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MSc Program
Environmental Technology & International Affairs

WILL EUROPE ACHIEVE ITS RENEWABLE ENERGY TARGETS?
A legal, technological and economic analysis of the wind energy sector in Italy, France and the UK

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, 07.06.2011

Affidavit

I, **Giovanna Sartori**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Will Europe achieve its renewable energy targets? A legal, technological and economic analysis of the wind energy sector in Italy, France and the UK", 117 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 07.06.2010

Signature

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List of abbreviations:

AEEG	Autorità per l'Energia Elettrica e il Gas (Italian authority for electric energy and gas)
CCL	Climate Change Levy
EEA	European Environment Agency
EEX	European Energy Exchange
EWEA	European Wind Energy Association
FIT	Feed-in tariff
GC	Green Certificate
GME	Gestore Mercati Energetici (Energy market manager)
GSE	Gestore Servizi Energetici (Italian energy services administrator)
GWEC	Global Wind Energy Council
IEA	International Energy Agency
LCBP	Low Carbon Buildings Programme
NREAP	National Renewable Energy Action Plan
O&M	Operation and Maintenance
Ofgem	Office of Gas and Electricity Markets
RES	Renewable Energies
ROC	Renewable Order Certificate
TGC	Tradable Green Certificate
TSO	Transmission System Operator
WEA	World Energy Council

Abstract

In 2008, the European Commission has set a frame of targets to speed up the transition towards a low carbon economy, including a 20% achievement of renewable energy share in final energy consumption by 2020. In order to reach such an ambitious goal, all European countries are adopting different support strategies and wind energy has emerged as one of the most promising solutions to reach these targets. However, the speed of wind power deployment in the different European countries has been markedly different over the past decade. In this paper, the specific situations of three representative countries (Italy, France and the UK) are examined to assess whether the European targets are likely to be achieved. The wind sector is analysed from three different points of view - legal, technological and economic. Regulatory issues and support schemes prove to be critical in the deployment process, as investments rates are highly dependant on them. Technology, industry development, costs and electricity prices are also investigated and compared. Final considerations are drown based on what emerged from the analysis.

Keywords: Wind energy, Renewables, Europe.

1. INTRODUCTION

In December 2008 the European Commission set a frame of medium-term targets to speed up the transition towards a low carbon economy, including a reduction of 20% of carbon emission and a 20% achievement of renewable energy share in final energy consumption by 2020. The electricity sector will likely bear the biggest share of the burden (compered to the heat and transport sectors) and among the different renewable energy sources, wind is emerging as one of the most promising solutions to replace conventional fossil fuels.

Wind power has indeed been the fastest growing renewable electricity source over the past years in Europe and accounted for about 5% of the total European electricity demand in 2010 (EWEA, 2001b). However, the speed of wind power deployment in the different European countries has been markedly different over the past decade, reflecting different local barriers and different support mechanisms. While Germany, Spain and Denmark have secured the biggest share of the industry, accounting for more than 70 percent of the EU's installed capacity, other countries just came into the market, with large space for further development ahead.

This thesis looks into three European countries - Italy, France and the UK - as three scaling and expanding wind energy markets, whose success or failure to take off in the wind sector will greatly affect the European wind energy deployment as a whole.

The paper analyses the wind sector from three different points of view - legal, technological and economic - within the purpose to identify strengths and weaknesses of the system and eventually to indirectly assess whether the European targets for 2020 are likely to be achieved.

The work is organised as follows: the first session gives some background on the current wind potential and wind power capacity in Europe. The patterns of wind power development across the three countries are explored and factors such as the energy mix, the national targets for renewable energy and wind energy perception are scrutinised.

The second section focuses on the legal background and the support mechanisms in place in each country. Regulatory issues and support schemes are critical in explaining the differences in the wind power development rates across Europe.

The third section gives a brief insight into wind technology and explores the different levels of development of the national manufacturing industries.

In the last section an economic analysis is presented, with cost and benefits of wind energy deployment. Figures on investments, the influence on electricity prices and the contribution to employment are analysed and compared.

Finally the paper concludes by drawing some final considerations on the trends that emerged from the analysis and by highlighting some critical points for the achievement of the European 2020 targets.

2. SCENARIOS

2.1. EUROPE

Europe will face tough challenges over the coming years: climate change, depleting indigenous energy resources, increasing fuel and carbon costs, and the threat of supply disruptions. At the same time, Europe's power plants and electricity infrastructures are ageing. Over the next 12 years, 360 GW of new electricity capacity (50% of current EU electricity generating capacity) need to be built to replace ageing power plants (EWEA, 2009a). Europe must use this opportunity to construct a new, modern power system capable of meeting the energy and climate challenges of the twenty-first century, while enhancing its competitiveness. In such a contest, renewable energy has started to gain increasing importance and in 2009 the European Union has issued a new Directive on Renewable Energy (EU, 2009) to address all these problems on a European basis. The Directive sets mandatory national targets to reach a 20% share of renewable energies in overall Community energy consumption by 2020. Not surprisingly, wind power has turned out to be one of the main and most important candidate among renewable energies sources (RES) to realise the meet EU's energy policy objectives. Wind is a source of clean energy free of carbon dioxide emissions. It provides low-cost indigenous power. It is already an important export industry. And although it changes the landscape, agricultural and industrial activities can continue around it.

2.1.1. Wind energy potential

There is still a vast untapped wind potential in Europe that needs to be exploited. As Table 1. makes evident, the extent of wind energy resources in Europe is huge. Leaving aside some of the environmental, social and economic considerations, Europe's raw wind energy potential amount to some 70,000 TWh of potential power. Evidently, raw potential is only part of the story as this potential is constrained first by environmental and social issues, and then by economical viability. Even so, a study from the European Energy Agency (EEA, 2009) has shown how both 'environmentally & socially constrained potential' and 'economically

competitive potential' are still considerably high and worth exploiting (Table 1).

Table 1. Projected potential for wind energy development in 2020 and 2030 in Europe.

		Year	TWh
Technical potential	Onshore	2020	45 000
		2030	45 000
	Offshore	2020	25 000
		2030	30 000
	Total	2020	70 000
		2030	75 000
Constrained potential	Onshore	2020	39 000
		2030	39 000
	Offshore	2020	2 800
		2030	3 500
	Total	2020	41 800
		2030	42 500
Economically competitive potential	Onshore ([b])	2020	9 600
		2030	27 000
	Offshore	2020	2600
		2030	3400
	Total	2020	12 200
		2030	30 400

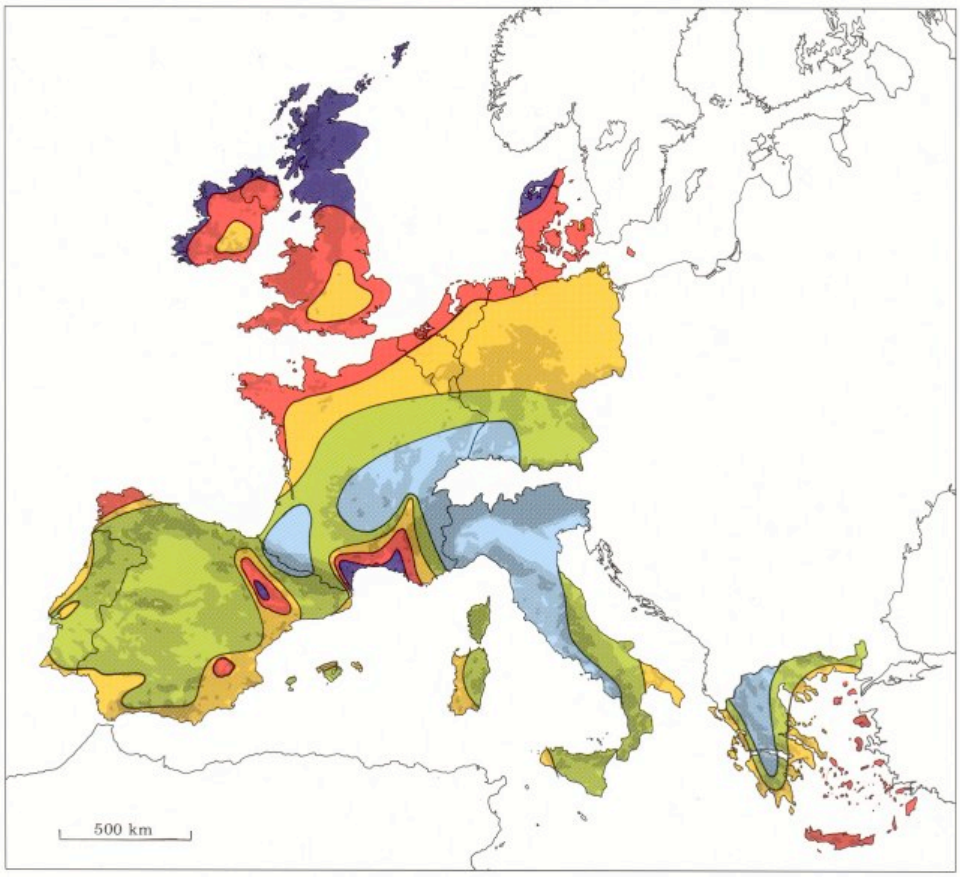
Source: EEA, 2009

The offshore 'constrained potential' has been calculated accounting for public opposition and the limitations imposed by shipping routes, military areas, oil and gas exploitation, tourist zones and protected areas. These environmental and social constraints have reduced the offshore potential by more than 90% (EEA, 2009). The onshore 'constrained potential' on the other hand is much less affected by environmental constraints. The 'economically competitive potential' has been determined by the average power production costs calculated based on forecasted costs of developing and running wind farms, CO_2 prices (22€/t in 2020 and 24€/t in 2030) and oil prices (55 USD/bbl in 2005 rising to 63 USD/bbl in 2030) (EEA, 2009).

Despite being a small proportion of the total technical potential (12,200 TWh out of 70,000 TWh), the 'economically competitive potential' of wind energy in 2020 is still *three times greater* than the expected European electricity demand in the same year which is reckoned to be around 4,000 TWh (EEA, 2009). The fact that this potential, even in a relative short time horizon, is so much bigger than the electricity demand, means that it is worth exploiting and that the key need for policy makers should be on facilitating the integration of wind energy into the energy system via research and development.

Although the wind resource is very high, it is unevenly spread between countries and within each country: Europe presents different wind scenarios whose potential normally changes with the latitude, increasing from the south to the north of the continent, as represented in figure 1. and 2. Figure 1. shows the so-called generalised wind climate over Europe, also sometimes referred to as the regional wind climate or simply the wind atlas. In such a map, the influences of local topography have been removed and only the variations on the large scale are shown. Therefore although data might indicate low wind speed for a particular grid cell, local effects can enhance the wind resource, making power generation possible. Highly elevated areas for example are usually complex terrain where in the valleys wind speed are low, while on top of mountains wind speed can increase by more than 70%, depending on the local slopes.

