demand. The generation of electricity from renewable energies can therefore replace either the energy from fossil fuels or hydroelectric power, or the electricity generated from nuclear power. If the final kWh used is of fossil origin, its CO_2 emissions will be approximately 800 g/CO_2MWh; if the kWh avoided is of hydroelectric or nuclear origin, its emissions will be zero. The type of final kWh used depends on multiple factors: instantaneous demand, available capacities, operating priorities, management of generating capacity, etc. An annual average of the thermal marginal rate was estimated at 35% in 2010 by ADEME. The emissions avoided by the use of renewable energies in Metropolitan France therefore total 300 gCO_2/MWh (DGEMP, 2003). We shall use this value in the rest of our calculations[13].

According to these data, the generation of 10 TWh of electricity from renewable energy sources avoided the emission of 3.14 metric tons of CO_2 in 2006. By relating this figure to the extra cost linked to the feed-in tariff, we get a cost of the carbon dioxide avoided on the order of 39.5 €/tCO_2.

These calculations are limited to Metropolitan France and do not take into consideration other forms of assistance such as the tax credit for individuals or regional subsidies for research or investment in renewable energies. Nor is any consideration given to other positive or negative external factors such as economic growth due to the development of renewable energies. The approximate nature of this calculation nevertheless gives an order of magnitude of the cost of this stimulus mechanism for renewable energies per ton of carbon dioxide avoided.

C. A policy based on quantitative objectives in the United Kingdom

The market for Renewables Obligation Certificates

In contrast to the French stimulus policy based on price, the United Kingdom has chosen to base its stimulus policy on quantitative production objectives. The obligation to buy green certificates, called "Renewables Obligation Certificates (ROCs)" took effect in the United Kingdom in 2002 in the context of the Utilities Act (2000), and is guaranteed to remain in place until 2027. This mechanism requires electric power distributors to offer in their portfolios an increasing proportion of electric power generated from renewable energy sources: 3% during the start-up period (2002-2003), followed by 7.9% in the period 2007/2008 and increasing to 10.4% in 2010. The British government thereby intends to meet the objectives of the 2001 European directive which sets the share of electric power from renewable energy sources in the United Kingdom's gross electric power consumption at 10% by 2010.

Producers of electricity from renewable energy sources, with the exception of the operators of large hydroelectric power stations, receive one Renewables Obligation Certificate for each MWh generated. These certificates are then sold to the power distributors, who must submit them to satisfy their obligation. There are several ways in which the electric power distributors can obtain these certificates:

- by generating electric power themselves from renewable energy sources;

- by buying the ROCs at the same time as the energy from the producers of electricity from renewable sources;

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[12] The "base" generation supplies the share of permanent consumption throughout the year, while peak production is the power generated in response to peak consumption.

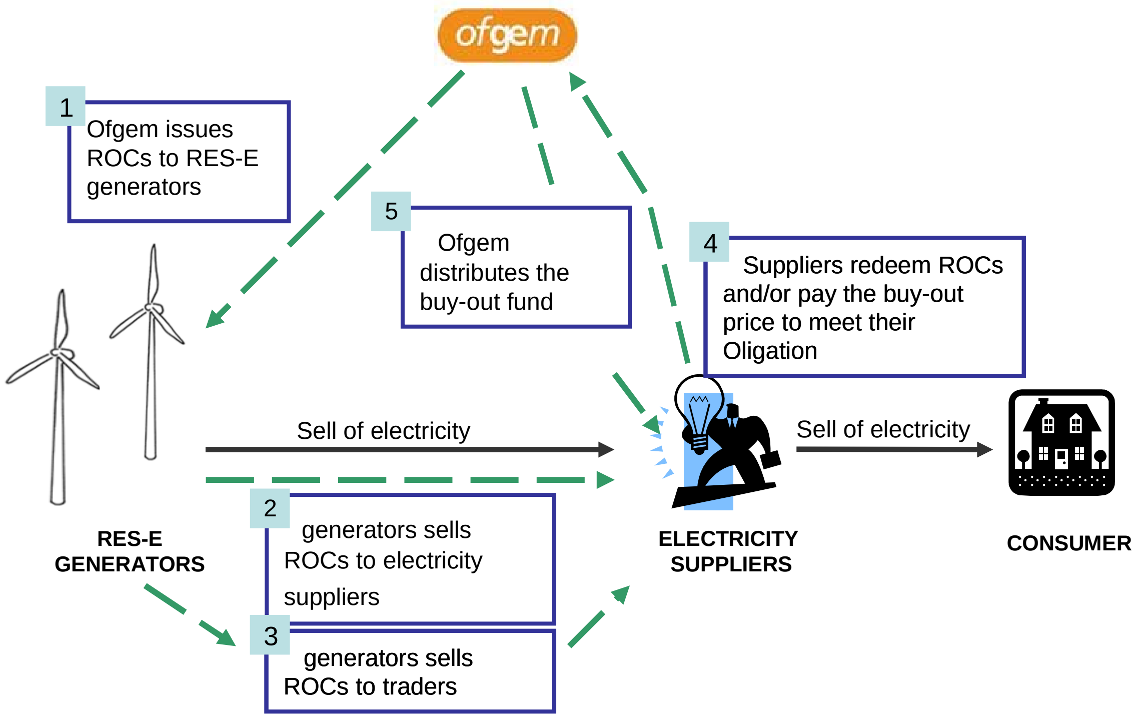
[13] The fluidity of trades in Europe, in particular with Germany, is making it increasingly more difficult to determine national value of the CO_2 content in the electricity. Moreover, this question of avoided emissions is a subject of debate among proponents of the use of the average of the emissions and those who prefer the marginal kWh.