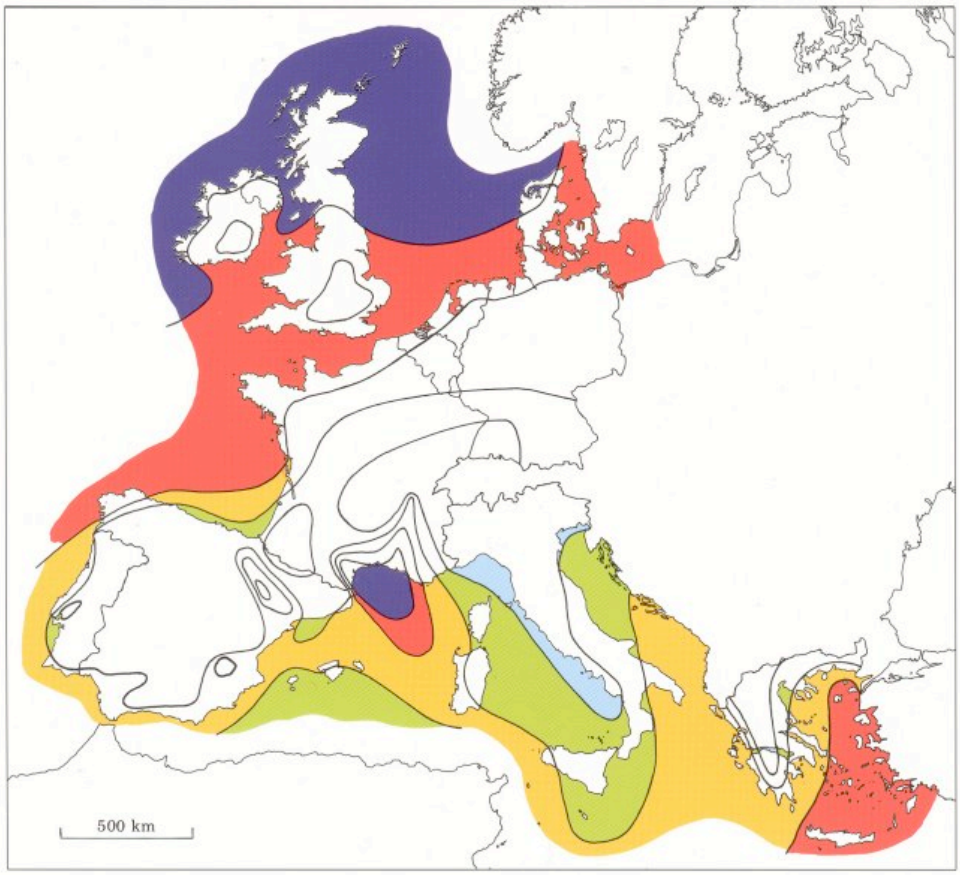
Figure 1. European onshore wind resources, at 50 metres a.g.l.



Wind resources[1] at 50 metres above ground level for five different topographic conditions										
	Sheltered terrain[2]		Open plain[3]		At a sea coast[4]		Open sea[5]		Hills and ridges[6]	
	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0- 8.5	400- 700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Source: European Wind Atlas

Figure 2. European offshore wind resources over open sea.

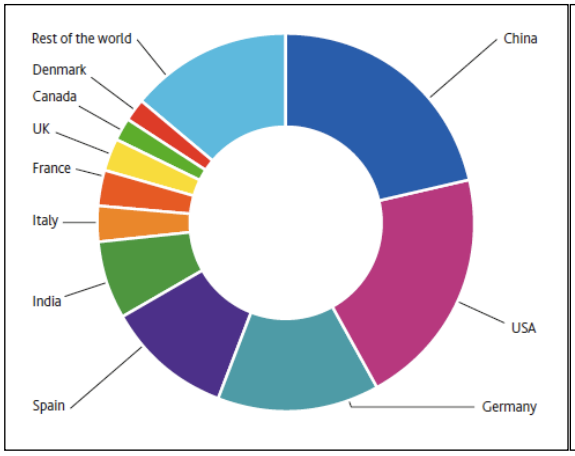


Wind resources over open sea (more than 10 km offshore) for five standard heights										
	10 m		25 m		50 m		100 m		200 m	
	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}
	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
	4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300

Source: European Wind Atlas

Looking at this map and considering the different wind potentials sweeping from the South to the North, I have chosen three different countries in Europe, a southern, a central and a northern one, so to cover all the main scenarios in the continent: these countries are Italy, France and the United Kingdom. I have chosen these three countries as they appear as the most interesting ones to study in terms of possible success or failure of their wind energy deployment. In fact, unlike Germany and Spain, that are already well established world markets (see Figure 3.), Italy, France and the UK are emerging markets with a good starting potential but with a lot to work on to develop it.

Figure 3. Top 10 cumulative world wind energy capacity in December 2010.



Country	MW	%
China	42,287	21.8
USA	40,180	20.7
Germany	27,214	14.0
Spain	20,676	10.6
India	13,065	6.7
Italy	5,797	3.0
France	5,660	2.9
UK	5,204	2.7
Canada	4,009	2.1
Denmark	3,752	1.9
Rest of the world	26,546	13.7
Total TOP 10	**167,844**	**86.3**
World Total	**194,390**	**100**

Source: GWEC, 2011

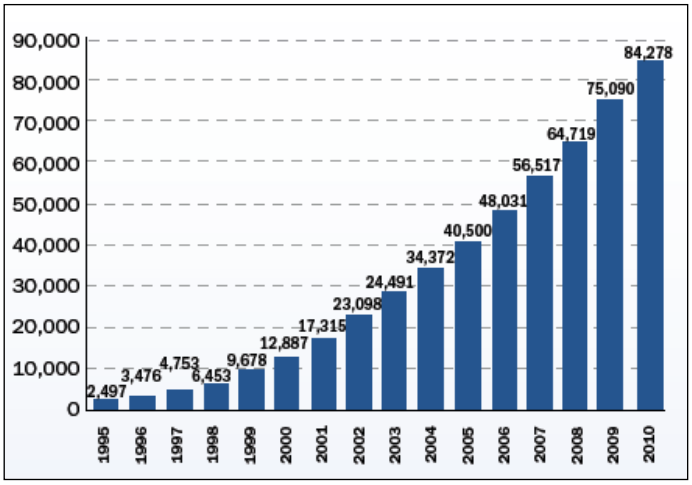
The competitive 2020 wind potentials for these countries, according to the EEA study (2009) mentioned above, will be 169 TWh for Italy, 1309 TWh for France and 4408 TWh for the UK.

France, the United Kingdom and Italy are respectively the second, third and fourth largest electricity consumers (after Germany) in Europe and wind energy is expected to contribute sustaining their electricity demand while being the main asset in their renewable energy share targets (IEA, 2010a).

2.1.2. Wind energy development

European wind power has known a fast development in the last decades. Supported by national frameworks and by the adoption of the two EU Directive on the Promotion of Electricity from Renewable Energy Sources (EU, 2001; EU, 2009), wind energy technology has taken off at high speed. Between 1991 and 2006, cumulative wind power capacity increased by an average of 33% per year, reaching in 2009 a capacity of 75 GW, from only 2.5 GW in 1995 (EC, 2011). The development was so important, that in 2008 more new wind power capacity was installed than any other power generating technology, including coal, gas and nuclear power. In the same year European manufacturers had a 60% share of the €36 billion global market for wind turbines (EWEA, 2009a). By the end of 2010 a total of 84 GW of wind power were installed in the European Union (Fig. 4). Such capacity will, in a normal wind year, produce 181 TWh of electricity, representing 5.3% of the EU's gross final electricity consumption (EWEA, 2011b).

Figure 4. Cumulative wind power installations in the EU in MW.



Source: (EWEA, 2011b)

The 2009 Directive on renewable energies expects the European share of *electricity* generation from renewables to climb from 17% in 2008 to 30% by 2020 with wind energy contributing with a 12% to the share. The World Energy Outlook 2010 reckons this target as achievable and expects wind energy to cover almost half of the 30% share (IEA, 2010c). Similarly the European Wind Energy Association's "baseline" scenario assumes 581 TWh of wind energy being produced in 2020, meeting 15.7% of EU electricity demand, from a total installed capacity of 230 GW of wind power. EWEA's "high" scenario is even more optimistic and assumes 680 TWh of electricity being produced in 2020 from a total installed wind power capacity of 265 GW. This would meet 18.4% of EU electricity demand (EWEA, 2011a).

Table 2. Primary energy demand (Mtoe), electricity demand (TWh) and wind share in EU.

	2000	2008	2020	2030
World - Primary energy demand (Mtoe)	10031	12271	14556	16041
EU - Primary energy demand (Mtoe)	1682	1755	1723	1719
EU - Electricity demand (TWh)	2627,9	2959	3500	3900
EU - Wind share in electricity demand	1%	4%	12%	18%

Data sources: Enerdata, 2010; EWEA 2011a; IEA 2010c.

2.2. ITALY

2.2.1. Energy situation

Italy, more than many other European countries, is very poor in indigenous resources. Its total domestic hydrocarbon production met less than 10% of the country's needs in 2008 and it will progressively decline in the coming years (IEA, 2011a). The supply mix is dominated by imported oil and natural gas that account for over 80% of the Total Primary Energy Supply (Fig. 14) and make the foreign energy dependance of the country one of the highest in Europe: 87.7% (Enerdata, 2010). Italy is now making strong efforts to increase capacity from renewable energy sources (RES), particularly from wind, geothermal, solar and biomass. Traditionally, hydropower has been the dominant form of renewable electricity in the country, representing more than two-thirds of present RES electricity output. Nevertheless in the last decades hydropower productions has fallen from over 50 TWh in 1990 to 38 TWh in 2007 (Fig. 5.), as a result of water regulation, ageing of plants, and reduced levels of precipitation (IEA, 2010a). To fill this gap in production, output from other renewable sources has emerged since 2000 and the country has witnessed strong growth in installed wind power capacity.

2.2.2. 2020 targets

Based on the targets set by the European Directive on Renewable Energy Sources (EU, 2009) Italy is expected to reach, by 2020, a 17% share of RES in total final energy consumption, which has been estimated at 133 Mtoe (Table 3.), assumed that energy efficiency will be improved (IMED, 2010). To reach the 17% share in total final energy consumption, the national targets for the RES share in electricity has been set at 26,4% by 2020 (starting from 18,71% in 2010).

Table 3. Expected gross final energy and electricity consumption in Italy, with RES share.

	2010	2012	2014	2016	2018	2020
Gross final energy consumption	131,8	132	132,3	132,5	132,7	133
RES-Overall share (EU 2020 targets):	8%	9%	10,5%	12%	13,8%	17%

of which:

	2010	2012	2014	2016	2018	2020
Electricity consumption (Mtoe):	30,7	31	31,3	31,6	31,9	32,2
RES-Electricity share:	18,7%	20,2%	21,7%	23,1%	24,6%	26,4%
Wind energy share:	3,4%					5,3%

Data sources: Italian Ministry for Economic Development, (2010); EWEA 2011a

The graphs below, plotted by the Italian Ministry of Economic Development, report an estimation of the deployment of renewable sources in electricity production and power generation up to 2020.

Figure 5. Estimation of gross electricity production from RES in Italy up to 2020.

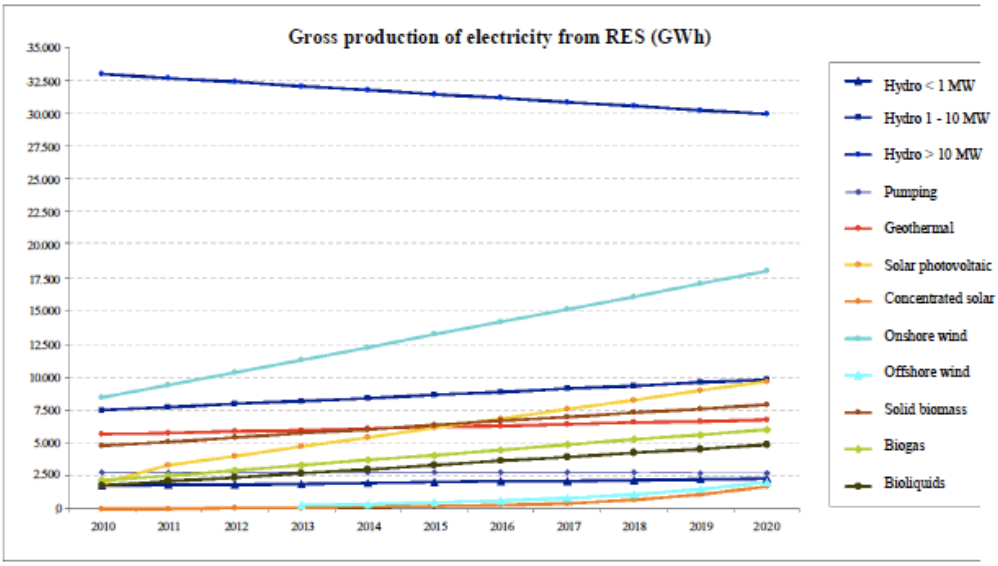
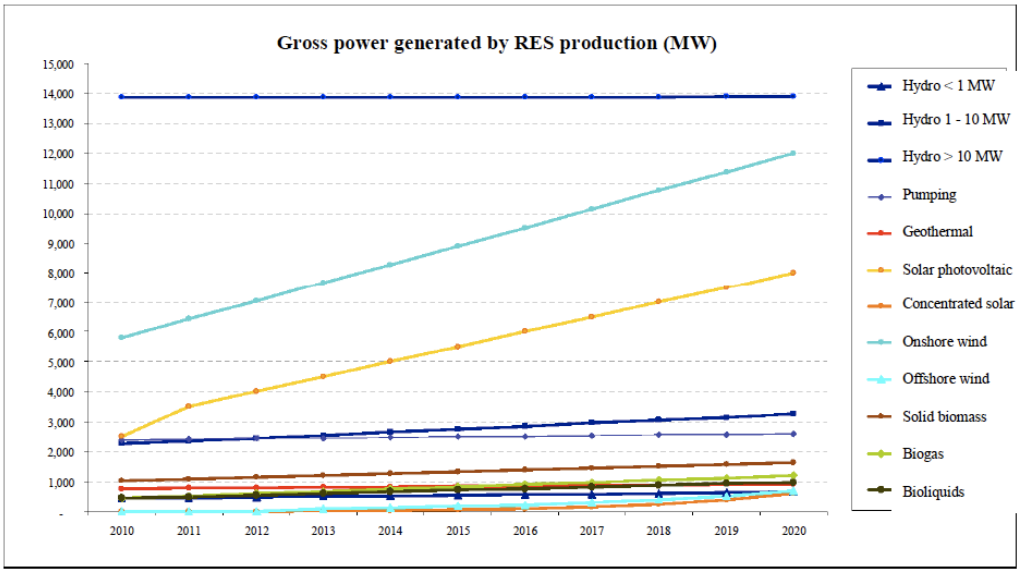


Figure 6. Estimation of gross power generated by RES in Italy up to 2020.



Source: IMED, 2010.

2.2.3. Wind energy development

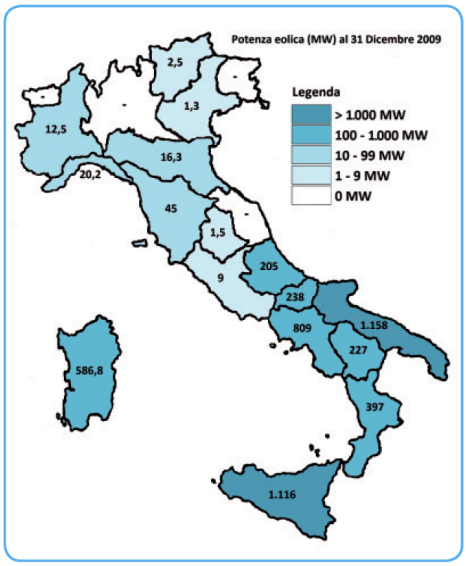
Wind energy is confirming its important role in Italy's electricity system, being now the third renewable source in the country, following hydro and biomass (IEA 2008). In 2008 wind energy started to enjoy a massive increase in power capacity: more than 1,010 MW was put into operation along the year, totalling a capacity of 3,736 MW or a share of wind energy of 1,9% of national electricity demand (IEA 2008). Installation of new wind farms continued at a brisk pace in 2009 when total online grid-connected wind capacity reached 4,850 MW (GWEC, 2009). The largest developments took place in the southern regions, particularly in Sicily, Apulia and Calabria, followed by Campania and Sardinia. Some developments started to take place in some central and northern regions as well, such as Liguria, Piedmont, Veneto, Emilia Romagna and Tuscany, with all onshore turbines and mostly at hill or mountain sites.

The Italian Wind Energy Association has estimated that more than 6.5 TWh were produced from wind farms in 2009, which was about 2% of total electricity demand on the Italian system (IEA, 2009a). In 2010 another 950 MW were installed in Italy, bringing the total capacity to 5,797 MW and the share of electricity production to approximately 2.5% (EWEA, 2011b). Nevertheless the development of wind energy in 2010 has slowed down compared to the previous years with a drop in installed capacity of 25% in relation to 2009 (ANEV, 2011). The reasons are probably to be found in the normative confusion and the international economic crisis which has led to increasing difficulties in financing new projects. Even so, wind is expected to be the renewable source that will grow the most in Italy, gaining an important position by 2020, second only to hydropower. The estimate made by the government for 2020, according to the 2007 Renewable Energy Position Paper of the Italian government, is of a maximum wind potential of 12,680 MW (680 MW of which from offshore installations).

Italy does not have a huge wind potential as shown in the atlas map (Fig. 5. and 6.) so only a few regions, mainly situated in the south of the country, can really engage in the development wind farms (Fig. 7.). At the same time the deployment process is hampered by geographic constraints - due to the mountainous and infertile terrain - and by demographic constraints - due to vast densely populated areas.

Nevertheless it is still worth exploiting the available and accessible areas as it has been shown that they can produce up to 5% of the national electricity demand, diversifying the energy portfolio, and contributing to a less dramatic foreign energetic dependance.

Figure 7. Wind power installed in Italian regions by end 2009.



Source: ANEV

2.4. FRANCE

2.4.1. Energy situation

France has a nuclear power and hydroelectric system that make its electricity one of the lowest in greenhouse gas emissions in the world. However, the Multi-annual Investment Programming for electricity (PPI) presented in 2009 contains a substantial increase in the share of renewable electricity to be produced in 2020 in order to cope with increased consumption and to position France as a leader in renewable energy. France is the second largest electricity consumer in OECD Europe (after Germany) and electricity is its only energy vector whose use should increase by 2020 (from 45.3 Mtoe in 2005 to 46.9 Mtoe in 2020): the main causes being the increase in electronic uses and the appearance of new uses such as electric cars and heat pumps (IEA, 2010b). The installed generating capacity in January 2009 stood at 117,7 GW and the share was distributed as this: nuclear 63,3 GW; hydro 25,4 GW; fossil fuels 24,7 GW; wind 3,3 GW; other renewables 1 GW (IEA, 2009a). As the foreign energetic dependance still amounts to 53,4% (Enerdta, 2010), wind could secure a ''third leg'' in the French power balance in addition to nuclear and hydro power.

2.4.2. 2020 targets

According to the EU Directive, France must increase its share of RES in its final energy demand from 10,3% in 2005 to 23% by 2020.

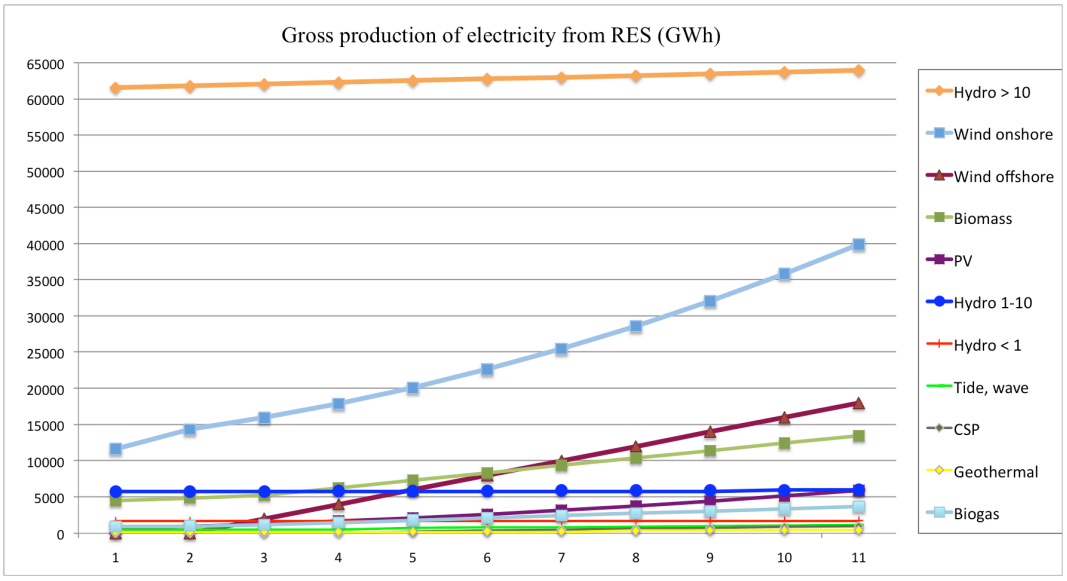
Table 4. Expected gross final energy and electricity consumption in France, with RES share.

	2010	2012	2014	2016	2018	2020
Gross final energy consumption (Mtoe)	164,4	162,5	160,7	159	157,3	195,7
RES-Overall share (EU 2020 target):	12,5%	14%	16%	18%	20,5%	23%
of which:						
Electricity consumption (Mtoe)	45,8	46	46,2	46,5	46,7	46,9
RES-Electricity share	15,5%	17%	19%	21,5%	24%	27%
Of which wind energy	2,3%					10,6%

Data sources: French Ministry, 2010; EWEA 2011a.