- by buying only the ROCs from producers;

- by buying ROCs on a secondary market.

Suppliers meet their obligations by presenting a sufficient number of ROCs to cover their obligations. Where suppliers do not have sufficient ROCs to meet their obligation, they must pay an equivalent amount into a fund known as buy-out, the proceeds of which are paid back on a pro-rated basis to those suppliers that have presented ROCs.The buy-out price is set each year by the Office of Gas and Electricity Markets (OFGEM), the organisation in charge of the management of the ROCs. It was introduced in 2002 at 30 £/MWh, has been adjusted each year due to inflation, and was 33.24 £/MWh during the period 2006/2007 (48 €/MWh at the exchange rate as of July 1, 2006).

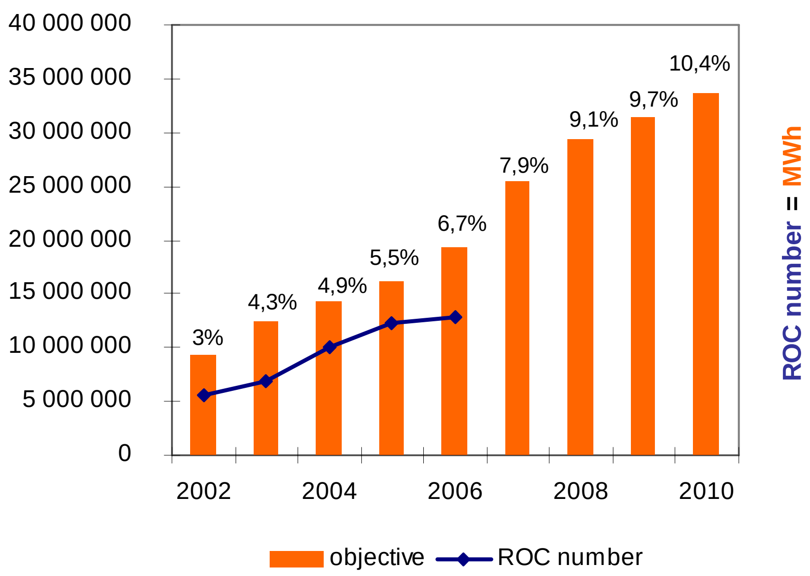
Figure 10 – Operation of the British policy or Renewables Obligation Certificates



Source: Mission Climat of Caisse des Dépôts, from Harrison, 2004.

The British policy based on Renewables Obligation Certificates subsidises the producers of energy generated from renewable sources. In addition to the market price of the electricity, there is a potential additional profit linked to the sale of the ROCs, which increases the ROI of their production. Figure 11 illustrates the growth trend of renewable energies since the implementation of the ROC mechanism, the number of ROCs increasing from 5.6 millions in 2002 to 12.9 millions during the period 2006/2007.

Figure 11 – Production target for electricity from renewable sources and growth in the number of ROCs presented



Source: Ofgem, 2008.

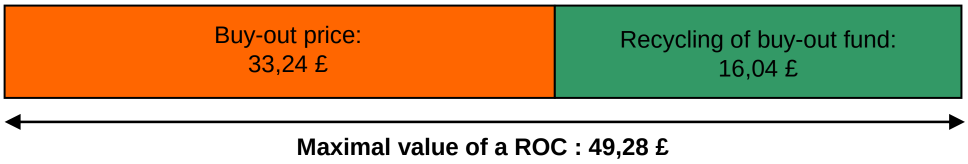
Value of the ROCs

The amount of the buy-out price and the level of the annual obligation are the two principal factors that determine the price of the ROCs. A high buy-out price ensures that the electric power distributors are prepared to pay a significant price to the producers of electricity from renewable sources.

For the electric power distributors, the value of the certificates is increased by the redistribution of the buy-out fund : each certificate presented guarantees that they will receive a share of this fund. This additional revenue is therefore taken into consideration by the generators of electric power from renewable sources in the calculation of the selling price of their ROCs, either ex-ante by estimating this additional revenue in advance or ex-post by utilizing OFGEM's annual financial statement reporting the amount of the fines to request the electric power distributors to repay the additional revenue to the generators of electric power from renewable sources.

When the supply of ROCs is insufficient to meet the objectives, the distributors of electric power are required to pay the equivalent amount and the buy-out fund increases. Consequently, the value of the ROCs also increases, which stimulates capital investment in renewable energies to build new power generation capacities.

Figure 12 – Maximum value of ROCs paid to producers of electric power from renewable sources during the period 2006-2007



Source: Brown, 2007.

The price of a certificate follows market trends, varying up or down with the buy-out fund. Most ROCs are sold simultaneously with the purchase of the electricity. The average value of the certificates on the *e-roc* auction website was £ 43.06 during the period 2006-2007. In the following portion of this study, we will use an average price of the ROCs of £ 45 (56 € at the current exchange rate).

The additional mechanism of the tax on electric power consumption

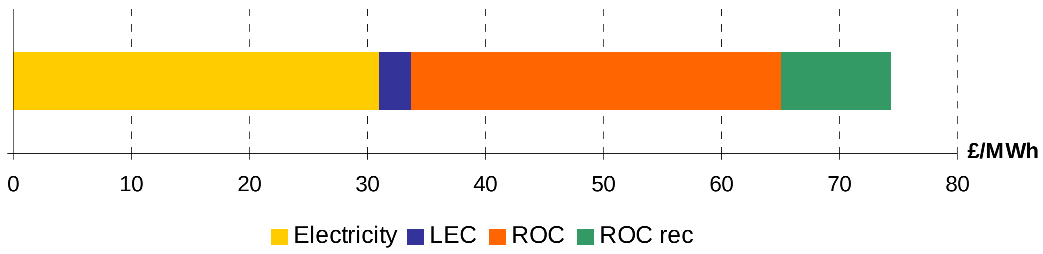
First imposed in 2001, the Climate Change Levy (CCL) is a tax measure applied to the energy sector to promote energy efficiency and to help the United Kingdom meet its greenhouse gas emissions reduction commitment. The CCL taxes energy used in industry, commerce and the public sector according to the type of energy used. It was 4.56 £/MWh in April 2008 (5.7 € at the current exchange rate).

Companies can be exempted from this tax by signing voluntary agreements or by purchasing their power from an electric power producer that uses renewable sources. According to the same principle as the ROCs, these producers receive one exemption certificate for each MWh generated. This certificate is then sold to companies in the public sector, industry and commerce. According to Harrison (2004), the average value of one exemption certificate equals 55% of the amount of the tax, i.e. £ 2.5 (3.2 € at the current exchange rate).

Repercussions of the tax mechanisms and the ROCs on the price of electric power from renewable sources

The ROCs, the recycling of the buy-out fund, and the exemption certificates linked to the tax on electric power consumption increase the selling price of electricity from renewable sources for the distributors. Nevertheless, the mechanism that provides the greatest incentive for the development of renewable sources remains the ROCs, the revenue from which can more than double the selling price of electric power from renewable sources. Figure 13 illustrates the example of the selling price of electric power generated from biomass.

Figure 13 – Components of the selling price of electricity generated from biomass in June 2006



Source: Parker, 2007, author's calculations.

Calculation of the cost of the British policies per ton of CO_2 avoided

The mechanisms of the ROCs and the Climate Change Levy tax exemption certificates are added to the price of electric power. In the same manner as above, we will analyse the cost of these incentive mechanisms in terms of the amount of carbon dioxide avoided.

During the period 2006-2007, almost 13 million ROCs were registered with OFGEM or, to be exact, 12,868,408 MWh of electricity generated from renewable sources. The average value of the ROCs was £ 45, to which we must add £ 2.5 corresponding to the average price of the exemption certificate. The cost of the stimulus mechanisms of the ROCs and of the Climate Change Levy is obtained by multiplying the amount of electricity generated from renewable sources by the cost of purchasing the certificates. The result is a compliance cost of £ 611 million.

To calculate the volume of carbon dioxide emissions avoided by the generation of electricity from renewable sources, let us consider the carbon emissions of the marginal electric power generated in the United Kingdom, i.e. around 800 gCO_2/MWh.

Power generation from renewable sources avoided slightly more than 10 million metric tons of CO_2 in 2006/2007 in United Kingdom. The cost of one metric ton of CO_2 avoided thanks to the stimulus mechanisms is therefore 59,4 £/tCO_2, i.e. 86 €/tCO_2, at the exchange rate as of July 1st, 2006.

D. Renewable energy incentive mechanisms: costs and outlooks

Results and evolution of incentive mechanisms

In each of the policies studied above, we can observe a net gain in terms of environmental protection, with several million tons of CO_2 avoided thanks to the growth of renewable energies. In terms of economic efficiency, the cost of one metric ton of CO_2 avoided thanks to the stimulus mechanisms is variable.

Table 5 – Balance sheet of the results achieved by the French and British policies promoting the growth of renewable energy in 2006

	France	UK
Electricty from renewable energy sources generated	10,5 TWh	12,9 TWh
Tons of CO_2 avoided	[300 g of CO_2/MWh] 3 M tons de CO_2	[800 g of CO_2/MWh] 10 M tons de CO_2
Additional cost due to incentives	124,1 M€	611 M£, soit 880 M€
Cost of public policies per tonne of CO_2 Cost of public policy per tonne of CO2	39,5 €/tCO_2	86 €/tCO_2

Source: Mission Climat of Caisse des Dépôts.

The British policy has resulted in the strong growth of renewable energy, which reached almost 13 TWh in 2006. This amount remains below the generation objectives, which explains the high cost of the ROCs. France generated 10.5 TWh thanks to new facilities. The increase in the feed-in tariffs, specifically for solar energy, presages an increase in capital investments toward new capacities for the generation of electricity from renewable sources.

In light of the evolution of the technologies and the reduction of the cost of generating electricity from renewable sources, the question arises of the appearance of undue profits linked to the renewable energy stimulus mechanisms. Several methods can be employed to fine-tune the subsidy policies to the growth of renewable energy. The feed-in tariffs for electricity generated from renewable sources are currently digressive in certain countries. That promotes innovation by encouraging producers to reduce their generation costs. In Germany, for example, the digressive curve of the feed-in tariffs follows the curve of progress achieved as a result of the learning effects.

As of April 1 2009, a new allocation method in the United Kingdom is designed to promote capital investments in the less profitable modes of power generation by increasing the number of ROCs per MWh for these technologies. The reverse method will be implemented for mature technologies. Overall the system will make it possible to achieve the objectives set by the British government more efficiently from an economic point of view.