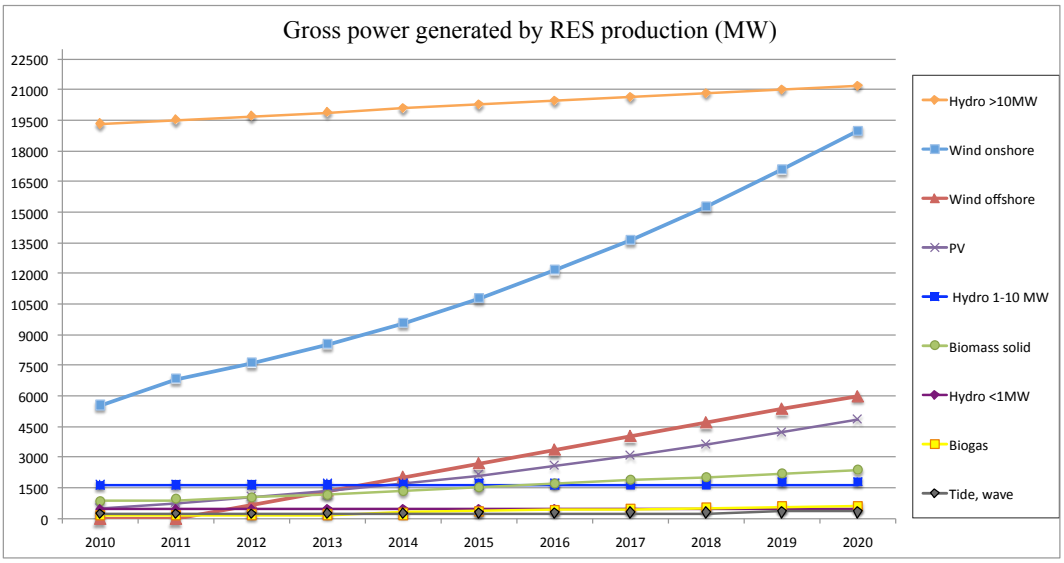
To meet these expectations, targets have been defined for each production sector. While the main source remains hydropower, wind power has been identified as the second main additional source, as shown in the two figures below (8. and 9.) based on the projection of the French Ministry for Ecology, Energy, Sustainable Development and See,

Figure 8. Estimation of gross electricity production from RES in France up to 2020.



Data source: FMEESDS, 2010

Figure 9. Estimation of gross power generated by renewable sources in France up to 2020.

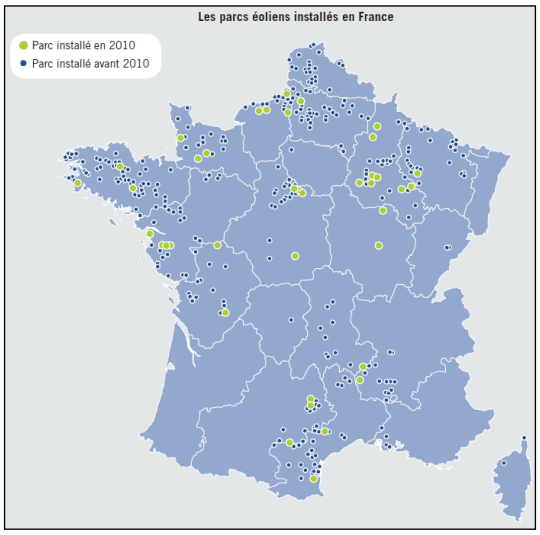


Data source: FMEESDS, 2010

2.4.3. Wind energy development

France enjoys Europe's second largest wind potential, and the wind resource is well distributed across the country (GWEC, 2010). The country had 3.3 GW of installed capacity in 2008 and that capacity grew to 4.6 GW in 2009 when wind turbines generated 7.8 TWh of electricity representing 1,6% of total power consumption (GWEC, 2010). Wind energy capacity reached 5.7 GW at the end of 2010 bringing overall wind power to produce 1,8% of the country's electricity demand (GWEC, 2011). The French government has set itself a target for achieving 11.5 GW of installed wind energy capacity by 2012 (1.5 of which should be offshore), and 25 GW by 2020 (6 GW of which offshore). 25 GW of wind energy would produce 55 TWh every year, thereby accounting for 10.6% of the country's total electricity consumption: this is more than half of the total expected RES share of 17% (EWEA, 2011a).

Figure 10. Wind parks in France in 2010.



Source: SRE, 2010

The installed capacity is evenly distributed on the whole territory, with the only exception of the south-west quarter of France due to smaller wind potential. Despite the high wind potential in France, there are still several barriers that hinder the development of wind energy in the country. These barriers include the slow authorisation procedure, inadequate grid connection capacity and the existence of zone in which wind power installations are forbidden. The constant changes in legislation and regulation and the addition of new authorisation requirements continue to hinder the pace of wind energy development.

2.4. UNITED KINGDOM

2.4.1. Energy situation

The United Kingdom is one of the major oil producers in the European Union, and, until recently, it was a net exporting country. However, the North Sea oil and gas production has been declining since its peak in 1999 making the country became a net importer of natural gas since 2004, and a net importer of oil since 2006. Oil and gas dominate the United Kingdom's Total Primary Energy Supply (TPES) mix, accounting for almost three-quarters of the total (40% and 33% respectively) (IEA, 2011b). The United Kingdom's TPES has remained quite constant since 1973 (with increased use of natural gas since the 1990s) but has declined marginally since 2005, dropping to an estimated 197 Mtoe in 2009 (IEA, 2011b) (Fig. 16.). The shares of oil and, particularly, coal have declined considerably over the same period, in favour of cleaner energies. The country has a foreign energetic dependance of 27,9% (Enerdata, 2010), which is quite low compared to Italy and France.

2.4.2. 2020 targets

The 2009 Renewable Energy Directive expects the UK to achieve a 15% share of its energy consumption from RES by 2020, starting from only 1.5% in 2005. Compared to many other Member States, the UK is starting from a very low level of RE consumption. While in recent years there has been a small increase in renewable energy use, reaching a 3% share in 2010, there will have to be a much greater level of deployment over the next decade in order to meet the target. The UK government assessed that delivering 15% of renewable energy by 2020 could be achieved and set the proportion to be fulfilled by each energy sector as such: around 30% of electricity demand; 12% of heat demand; 10% of transport demand. The focus here will be only on the electricity sector as it is the one to which wind energy contribute the most.

Table 5. Expected gross final energy and electricity consumption in the UK, with RES share.

	2010	2012	2014	2016	2018	2020
Gross final energy consumption	146,5	146,2	145,9	145,1	144,6	144,1
RES-Overall share (EU 2020 target):	3%	4%	6%	8%	11%	15%

of which:

Electricity consumption (Mtoe):	31,7	31,8	32	32,1	32,2	32,4
RES-Electricity share:	9%	11%	14%	19%	25%	31%
Of which wind energy:	3,2%					20,8%

Source: DECC 2010; EWEA 2011a.

Figure 11. Estimation of gross electricity production from RES in the UK up to 2020.

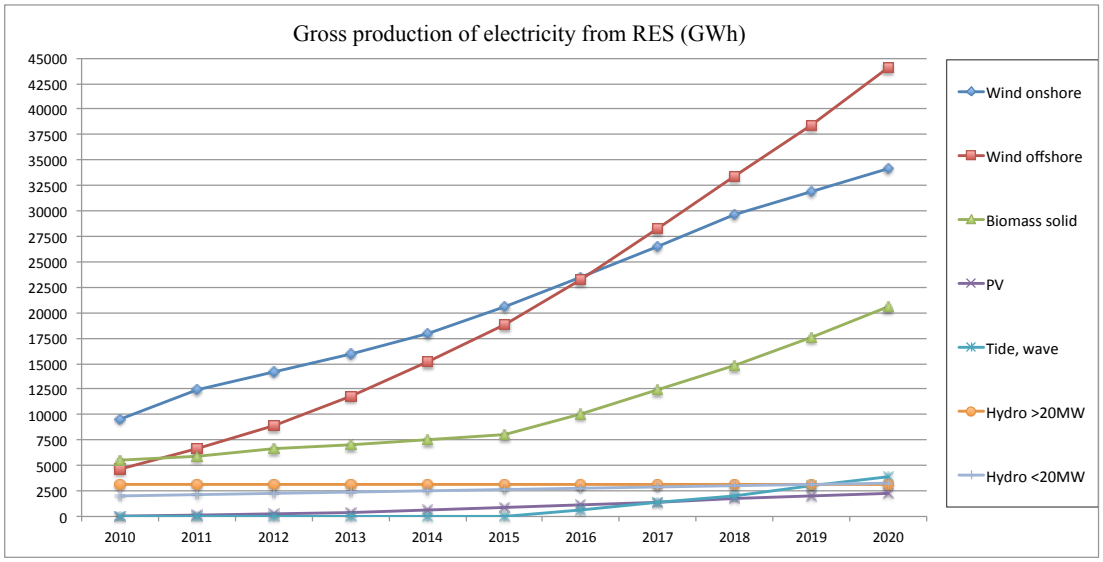
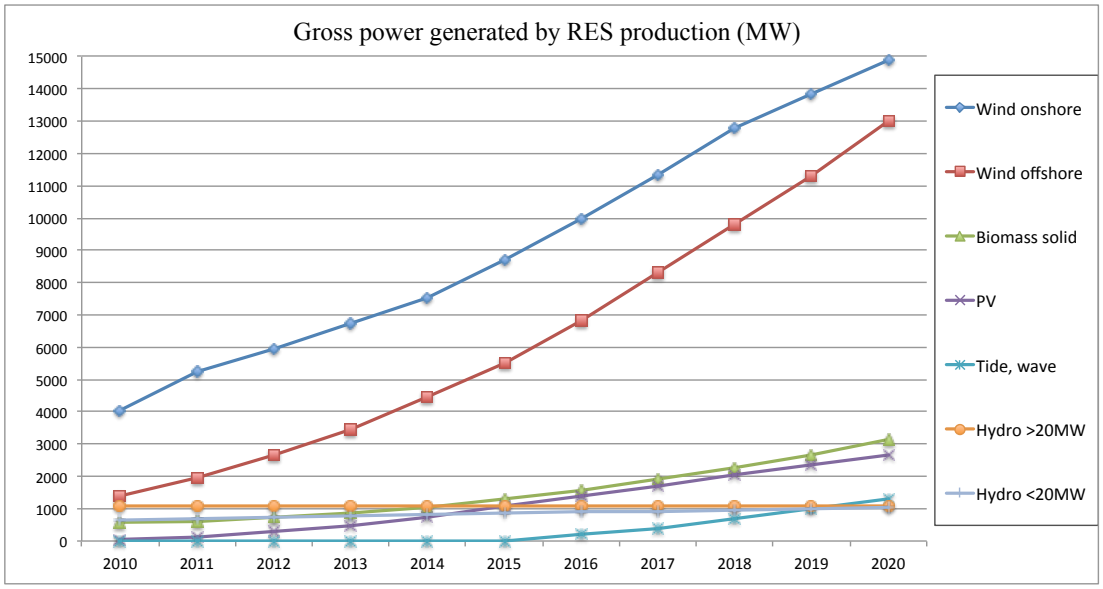


Figure 12. Estimation of gross power production by RES in the UK up to 2020.



Source Fig. 11,12: DECC, 2010.

2.4.3. Wind energy development

The UK has some of the best wind resources in Europe - if not in the world - in both onshore and offshore locations. Offshore wind is a key area for development, given the high potential of the wind and the extent of the sea area around the country. It is therefore highly expected, both by the government and industry experts, that wind power will represent the majority of new renewables capacity up to 2020. The British Wind Energy Association (BWEA) estimates that a substantial part of the huge offshore potential could be delivered by the end of the next decade, during a time when a considerable number of old fashioned coal and gas generation plants would reach the end of their lifetime or would have to be decommissioned for environmental reasons. Since 2008 wind energy deployment has been considerable in the UK. After a slow start the country has started to realise its wind power potential and to develop it. In 2008 more than 3,300 MW of wind energy capicity were installed and, with 598 MW of offshore wind energy capacity, the UK became the world leader in offshore wind energy (IEA, 2008). By the end of 2009 the total capacity amounted to 4,051 MW (IEA, 2009a). From January to December 2010, around 40 new wind farms came online, totalling 962 MW of additional capacity and bringing the total installed capacity to 5,204 MW (GWEC, 2010). With 1,341 MW of installed capacity offshore, the UK continues to be the world's leading offshore wind market.