Table 6 – Methods for the allocation of ROCs in the United Kingdom by technologies, beginning April 1, 2009

0,25 CV/MWh	1 CV/MWh	1,5 CV/MWh	2 CV/MWh
- Sewage gas - Landfill gas - Co-firing of non-energy crop biomass	- Onshore wind - Hydro-electric - Co-firing of energy crops - Energy from Waste with Combined Heat & Power	- Offshore wind - Dedicated regular biomass	- Wave - Tidal stream - ACT (anaerobic diestion, gasification, pyrolysis) - Dedicated biomass burning energy crops (with or without Combined Heat & Power, CHP) - Dedicated regular biomass with CHP - Solar PV - Geothermal

Source: Brown, 2007.

Guarantees of origin, toward European harmonisation?

The 2001 European directive introduced the mechanism of guarantees of origin which certify the renewable origin of electric power and allow observers to follow the evolution of renewables in European electricity consumption. The guarantees of origin indicate the source from which the electric power is generated and specify the dates and locations of generation. This system enables producers of renewable sources generated energy to prove that the electricity they sell is generated from renewable sources. However, these certificates have no value because they are not currently traded.

Following the model of the ROCs in the United Kingdom, these certificates could be traded on the European level. This issue is under discussion among power producers and the Member States. There are many arguments in favour of a market that employs the same principle as the carbon market, specifically that of optimizing the use of renewable energy where it would be the least expensive. For example, developing biomass power generation in Slovakia would be economically more efficient than the installation of off-shore wind farms in the United Kingdom. Nevertheless, there are doubts about the impact of a new renewable energy stimulus policy, in particular in the countries that have instituted feed-in tariffs. Because the 20% renewable energy target is well above the current share (8.5%), there is a risk that the certificates would reach a very high price (Toke, 2008).

The European Commission resolved the issue by stipulating in its January 2008 proposal[14] that only the States that meet their intermediate commitments would be able to sell their excess guarantees of origin to other countries. According to the working paper that accompanied the draft directive, another argument is being taken into consideration, namely not making a European market mandatory: the capital investments linked to the development of renewable energies are a territorial economic development instrument that individual States do not want to delegate to the market laws. Amendments were made to introduce various flexible mechanisms that governments may use to achieve their objectives in more economically efficient manner; these remain subject to a parliamentary vote.

III. Impact of the European carbon market on the growth of renewable energy

The national subsidy policies are designed to support the growth and development of renewable energies by assigning an additional value to the generation of electric power from renewable energies on top of the market price of electricity. Although the renewable energy development policies are generally selected at the level of the States, a community system already exists to reduce greenhouse gas emissions in the form of the European Union Emissions Trading Scheme. The EU ETS covers electric power producers, and could indirectly play a role in the development of renewable energy.

A. *A new constraint for electric power producers*

The electric power sector under the EU ETS

Beginning in 2005, the EU ETS imposed a new constraint on electric power producers. Combustion plants with an output greater than 20 MW are subject to a cap on their CO2 emissions in the form of allowances, where one allowance is equivalent to one metric ton of CO_2. Each installation receives an annual initial allocation of allowances, and each year must submit a number of allowances equal to its carbon dioxide emissions in the previous year. The economic benefit of this market resides in the ability to trade allowances, which promotes an efficient distribution of emissions-reduction efforts among the participants subject to the EU ETS. Installations that can employ low-cost measures to reduce their emissions can sell their excess allowances to installations for which the costs of reducing emissions would be higher. The scarcity of supply in the market results from a cap on the number of allowances and leads to the

[14] Climate Energy Package (Article 9, Paragraph 1) - Proposals are subject to a vote by the Parliament.

appearance of a carbon price which gives the installations that are subject to the market an incentive to reduce their emissions.

The combustion sector, which includes the generation of heat and electricity, cogeneration and the combustion activities of other industries, is the sector included in the market that emits the most CO_2. By itself it represents 70% of the total of the allowances allocated. A detailed study of the Allowance Allocation Plans and the emissions recorded in the Community Independent Transaction Log (CITL) conducted by the Mission Climat of Caisse des Dépôts has shown that within the combustion sector, only the electric power generation installations had a net deficit of allowances during the first phase of the EU ETS between 2005 and 2007.[15]

Therefore the electric power sector was subject to the greatest constraints under the EU ETS during the period 2005-2007. This can be explained by recalling that, because this sector is less exposed to international competition than other sectors, it was selected by many Member States to bear the majority of the burden of emissions reduction efforts. This absence of international competition allows the power sector to incorporate the additional cost of the emissions allowances into the prices it charges for its electric power.

The additional cost of CO_2 allowances and the market price of electricity

Electric power companies have the choice of using the allowances to cover emissions from their power generation operations or to reduce their emissions and resell their allowances to other installations that need additional allowances. Each allowance therefore has an opportunity cost equal to its price on the allowance market, which is included in the cost of production. The price on the electric power market reflects this new constraint, whether or not the allowances were allocated free of charge (Reinaud, 2003).

The marginal cost of the CO_2 constraint borne by an electric power producer depends on the carbon intensity of the means of production it uses (see Figure 20). According to an analysis by Sijm et al. (2006), an allowance price of 20 €/t would therefore increase the price of electricity by 1 to 5 €/MWh in France and from 13 to 14 €/MWh in the United Kingdom. The small increase in the cost of electricity in France occasioned by the CO_2 market is explained by the predominance of nuclear energy in the French energy mix.

Overall, the new CO_2 constraint has had the effect of increasing the price of electricity, which reduces the differential between the cost of generating electric power from renewable energy sources and the selling price on the market. If the electricity sold by a producer originates from forms of energy that do not emit carbon dioxide, the producer also benefits from a higher market price of electricity, which increases its profits. The price signal given by the CO_2 price, provided that it is significant, therefore makes renewable energy installations increasingly competitive.

B. The CO_2 allowance price that stimulates capital investments in renewable energies

The long-term marginal costs of installations that burn fossil energy sources such as natural gas or coal will be increased by the price of the CO_2 allowances. For the CO_2 constraint to make the generation of electric power from renewable sources competitive, the price of the allowances must be high enough to compensate for the expensive initial capital investments which make the cost of generating electricity from renewable sources very high.

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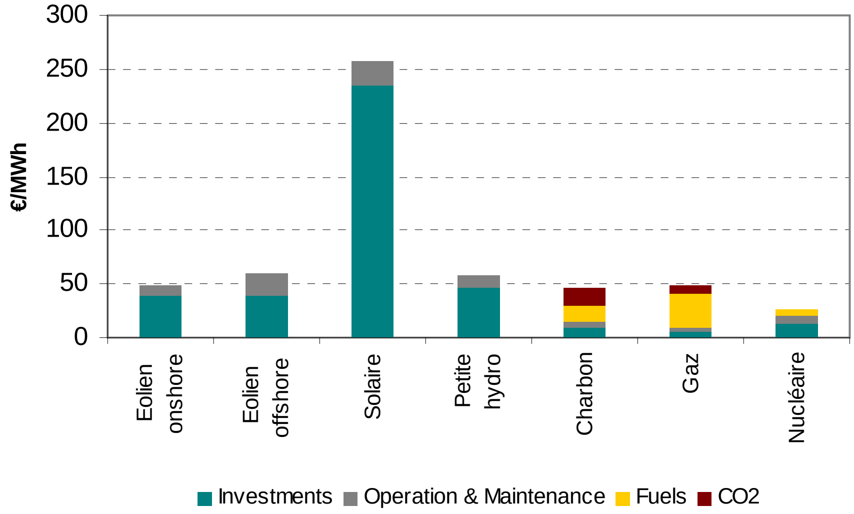
[15] *Allowance trading patterns during the EU ETS trial period: what does CITL reveal ,* Climat Report No. 13, June 2008.

Figure 14 – Long-term marginal cost of electricity as a function of the energy source utilised



Source: International Energy Agency, author's calculations.

We will calculate the price of the CO_2 allowance that stimulates capital investments in renewable energies by using the method developed in *Tendances Carbone*, the newsletter of Mission Climat of Caisse des Dépôts, which every month evaluates the price at which it becomes attractive to switch from coal to natural gas for electricity generation.

The switch price – the price of the CO_2 allowance that makes the production cost for the generation of electric power from the two sources equal – is calculated as follows:

$$\textit{Switch Price} = \frac{\cos t(energy1)/MWh - \cos t(energy2)/MWh}{tCO_2(energy2)/MWh - tCO_2(energy1)/MWh}$$

where:

Energy 1 represents a source of energy from a renewable source: wind, solar or small hydro

Energy 2 represents a source of fossil energy: natural gas or coal

Cost (natural gas) / MWh: cost of generating one MWh of electricity from natural gas (€/MWh)

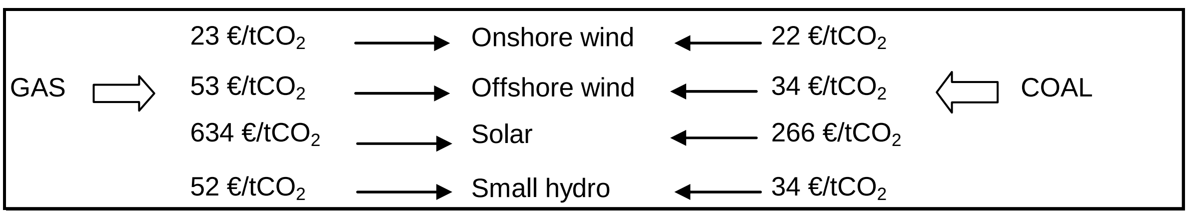
Cost (coal) / MWh: cost of generating one MWh of electricity from coal (€/MWh)

tCO2 (natural gas): CO_2 emissions from a standard natural gas-burning power plant per MWh of electricity (0.36 tCO_2/MWh)

tCO_2 (coal): CO_2 emissions from a standard coal-burning power plant per MWh of electricity (0.87 tCO_2/MWh)

The generation of electric power from renewable sources is CO_2-neutral. By applying the calculation method and the long-term marginal costs of electric power generation described above, one arrives at the prices that encourage the switch from a fossil energy source, e.g. natural gas or coal, to a renewable energy source.

Figure 15 – CO_2 allowance prices required to encourage the switch from fossil fuel to renewable energy sources for electric power generation on the European CO_2 market



Source: Mission Climat of Caisse des Dépôts.

As observed in Figure 15, the price of CO_2 must reach 23 €/tCO_2 for wind power technology to become competitive with natural gas, while it must reach 634 €/tCO_2 to provide an incentive to switch to solar power generation. The switch from coal to renewable energies occurs at a lower price per metric ton of CO_2 on account of CO_2 emissions factors that are higher for coal than for natural gas.

The average spot price of the CO_2 allowance traded on the BlueNext exchange has been 24.2 € since the beginning of the second phase of the EU ETS until October 31, 2008. This means that onshore wind energy has become competitive with fossil energies thanks to the CO_2 market. Nevertheless, the procedure used for the allocation of the CO_2 allowances during the first trading phase has limited the impact of the CO_2 constraint on the electric power sector.