As shown by Figure 11. and 12., wind energy will soon represent the main player among renewable energy sources in the country. This is due also to the fact that unlike other European countries, the UK has very limited hydropower.

The key problem for renewable energy developers in the UK is the public opposition to wind farms. Despite being only a small minority of the public, the anti-wind farms campaigners continue to have a strong public voice.

2.5. Analytical comparison

Table 6. Figures comparison.

	ITALY	FRANCE	UK
RES share in gross energy demand (2020 target)	17%	23%	15%
RES share in electricity demand - 2010 (of which WIND share)	19% (3,4%)	15% (2,3%)	9% (3,2%)
Wind installed capacity - 2010	**5,8 GW**	**5,7 GW**	**5,2 GW**
RES share in electricity demand - 2020 (of which WIND share)	26% (5,3%)	27% (10,6%)	31% (20,8%)
Wind installed capacity - 2020	**12,7 GW**	**25 GW**	**27,9 GW**

Data source: Enerdata, 2010; GWEC 2009; GWEC 2010; EIA 2009a; Italian, French Ministry 2010; DECC 2010.

While all three countries, Italy, France and the UK, are now at the same starting point with very similar total installed capacity (Table 6), their background, attitudes and expectations differ considerably. Starting from the wind potential, we find Europe's first and second largest wind potential in the UK and France, respectively, while Italy presents a much restricted potential. The rank of the foreign energetic dependance is inverted, starring Italy at the first place with an unlucky 87,7% followed by France with 53,4% and the UK with 27,9%. France has been producing electricity mainly from national nuclear and hydropower; the UK has always relied on indigenous gas; while Italy is heavily dependant on foreign gas (Fig. 14,15,16).

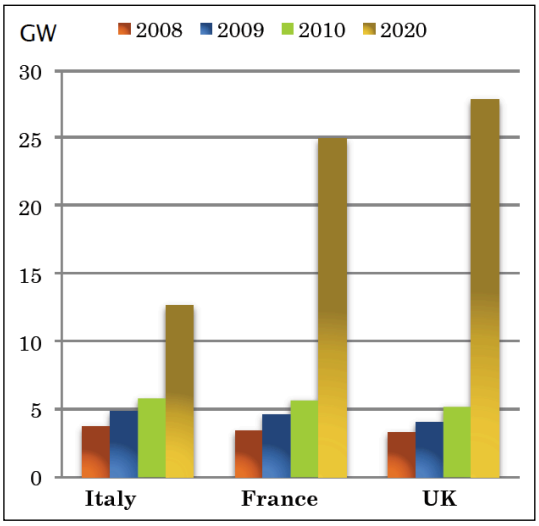
Table 7. Onshore and offshore wind capacity in Italy, France and the UK.

Country	2008 capacity (GW)		2020 national plan[a] (GW)		2020 EWEA high capacity (GW)	
	Onshore	Offshore	Onshore	Offshore	Onshore	Offshore
UK	2.7	0.59	14.9	13.0	14.0	20.0
France	3.4	–	19.0	6.0	20.0	6.0
Italy	3.7	–	12.0	0.7	17.0	1.0

Data source: Italian, French Ministry 2010; DECC 2010; EWEA, 2009a, Green (2011).

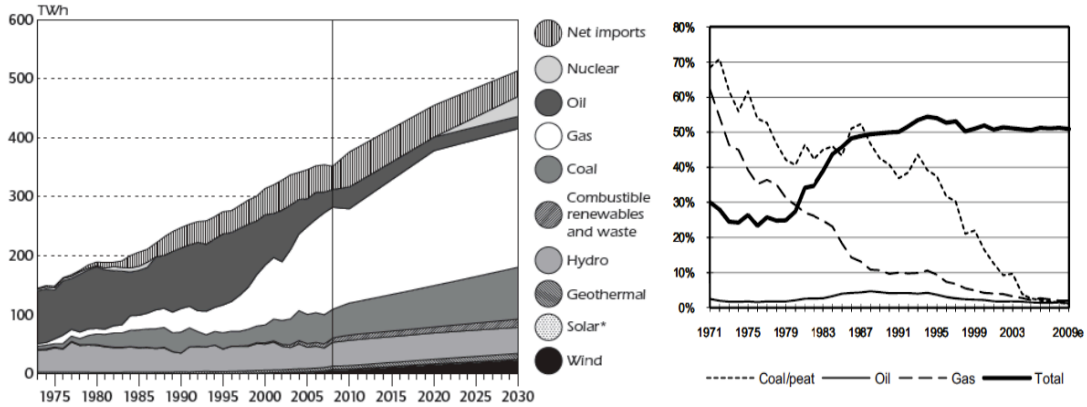
Having to develop new energy production from renewable resources, the UK, that presents an extremely low renewables share at the moment, due to lack of hydropower, has decided to exploit the huge wind potential and is proving itself quite efficient in doing so, with good probability to reach its 2020 targets. Doubting is still justifiable though, given the highly ambitious target they aim at. Both France and Italy are affected by administrative bureaucracy and policies' ambiguities with constant changes in legislation and regulation that hinder the wind energy development. In France, although the sector is continuing to grow (with about 1 GW of new installed capacity every year), the current pace of annual installation will not be sufficient for the country to meet its 2020 objectives. In Italy the growth has seen a slowdown in 2010 and will need to be more strongly support in order to reach the European objectives. In the table below figures are compered among the three countries.

Figure 13. Wind installed capacity pattern in Italy, France and UK.



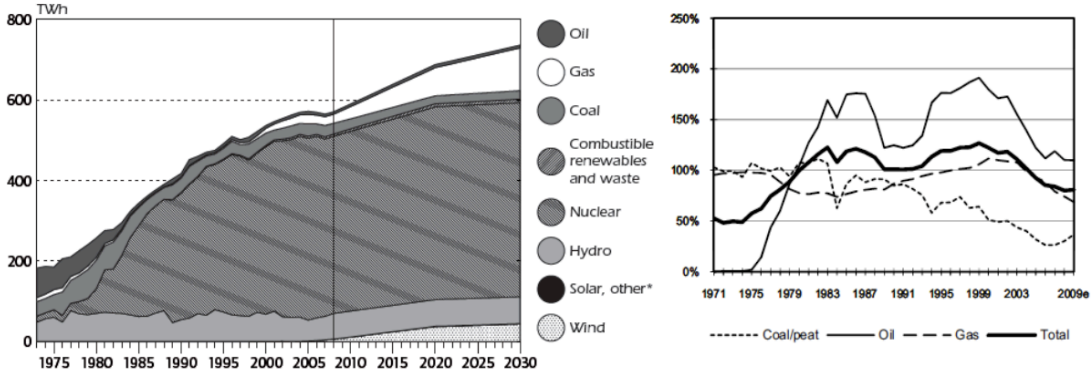
Data sources: DECC 2010; IMED, 2010; FMEESDS 2010.

Figure 14. Electricity generation by source in Italy, 1973 to 2030 and energy self sufficiency 1971 to 2009.



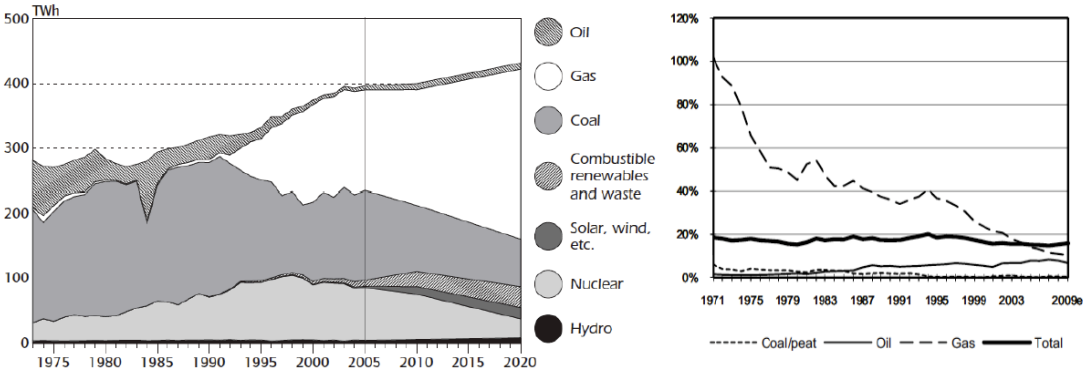
Source: IEA, 2010a

Figure 15. Electricity generation by source in France, 1973 to 2030 and energy self sufficiency 1971 to



Source: IEA, 2010b

Figure 16. Electricity generation by source in UK, 1973 to 2020* and energy self sufficiency 1971 to 2009.



** Because the prediction dates back to 2006, before the Renewable Energy Directive, wind energy presents a much smaller share than it actually has today and will have by 2020.*

Source: IEA, 2006

3. LEGAL FRAME

Comparison of national strategies

3.1 EUROPE

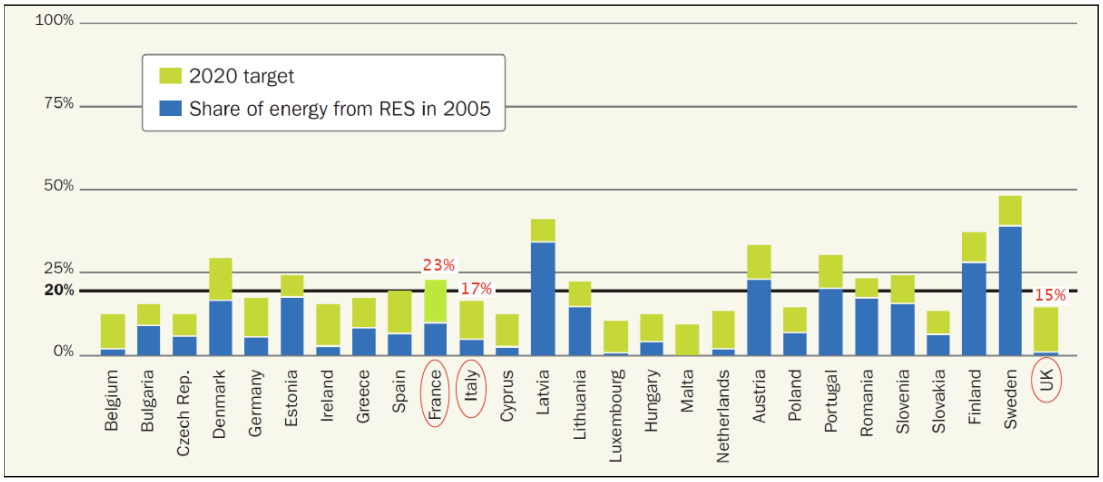
3.1.1. THE EU DIRECTIVE 2009/28/EC

On 17 December 2008, the European Union officially adopted the "20-20-20" Renewable Energy Directive (EU, 2009), setting climate change reduction goals for the next decade. The targets to be achieved by 2020 call for:

- a 20% reduction in greenhouse gas (GHG) emissions compared with 1990 levels;
- a 20% cut in energy consumption through improved energy efficiency;
- a 20% overall share of renewable energy in final energy consumption starting from 8.6% in 2005.

To achieve these objectives, mandatory and binding national targets for the share of renewable energy are set for each of the 27 EU Member States, in relation to their energy situation and potential (Fig. 17). In specific Italy has to increase his share from 5% (in 2005) to 17% (in 2020), France from 10% to 23% and the UK from only 1,3% to 15% (EU, 2009).