C. Effect of the institutional rules of the EU ETS on the CO_2 constraint

The allowance allocation procedure has provided limited incentives for the growth of renewable energies

The market constraint for CO_2 allowance trading depends on the level at which emissions are capped and the method by which the allowances are allocated. During the first two phases of the EU ETS (2005-2007 and 2008-2012), the "grandfathering" method, by which allowances are distributed according to installations' historical emissions, was used in the majority of cases. Moreover, the allowances were distributed to the installations essentially free of charge[16].

Two rules for the allocation of allowances distorted the incentive effect of the CO_2 market, in particular for the electric power sector: the allocation reserved for new entrants and the rule that applies in the event of the shutdown of installations.

Member States had the option of reserving some allowances for new generation capacities (new installations or extensions of existing installations), which also benefit from free allowances. The carbon constraint was therefore not integrated either completely or directly in capital investment decisions. This principle is a disincentive because it causes investors to prefer less expensive technologies even if they emit more CO_2 (Godard, 2005). These allocation rules are all the more distortionary for electric power generation installations because they result in major differences between the treatment of power generation installations that burn fossil fuels and plants that produce no CO_2. The reserves of free allowances are in effect reserved exclusively for installations that emit CO_2, which results in a reduction in their investment costs. On the other hand, CO_2-neutral installations, nuclear power plants or plants that use renewable energy do not enjoy this benefit. These free allocations for new entrants can therefore result in generating capacities that emit more CO_2 than would be the case without the reserve mechanism (Ellerman, 2006).

Moreover, the majority of the National Allocation Plans specify that all allowances must be returned after an installation is shut down. The argument is that companies should not be able to make a profit on allowances they received free of charge, and that above all they should not benefit from relocating production outside the European Union (carbon leakage). However, the electric power sector is not able to move its installations easily. On the contrary, the ability to keep the allocations when an installation is shut down could provide an incentive to shut down old installations and open more modern and efficient installations, resulting in emissions reductions and including the utilisation of renewable energies. For example, the shutdown of a fossil fuel power generation site might make it possible to invest in a biogas plant. Under the current requirements, however, such a solution would lead to the loss of the allowances and the resulting opportunity cost. Therefore this mechanism acts as an incentive to keep installations in operation although they are no longer competitive (Godard, 2003).

[16] The sale of allowances at auction was limited to 5 % in Phase I and 10% in Phase II. During Phase I, only 4 of the 25 Member States held auctions and only Denmark reached the limit of 5 %.

The institutional rules for the allocation of allowances and the fact that they are free therefore do not strategically promote the development of renewable energies. The pilot phase of the EU ETS provided an opportunity to clarify the rules of the game of the emissions trading scheme, and it is now a question of ensuring that it evolves in a direction that guarantees a greater incentive.

The EU ETS will likely provide a greater incentive after 2012

Changes to the EU ETS have been proposed by the European Commission in its Energy Climate Package, which was presented in January 2008. The proposal to modify the emissions trading scheme beginning in 2013 (revision of the Directive 2003/87) would change the rules for the allowance allocation and would specifically exclude the energy sector from receiving any free allocations. The sale at auction of 100% of the electric power sector's allowances could be a watershed for the reduction of CO_2 emissions. Considering the weight of the energy sector, the share of allocations up for auction would represent approximately 60% of total Community volume.

The sale at auction of the allowances for the electric power sector would have the effect of avoiding:

- any distribution of the allocations by governments and the related problems, such as an excessively high cap on emissions for certain installations in relation to their emissions;
- profits generated by electric power companies thanks to the free allocation of allowances.

This new allocation system should not have much of an effect on the price of electricity. The CO_2 constraint will henceforth be shifted 100% into the price of the electricity, due to the purchase of the allowances at auction. Nevertheless, the ability of the electric sector to reflect the cost of the emissions allowances has already been demonstrated during the first phase of the EU ETS. On the other hand, an increase in the cost of the electricity could occur as a result of the reduction of the cap on emissions in the third phase, which will make allowances harder to come by. The European Commission estimates that the increase from now until 2020 will not exceed 10 to 15% compared to the price of CO_2 in Phase II.

Overall, the system of allocating allowances by auction will make it possible to re-establish the CO_2 constraint for new entrants and to provide an even greater incentive to reduce emissions, as installations seek to avoid purchasing allowances at the market price. Companies that generate electricity from renewable sources will then have a real advantage because they will not be subject to this CO_2 constraint and it will become that much more attractive to invest in CO_2-neutral energies as a way to reduce CO_2 emissions.

IV. Outlook

Faced with an anticipated rise in the demand for energy and a limit in the stock of fossil fuels, it is important to improve energy efficiency and to develop low-carbon methods of energy production, including renewable energies. The European Union has proposed new goals in the Energy-Climate Package and the Member States have put in place direct incentives which have helped stimulate the renewable energy market. In the fight against climate change, the EU ETS also provides incentives for the electricity sector to reduce its CO_2 emissions.

This report allows us to observe that the constraint imposed by the carbon market could stimulate the development of already-mature renewable technologies over the short term, including wind power. The reduction in the emissions cap and the end of free allowance allocation, especially for new market entrants, will impose a stronger constraint on the electricity sector. From 2013 onward, the carbon price signal should play a more important role and electricity producers will have a greater inventive to reduce their CO_2 emissions by investing in renewable energy sources. A CO_2 price of 23 € per ton is already a large enough incentive for power producers to switch from natural gas to wind power generation.