Figure 17. EU national and overall 2020 targets for the share of energy from renewables in final energy consumption.



Source: EWEA 2009a.

Article 4 of the Renewable Energy Directive has required each Member State to submit a National Renewable Energy Action Plan (NREAP) by 30 June 2010, detailing all legislation affecting renewables (from spatial planning to grids and support mechanisms) and explaining what measures will be taken to streamline procedures and generally promote energy production from renewable energy sources. The NREAPs, which follow a binding template, indicate three separate sectorial energy targets: Electricity, Heating and Cooling, and Transport. Within these sectorial targets, Member States are required to indicate the contribution of each renewable energy technology and its share in final consumption (estimated using a high energy efficiency scenario). Out of these three 'sectors', heating and cooling is forecasted to reach 22.2% of share from renewables, transport target should be around 10%, while for electricity, according to the 27 NREAPs, the share of renewable sources will be by far the largest, reaching 34% of consumption in 2020. Analysing the action plans, it is clear that wind energy will be the most important source that will allow this 34% share in electricity production to be reached.

According to the NREAPs, fifteen Member States plan to exceed their national target, led by Bulgaria at +2.8% above its target, Spain (+2.7%), Greece (+2.2%), Hungary (+1.7) and Germany (+1.6%). Ten Member States will meet their national target, and just two Member States, Luxembourg (-2.1%) and Italy (-0.9%), have informed the European Commission that they envisage using the cooperation mechanisms to meet their national targets (EWEA, 2011a). However, their deficits (93 Ktoe and 1,127 Ktoe respectively in 2020) remain marginal compared to the surpluses forecast in the 15 Member States that indicate they will exceed their targets (8,991 Ktoe) (EWEA, 2011a).

3.1.2. The European Strategic Energy Technology Plan (SET-Plan)

The SET-Plan, adopted by the European Union in 2008, is a first step to establish an *energy technology policy* for Europe The SET-Plan represents the principal decision-making support tool for European energy policy. Implementation of the SET-Plan started with the establishment of the European Industrial Initiatives (EIIs) which brings together industry, the research community, the Member States and the Commission. In parallel, the European Energy Research Alliance (EERA) has

been working since 2008 to align the R&D activities of individual research organisations to the needs of the SET-Plan priorities, and to establish a joint programming framework at the EU level. The projected budget for the SET-Plan has been estimated at up to €71.5 billion. For 2020, the SET-Plan provides a framework to accelerate the development and deployment of cost-effective low carbon technologies. It includes initiatives for all kinds of renewable and clean energies among which two are of interest for the wind energy sector:

- The European Wind Initiative
- The European Electricity Grid Initiative

The European Wind Initiative (EWI)

The European Wind Initiative is the result of a joint effort by the European Commission, Member States and the European Wind Energy Technology Platform (TPWind). It constitutes the basis of a ten-year 'roadmap' for the research and development of electricity produced by the wind. The objective of EWI is to make wind energy more competitive, to harness the potential of offshore resources and deep waters, and to facilitate grid integration of wind power. The timely implementation of the EWI would lead to a high wind energy penetration level, the ambition being to reach a 20 % penetration level in 2020, 33 % in 2030 an 50 % in 2050 (EWEA, 2010). Four focus technology areas are individualised: new turbines and components; development of offshore technology (machines with power between 10 and 20 MW); network integration forecasting and resource assessment; planning. Among the prioritised activities of the EWI there are:

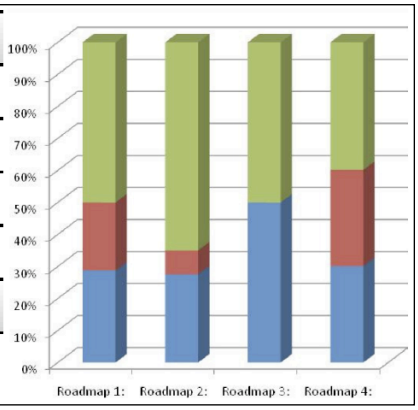
- development of more accurate mapping of wind resources and of capacity potentials in Europe;
- 5 to 10 new testing facilities for new turbine systems;
- up to 10 demonstration projects of next-generation turbines including a 10-20 MW prototype;
- at least 4 prototypes of new offshore structures tested in different environments.

The funding will be provided partly by the private sector and partly by the public. For the first phase (until 2012), the European Wind Energy Association estimates that the financial 'effort' will be distributed as follows: 52% to the industry, 31% to the EU (EU funds for renewables and "low emission" technologies

and European Investment Bank) and the remaining 17% to the Member States (Table 8.). The total cost is estimated at €6 billion over ten years.

Table 8. Indicative costs of the EWI over ten years, and financial repartition for each objective for 2010-2012.

Technology objective	Coss (M€)
1. New turbines & components	2 500
2. Offshore technology	1 200
3. Grid integration	2 100
4. Resource assessment & spatial planning	200
Total	**6 000**



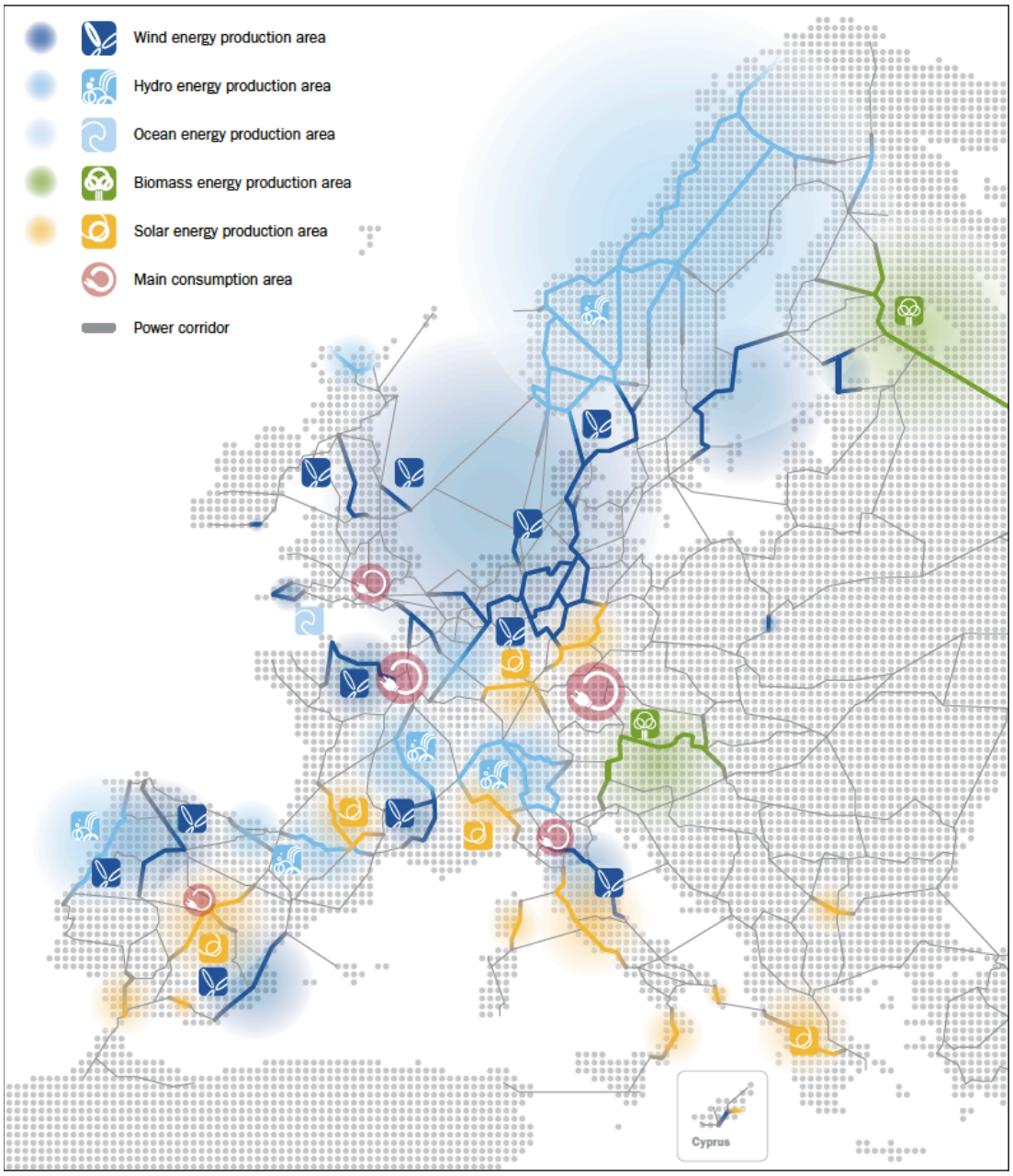
Data source: EC 2009; TPWwind secretariat 2010.

The European Electricity Grid Initiative (EEGI)

The European Electricity Grid Initiative proposes a nine year European research, development and demonstration program to develop a next generation smart grid electricity network for Europe, which will be deployed between 2010 and 2030. EEGI aims at enabling the transmission and distribution of up to 35% of electricity from dispersed and concentrated renewable sources by 2020. It also aims at further integrating national networks into a truly pan-European, market-based network. The cost of this initiative is estimated at €2 billion over ten years.

In 2010, EWEA developed a grid map in order to depict the evolution of wind energy and other renewables in the European power system up to 2050, identifying the main renewable electricity production and consumption areas, and showing where the major power corridors would be situated in an integrated electricity market. The map for 2020 (Fig. 18) shows the increasingly importance of renewable energy and of wind energy in particular: in 2020, 230 GW of installed wind power capacity is expected to supply between 14 and 18% of EU electricity demand: 40 GW would be offshore (EWEA, 2011a).

Figure 18. European renewable energy grid for 2020.



Source: EWEA 2011a.

3.2. ITALY

According to the Directive 2009/28/EC, Italy has to increase its renewable energy share from 5% in 2005 to 17% by 2020. Yet Italy is one of the two Member States to indicate in its National Renewable Energy Action Plan that it will not meet its 17% RES target domestically, forecasting a shortfall of 0.85 percentage points in 2020. Consequently, the Italian authorities intend to turn to the co-operation mechanisms, indicating a preference for physically imported RES from countries outside the EU.

SUPPORT SCHEMES to promote the use of energy from renewable resources

In Italy, electricity from renewable sources is mainly promoted through a quota system developed as a market mechanism through the trade of Green Certificates. With the restructuring of the energy sector (LD, 1999), from 2001 all electricity producers and importers have been obliged to certify that at least 2% of their net sales come from RES. Given that the Trade of Green Certificate scheme is more suited to big producers, smaller plants have been given the option to choose between this and two other schemes (Law No. 244/07): a feed-in-tariff and a net metering system. 'Ritiro Dedicato' is another option, available to production up to 2 GWh, which is not really an incentive, but is rather a bureaucratic simplification for the sale of energy produced from renewable sources. Other supportive measures are the Kyoto fund, the fund from the Interregional operational plan focused on the southern regions and the VAT tax deduction for renewables. It is worth noting though, that the new Legislative Decree 28/11 has abolished the Green Certificate system that will disappear by 2015. The decree also contains provision for a new incentive system which should come into service after December 2012 and replace the current support schemes but no clear information about has been given. The future of the financing of wind projects is therefore somewhat uncertain at the moment in Italy.

All the support schemes to promote the use of energy from renewable resources in Italy are listed and then explain in detail below:

Table 9. Support schemes to promote the use of energy from renewable resources in Italy.

Measure	Type	Eligibility	Funding	Start/end dates
1. GREEN CERTIFICATES	Quota system	Plants with a capacity of at least 1 kW	Consumers through the electricity price	2002 -2015
2. ALL-INCLUSIVE TARIFF	Price regulation	Only plants with a capacity up to 1 MW (200 kW for wind power)	Consumers through the electricity price, GSE through market price.	Jan 2008 -Dec 2012
3. NET METERING	Price regulation	Only plants with a capacity up to 20 kW or up to 200 kW and high efficiency	System operators through an annual fee	2008 -->
4. PURCHASE & SALE BY THE GRID OPERATOR	Price regulation	All plants generating electricity from RES	System operators and consumers through the electricity price	2007 -->
5. POIN	Financial	RES and anergy saving projects in the 8 target regions.	EU Structural Funds (SF) and Italian Underused Areas Fund (FAS).	June 2007 -Dec 2015
6. KYOTO FUND	Financial	Wind power plants with a capacity of between 1 kWp and 200 kWp.	The State through low interest loans	2007 -2013
7. TAX DEDUCTION	Fiscal	Photovoltaic and wind energy systems	The State	1993 -->

Own elaboration.

1. Green Certificates (Quota system)

According to the quota system introduced in 2002, producers and importers of electricity are obliged to prove that a certain quota of the electricity they produce or import is generated from renewable energy sources. The quota, that was set at 2% in 2001, gradually increased by 0,35% every year until 2007 when the 2008 Finance Act raised the annual increase to 0.75% for the years 2007 to 2012. That translate into a quota of 6.05% in 2010, 6.8% in 2011 and 7,55% in 2012. Green Certificates (GCs) are used to fulfil the quota obligation. They are tradable commodities (1 GC verifies that 1 MWh has been produced), issued by the energy services regulator (GSE); based on them a market is created between those who produce electricity from renewable sources and and those who have to demonstrate each year that they have fulfilled their obligation. So producers of renewable energy, except solar,

receive green certificates, which conventional power generators buy to meet their environmental obligations. The GSE must buy any green certificates that at the end of the year remain unsold. The support scheme started in 2001 and did not initially provide for an end date, until the current Berlusconi's government decided to abolish it by 2015. Before 30 September 2011, a ministerial decree will be published containing specifications of a new support system and provisions related to the transition from this system to the other (Art.24, c.5,6 DL 28/11). From 2012 onwards, the quota (7,55% in 2012) will linearly decrease until becoming equal to zero in 2015 (Art.24, c.3 DL 28/11).

Procedure: The GSE (the energy services regulator) has been appointed to implement and monitor the Green Certificate Scheme, while the AEEG (authority for electricity and gas) is responsible for regulating the market and imposing any sanctions. The term of promotion lasts for 12 to 15 years depending on the date of commissioning. The support mechanism differs according to the technology used. Law No 244/07 introduced a table of multiplication coefficients on the basis of which, the number of GCs issued varies according to the renewable source used. Basically, the number of GCs one can get equals the number of produced MWh multiplied by a coefficient depending on technology as shown below:

	Source	Coefficient
1	Wind power, for plants larger than 200 kW	1.00
1a	Offshore wind power	1.50
3	Geothermal	0.90
4	Wave and tidal power	1.80
5	Hydro	1.00
6	Biodegradable waste, biomass other than that included in the point below	1.30
7	Biomass and biogas produced by local agriculture or forestry	1.80
8	Landfill gas and residual gases from purification processes and biogas other than those included in the point above	0.80

The multiplication coefficients for the issue of GC can be revised through ministerial decrees every three years to ensure that remuneration is adequate.

Eligibility: Wind plants with a capacity of at least 200 kW which are connected to the electricity network are eligible for the GC mechanism. All those importing or producing more than 100 GWh of electricity are obliged to satisfy the national quota (Art.11 DL 79/99). This system will not be applicable for plants entering into function from 1 January 2013 (Art.25 DL 28/11). Eligible plants entering into function before 31 December 2012 will still receive incentives under this scheme for the whole period for which they hold the right to (Art.25 DL 28/11).

Funding: Green certificates create additional costs to producers and importers that are mirrored by the market prices for electricity and are ultimately beard by the consumers.

Market: Since 2006, the TGC offer has somehow exceeded demand and this has pulled down the TGC trading price. The poor price conditions have been blamed also on the factor that the RES obligation percentage rose at too slow a rate, which did not allow TGC demand to grow enough. The rules for RES quota have then been reshaped by the 2008 Financial Law (Law 244/07) raising the yearly increase of the mandatory quota. No real floor bottom price has been set for GCs, since the price is determined by the market, according to the principle of supply and demand. Nonetheless, the Ministerial Decree of 18/12/2008 established that, in order to prevent an excessive supply, during the three-year period and at the holders' request, the GSE can withdraw the GCs for production referring to years up to 2010. The withdrawal price is the average price over the previous three years for exchanges of all GCs regardless of the reference year, either on the GME-regulated market or through bilateral contracts. The 2010 withdrawal price for GCs is €88.90/ MWh.

2. All-inclusive Tariff - "Tariffa Omnicompresiva"

All-inclusive tariffs are tariffs paid for renewable energy fed into the network. They have been introduced by Law No 244/07 (Art.2 par.145) as an alternative to the green certificates mechanism to meet the need of the smallest energy producers. They have opened new market prospects to small wind systems, whose deployment had so far been poor in Italy.

Management: The all-inclusive tariff mechanism has been operational since 1 January 2008 and is managed by the energy service regulator, GSE. The support differs according to the technology used. Wind plants with a capacity between 1 kW and 200 kW are entitled to a fixed comprehensive feed-in tariff of 30 €/kWh. The value of the tariffs covers both the incentive and the sale price for the energy fed into the network and the tariffs are paid for a period of 15 years. Tariffs can be revised every three years to ensure that remuneration is adequate (Law No 244/07).

Eligibility: It is only applicable to plants which became operational after 31 December 2007 and have a capacity no greater than 200 kW for wind power (and

no greater than 1 MW in general) (Art.3 par.2 DM18/12/2008). Only plants that enter into function by 31 December 2012 will be eligible: from 1 January 2013, a new incentive system will be in place which will be published through a ministerial decree before 30 September 2011 (Art. 24, c.5,6 DL 28/11).

Funding: The costs that arise from the price-regulation system is borne by the consumer through the electricity price. The costs are listed on the electricity bill as "system costs" (tariff A3) (Art. 153 b L 244/07).

3. Net Metering - "*Scambio sul posto*"

The net metering offers the possibility for owners of wind plants between 1 kW and 200 kW to sign a contract for 'on-the-spot exchange' of the energy they produce with the energy they take in from the grid as customers on an annual basis. System operators thus receive as much energy for free as they produce (Art.5 par.2 ARG/elt 74/08). It can also be seen as an electricity banking system where renewable generators can essentially 'store' their electricity in the utility grid, to be used later, overcoming the timely and seasonally variable nature of wind energy.

Procedure: This mechanism does not result in direct payments and is based on the balance of the energy fed in and consumed (Art. 1, 2 ARG/elt 74/08). If more energy is fed in than it is consumed, this positive balance can compensate for a possible negative balance in the following years, while, if less energy is fed than consumed, the difference is subject to a payment (Art.5 ARG/elt 74/08). For this reason, net metering is cost-effective only if the amount of electricity produced does not substantially exceed the amount consumed. In order for the support scheme to apply, electricity must be supplied to and received from the grid at one and the same connection point (Art.1 ARG/elt 74/08). L 99/09 was introduced to enable municipalities with less than 20,000 inhabitants to make use of net metering without being obliged to use the same connection point to supply and receive electricity (Art.27 par. 4 L 99/09).

Eligibility: The persons entitled are the operators of renewable energy systems with a capacity of up to 200 kW.

Funding: Operators of renewable energy generation systems are obliged to pay an annual fee of 30 € per connection point to cover the grid operator's administrative costs (Art.6 par. 1c ARG/elt 74/08).

4. Purchase & Sale by the Grid Operator - "Ritiro dedicato"

'Ritiro Dedicato' is a simple way, available to producers of electricity from RES, for placing the electricity fed into the grid on the market. The producer can sell its electricity to the grid operator (GSE) which then manages to sell it on the free market on behalf of the producer. This system aims to enable renewable energy to access the market indirectly and more easily. The producer can avoid the direct sale on the open market through the Power Exchange or through unregulated markets and its profit is secured thanks to guaranteed minimum prices by the GSE.

***Procedure*:** Producers of up to 2 GWh of electricity from renewable sources may choose between the minimum tariff (prezzo minimo garantito) determined by the energy authority (Art.7 AEEG 280/07) and the market prices dependent on time of day and region (prezzo zonale orario) (Art.4 AEEG 34/05). When 2 GWh are exceeded, the surplus is automatically subject to the market price. The amount of payment decreases with increasing output and depends on the following categories:

- For outputs of up to 500 MWh per year (2011: 103,4 €/MWh)
- For outputs from 500 to 1000 MWh per year (2011: 87,2 €/MWh)
- For outputs from 1000 to 2000 MWh per year (2011: 76,2 €/MWh)
- For outputs > 2000 MWh per year: Market price (prezzo zonale orario)

The guaranteed minimum prices are reassessed every year thus the above reported amounts represent the payments for 2011.

***Eligibility*:** All operators of systems that generate electricity from renewable energy sources are eligible, and all technologies are eligible (Art.13, Art.17 DL 387/03). The output of a given system must not exceed 10 MVA. Systems shall be commissioned after 1st April 1999 (Art.1, L 239/07).

***Funding*:** The system operators bear part of the costs paying a fee to the grid operator for the services regarding the sale of electricity. Another part of the costs is borne by the consumers through the electricity price (Art. 56 AEEG 348/07).

5. POIN - Interregional Operational Plan

The Interregional Operational Plan (POIN) on "Renewable Energy and Energy Saving" is a financial support plan for incentivizing the production of renewable energy and energy saving measure in southern Italy. The operational plan falls within the National Strategic Framework (NSF) and relates to the 2007-2013

planning cycle for the European and national cohesion policy.

Procedure: Each of the actions provided for by the plan will be implemented through calls for bids and/or public tendering procedures. The Apulia Region is responsible for managing and implementing the operational plan.

Eligibility: Plants operated in the following Italian regions: Sicily, Calabria, Apulia, Campania, Basilicata, Molise, Abruzzo and Sardinia.

Funding: The funding is covered by European Union Structural Funds (SF) and the Italian Underused Areas Fund (FAS).

6. Kyoto Rotating Fund *for Renewables*

It supports installation of small-scale plants that use renewable sources to generate electricity or heat. It does so by providing low interest loans.

Procedure: The Ministry for the Environment, Land and Sea, which holds the Kyoto Rotating Fund, has appointed the bank 'Cassa Depositi e Prestiti S.p.A.' to manage the fund. No calls for bids are planned for access to the rotating fund. The soft loans are accessed through the presentation of an application for the related investigation to be carried out by the Cassa Depositi e Prestiti S.p.A. bank and are dependent on the annual availability of the fund.

Eligibility: small-scale plants using a single renewable source. For wind, power plants with a nominal installed capacity of between 1 kWp and 200 kWp are eligible.