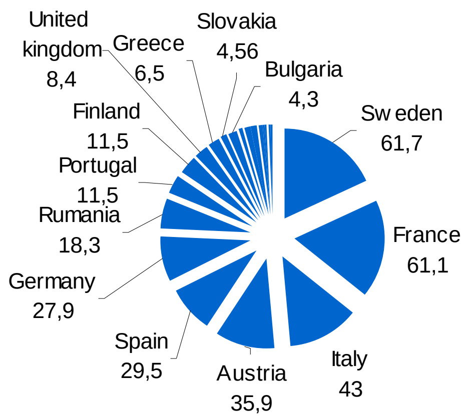
However, the CO_2 price will not be sufficient to assure the deployment of renewable energies that are still in the early stages of development, like solar power. It would thus be wise to concentrate the funds supporting renewable energy development on the technologies that are not yet mature but that could have great environmental benefits. The effectiveness of action against climate change will thus rest on the implementation of complementary policy instruments: a CO_2 price to encourage the deployment of mature technologies like wind, and additional policies to stimulate the development renewable energy sources that are still maturing. Finding the correct balance between these complementary policies is one of the conditions that will make possible the achievement of the objectives set forth in the post-2012 Energy-Climate Package.

ANNEX 1 – THE EVOLUTION OF THE RENEWABLE ENERGY MARKET IN EUROPE

Stabilization of the market for hydroelectric power

Hydroelectric power production totalled 341 TWh in 2006, a figure which has remained relatively stable in recent years. The potential for small hydroelectric installations in Europe, taking environmental and economic factors into consideration, is estimated at 24 TWh[17].

Figure 16 – Principal European countries producing hydroelectric power in 2006 (TWh)

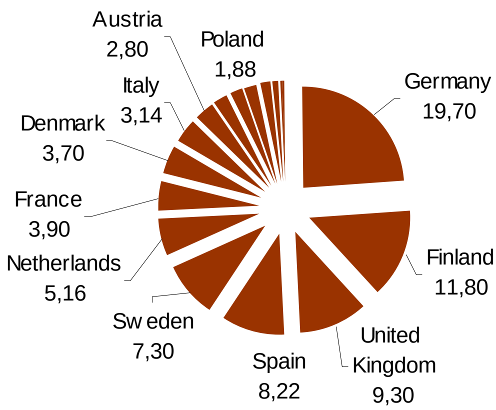


Source: Observ'ER, 2007.

Biomass: the engine for cogeneration and natural gas production

The principal countries that produce solid biomass (wood, wood chips, other plant material and solid animal materials) are countries with large forested areas such as France, Sweden, Germany and Finland. The generation of electric power from solid biomass increased to 48.8 TWh in 2006, primarily due to the growth of cogeneration in Germany. For its part, renewable solid municipal waste generated 13 MWh of electricity in 2006. Electric power generation from biogas rose by 28.6% in 2006 to 17.8 TWh. Germany took the lead by increasing the generation of electric power from small agricultural methane units operated in cogeneration.

Figure 17 – Principal countries generating electricity from biomass in 2006 (TWh)



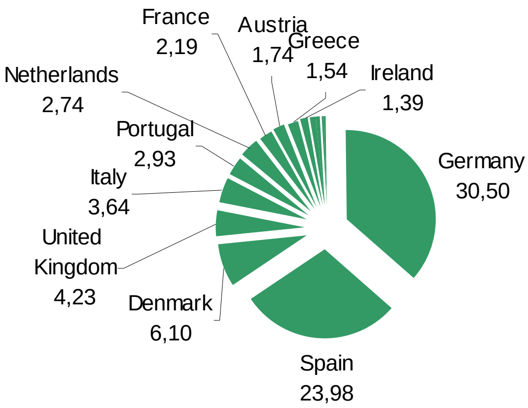
Source: Observ'ER, 2007.

[17] European Small Hydraulic Association, 2004.

A large increase in wind power generation

Installed wind power in Europe increased by 17% from 2006 to 2007, to 56 MW. This represents 60% of the world's installed capacity. The generation of electric power from wind totalled 90 TWh in 2007. France, which is considered to have the second-largest wind resources in Europe, was nevertheless barely able to maintain the growth of its market. In terms of per capita installed capacity, Denmark is in first place among countries that generate electricity from wind power. The offshore market is solidifying, in particular thanks to the voluntary policy of the United Kingdom, where this mode of production passed the 1 GW mark in installed capacity.

Figure 18 – Principal European countries generating electricity from wind power in 2006 (TWh)

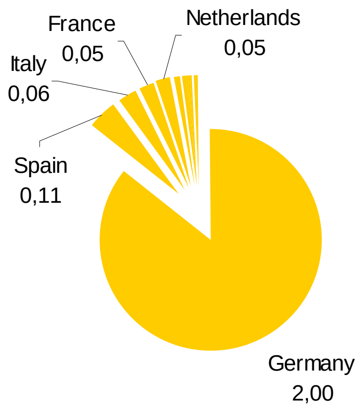


Source: Observ'ER, 2007.

Technological evolutions in the photovoltaic sector

The German market is still the leader in the solar photovoltaic sector. The growth of the Spanish and Italian markets continued in 2007. On the technological level, reductions in generating cost are expected, in particular as a result of the development of thin-layer technologies which can be used to produce panels using less material.

Figure 19 – Principal European countries generating photovoltaic electricity in 2006 (TWh)



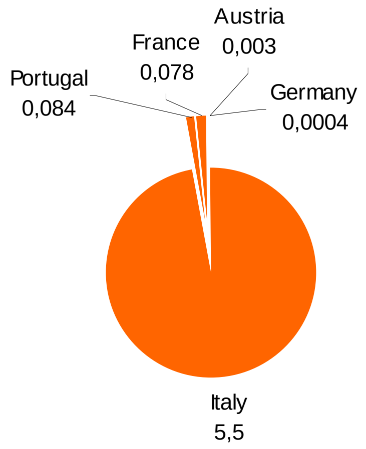
Source: Observ'ER, 2007.

The growth of thermal solar energy is also encouraging. As of the end of 2006, the total surface area of solar installations in operation in the European Union exceeded 20 million m^2. Germany leads the way with 8 million installed m^2, or approximately 6 GW of cumulative installed capacity in 2006. France is the fourth country in the Union to pass the bar of one million installed m^2, after Greece and Austria.

Geothermal: electricity and heat

The high-temperature geothermal resources are essentially all in Italy. They were used to generate 5.5 TWh in 2006. In France, these resources exist only in the French Overseas Territories, with two power plants in Guadeloupe.

Figure 20 – Principal European countries generating geothermal electricity in 2006 (TWh)



Source: Observ'ER, 2007.

The installed capacity for low-temperature and medium-temperature geothermal energy was 2.2 GW in 2007. Hungary is the largest user of this resource, followed by Italy and France.

Finally, the market for geothermal heat pumps is currently experiencing rapid growth in Europe. During 2006, it passed the mark of 100,000 units sold, reaching a total of approximately 600,000 units and 7.3 GW of installed capacity in Europe. Sweden has almost half of the European units, followed by Germany and France, which have 91,000 and 84,000 units respectively.

ANNEX 2 – BUDGET OF THE CSPE

Table 7 – 2006 budget of the CSPE for reimbursement of the feed-in tariff to EDF

	prod hydro (GWh)	prod wind (GWh)	incineration (GWh)	biogas (GWh)	others (GWh)	total production (GWh)	monthly electricity market (€/MWh)	avoided cost (M€)
January	474	127	194	8	52	855	66,71	57,0
February	462	136	177	7	52	834	73,14	61,0
March	733	190	200	9	60	1192	64,04	76,3
April	819	140	142	9	56	1166	41,59	48,5
May	704	158	169	10	27	1068	32,92	35,2
June	414	93	118	11	12	648	39,81	25,8
July	301	84	142	11	10	548	71,11	39,0
August	281	179	159	11	13	643	38,98	25,1
September	318	151	140	11	14	634	43,73	27,7
October	433	232	150	16	30	861	40,15	34,6
November	377	290	193	11	56	927	48,12	44,6
December	507	312	202	11	62	1094	41,46	45,4
						total : 10470	average : 50,14	total : 520,1
total prod (GWh)	5823	2092	1986	125	444			
cost unit purchase (€/MWh)	55,1	84,6	50,4	64	86,3			
total cost of feed-in tariffs by sector (M€)	320,8	177,0	100,1	8,0	38,3	total purchase : 644,2		excess : 124,1

Source: Energy Regulation Commission, 2008, author's calculations.

Table 8 – 2003-2008 budget of the CSPE for reimbursement of the feed-in tariff to EDF

	2003	2004	2005	2006	2007	2008
Quantity of RES-E eligible for feed-in tariffs (GWh)	6054	8059	9096	10470	12630	14480
Cost of purchase with feed-in tariffs (M€)	344	451	519	644	801	1007
Cost of purchase on electricity market (M€)	175	203	421	520	729	907
Charges dues to feed-in tariffs (M€)	169	248	99	124	72	100

Source: Energy Regulation Commission, 2008, author's calculations.

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Publication Director:

Christian de Perthuis +33 1 58 50 22 62
christian.deperthuis@caissedesdepots.fr

Mission Climat Contacts:

Emilie Alberola +33 1 58 50 41 76
emilie.alberola@caissedesdepots.fr

May Armstrong +33 1 58 50 76 27
may.armstrong@caissedesdepots.fr

Valentin Bellassen +33 1 58 50 19 75
valentin.bellassen@caissedesdepots.fr

Cécile Bordier +33 1 58 50 85 20
cecile.bordier@caissedesdepots.fr

Malika Boumaza +33 1 58 50 37 38
malika.boumaza@caissedesdepots.fr

Henri Casella +33 1 58 50 98 10
henri.casella@caissedesdepots.fr

Ian Cochran +33 1 58 50 41 77
ian.cochran@caissedesdepots.fr

Anaïs Delbosc +33 1 58 50 99 28
anais.delbosc@caissedesdepots.fr

Anita Drouet +33 1 58 50 85 19
anita.drouet@caissedesdepots.fr

Morgan Hervé-Mignucci +33 1 58 50 99 77
morgan.herve-mignucci@caissedesdepots.fr

Cate Hight +33 1 58 50 98 19
cate.hight@caissedesdepots.fr

Audrey Holm +33 1 58 50 74 89
audrey.holm@caissedesdepots.fr

Benoit Leguet +33 1 58 50 98 18
benoit.leguet@caissedesdepots.fr

Alexia Leseur +33 1 58 50 41 30
alexia.leseur@caissedesdepots.fr

Maria Mansanet-Bataller +33 1 58 50 85 22
maria.mansanet@caissedesdepots.fr

Carol Simon +33 1 58 50 98 20
carol.simon@caissedesdepots.fr

Raphaël Trotignon +33 1 58 50 96 04
raphaël.trotignon@caissedesdepots.fr

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