Funding: the State through soft loans.

7. VAT deduction

Wind energy systems (and PV) are eligible for a reduced VAT of 10% (instead of 20%) (Decree 633/1972). This fiscal benefit applies to enterprises, the professions and private individuals. When importing electricity from abroad, companies are exempt from the foreign VAT and shall pay the Italian VAT instead.

3.3. FRANCE

France has an overall 23% RES target to reach by 2020 and plans to cover 27% of electricity consumption by renewables. The French National Renewable Energy Action Plan expects around 11% of all electricity consumption to be met by onshore and offshore wind power in 2020. A major national consultation, the "Grenelle Environment Forum", was held from July to November 2007 and led to the emergence of priority targets to promote renewable energies, establishing a reference scenario to achieve the target of 23% of RE in the total final energy consumption. It also led to the implementation of two laws: Grenelle 1 and Grenelle 2. Grenelle 2 established an obligation to install 500 wind towers each year and imposed a minimum of 5 turbines per project.

SUPPORT SCHEMES to promote the use of energy from renewable resources

In France, electricity from renewable sources is mainly promoted through a price regulation system based on a feed-in tariff. Other than that persons investing in renewable energy systems are eligible for an income tax credit (Crédit d'Impôt). While persons who install renewable energy systems are eligible for a reduced VAT rate. Under certain conditions, persons installing a renewable energy system on a new building may also be eligible for exemption from real estate tax. In order to reach the target production of electricity from renewable sources, the government also issues tenders and awards the winner with special feed-in tariffs.

All the support schemes to promote the use of energy from renewable sources in France are listed and then explain in detail below:

Table 10. Support schemes to promote the use of energy from renewable resources in France

Measure	Type	Eligibility	Funding	Start/end date
1. FEED-IN TARIFF	Price regulation	Only systems within the ZDE and capacities upon Art. 29 Loi n°2005-781	Consumers	2001 -->
2. TAX CREDIT	Tax incentive	All natural persons/plants	Federal budget	2005 - 2012
3. VAT REDUCTION	Tax incentive	All natural persons/plants	The State	2001 -->
4. TENDERS	Financial	All natural persons	Consumers	2000 -->

Own elaboration.

1. Feed-in Tariff - “Tarif d'achat”

Operators of renewable electricity systems are contractually entitled against the suppliers (EDF and private suppliers) to payment for electricity exported to the grid. The distribution grid operator is obliged to enter into agreements on the purchase of electricity at a price fixed by law ("obligation to conclude a contract") (Art.10 Loi n°2000-108).

***Procedure*:** Orders on the single technologies (arrêtés) determine the feed-in tariff for a certain source of energy. Tariffs for wind energy are 2,8-13 €/kWh, depending on the site (onshore/offshore) overall time of operation and time of operation per year (Arrêté du 17 novembre 2008) as shown in the table below:

Table 11. Wind feed-in tariffs rates in France:

		Onshore	Offshore
Mainland			
For the first 10 years:		8,2 €/kWh	13 €/kWh
For the next 5 years:	2400 hours/year	8,2 €/kWh	13 €/kWh
	2800 hours/year	6,8 €/kWh	9 €/kWh
	3600 hours/year	2,8 €/kWh	3 €/kWh
Overseas			
for 15 years independent from productivity		11 €/kWh	

Data source: French Government, 2008.

The French government invites tenders for the construction of system using RES and the electricity suppliers are obligated to pay the feed-in tariff and satisfy the obligations arising from the tenders (Art. 8, 10 Loi n°2000-108).

Eligibility: Both onshore and offshore wind-energy plants are eligible if they are within the designated wind development areas ZDE (zone de développement éolien). If they are outside the ZDE they must have a maximum capacity of 12 MW. The minimum and maximum capacities allowed depend on the particular development area of a system (Art.29 Loi n°2005-781).

Funding: The end consumers bear the costs arising from the suppliers' (EDF's and private suppliers') obligation to pay for electricity from renewable sources exported to the grid.

2. Tax credit - “Crédit d'impôt”

Since 2001 natural persons may deduce from income tax a certain percentage of investments in renewable energy systems (Loi 2000-1352). Arrêté 9.2.2005 lists all eligible systems, including wind, and specifies technical and performance requirements. The tax credit for renewable energy systems will apply until the end of 2012 (IIF 5 B-10-09 N°38).

Eligibility: All natural persons that are owners, tenants or free users of their main residence are eligible (IF 5 B-26-05 N° 147). The tax credit may be claimed for investments in the main residence (Art.90 Loi 2004-1484). Entitlement to the credit is guaranteed by law. Wind energy is eligible (Art.1 Arrêté du 9.2.2005).

Funding: The tax credit results in lower state revenue.

3. Value-added tax reduction

Loi n° 2000-1352 made renewable energy sources eligible for the reduced VAT rate. Wind energy is eligible with the following reduction rates:

- On the French mainland and in Corsica, the reduced VAT rate is 5.5%.
- In the overseas departments and regions of Guadeloupe, Martinique and Réunion, the VAT rate is 2.10%.

Eligibility: The reduced VAT rate applies to investments made by the owner of a building, a co-owner syndicate, a tenant, an inhabitant or his representative (Code Général des Impôts, art. 279-0 to 3). This means that every natural person or legal entity may be granted a VAT reduction as long as all obligatory prerequisites are met (Instruction fiscale 3 C-7-06 N°202). Legal entities involved in business activities are not eligible for the reduced VAT rate, as they have to pay input-VAT, which may be deduced from the VAT they charge.

Funding: The reduced VAT rate for RE systems leads to lower state revenue.

4. Tenders

A special feed-in tariff may be awarded to the winners of tenders for the construction of renewable energy systems. The Ministry in charge invites tenders for the installation of systems for the generation of electricity from renewable sources at irregular intervals. For wind energy the conditions for tender are to be found in the invitation to tender (art. 1 Décret n°2000-1434). The suppliers (EDF and private

suppliers) are obliged to conclude purchase agreements with the successful tenderers. They are also obliged to pay the electricity price specified in the tenders (art. 8 Loi n°2000-108).

Eligibility: Tenders cover all sources of renewable energy, wind included. According to statutory law, the tenders are open to every person that resides in an EU member state or in a country specified by a corresponding international treaty and plans to install a renewable energy system in France (art. 8 Loi n°2000-108).

***Funding*:** The end consumers bear the costs arising from the suppliers' obligation to pay for electricity from renewable sources exported to the grid.

3.4. UNITED KINGDOM

The United Kingdom has an overall 15% RES target for 2020, up from just over 1% in 2005 and its National Renewable Energy Action Plan expects the target to be met. The country's National Plan on RE forecasts that around 70% of RES in electricity consumption will come from onshore and offshore wind, with onshore wind representing 9% of total electricity consumption and offshore wind 12%.

SUPPORT SCHEMES to promote the use of energy from renewable resources

In the UK development of renewable energy has always been supported through the market-based mechanism of green certificates (renewable orders certificates). As a strong believer in the market logic, the country has also planned to launch a Green Investment Bank starting from 2012. Other than that, a tax is levied on energy produced from non-renewable sources and only recently a feed-in tariff mechanism has been introduced to support small renewable energy producers. Subsidies are also granted to low carbon technology through the Environmental Transformation Fund. All the support schemes to promote the use of energy from RES in the UK are listed and then explain in detail below:

Table 12. Support schemes to promote the use of energy from renewable resources in the UK

Measure	Type	Eligibility	Funding	Start/end date
1. QUOTA SYSTEM	Regulatory	All electricity suppliers	Consumers	2002 - 2037
2. ENVIRONMENTAL TRANSFORMATION FUND	Subsidy	Enterprises, public sector, research projects	State	2008 -->
3. CLIMATE CHANGE LEVY	Fiscal	All electricity suppliers	Consumers	2000 -->
4. FEED-IN TARIFF	Price regulation	Up to 5MW net capicity	Consumers	2010 - 2021
5. GREEN IVESTEMENT BANK	Bank	---	Initial fund by the State	2012 -->
6. LOW CARBON BUILDINGS PROGRAMME	Financial	Householders	The State	2006 -2010
7. OFFSHORE TENDERS	Financial	---	The State	2009 -->

Own elaboration.

1. Quota system (Renewables Obligation Order)

Under the Renewables Obligation Orders, electricity suppliers are obliged to prove that a certain percentage of electricity supplied to final consumers was generated from renewable sources. To this end, they shall present Renewables Obligation Certificates (ROCs, or SROCs in Scotland) to the regulatory authorities of Ofgem (in charge of England, Scotland and Wales). The amount of quota does not account for the initial costs of different types of technology and increases every year till 2016. Since 2007 Northern Ireland is subject to a different system that refers to Ireland.

Table 13. Quota of electricity to be generated from RES in the UK.

Obligation period	Great Britain	Northern Ireland
1 April 2008 – 31 March 2009	9,1%	3%
1 April 2009 – 31 March 2010	9,7%	3,5%
1 April 2010 – 31 March 2011	10,4%	4%
1 April 2011 – 31 March 2012	11,4%	5%
1 April 2012 – 31 March 2013	12,4%	6,3%
1 April 2013 – 31 March 2014	13,4%	6,3%
1 April 2014 – 31 March 2015	14,4%	6,3%
1 April 2015 – 31 March 2016	15,4%	6,3%
Any further 12-month obligation period until 31 March 2037	15,4%	6,3%

Data source: RESlegal

The amount of electricity to be stated in a renewables obligation certificate is 1 MWh for onshore wind and 2/3 MWh for offshore wind (which corresponds to the italian standards) both in Great Britain and in Northern Ireland.

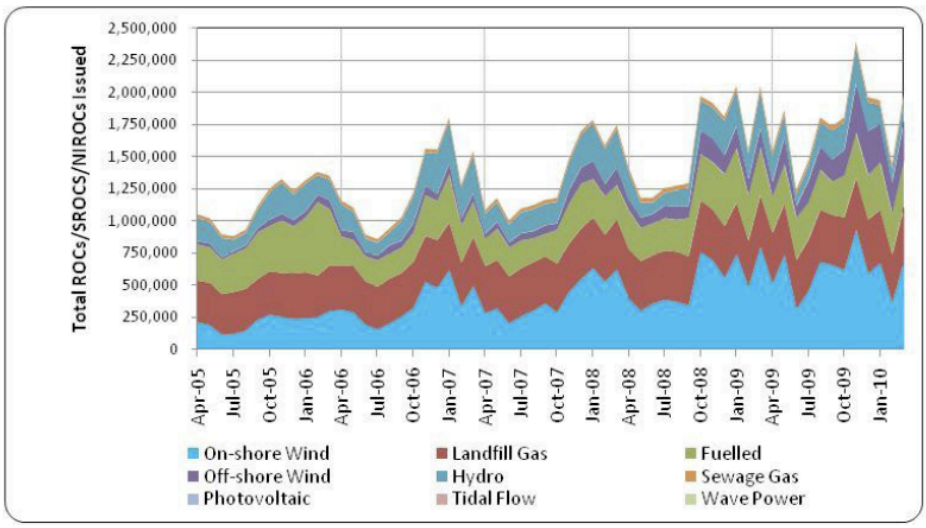
Eligibility: Both onshore and offshore wind energy stations are eligible. The quota system is a statutory obligation for energy companies that supply electricity to final consumers within the United Kingdom.

Funding: The costs of the quota system are borne by the consumers through the electricity price.

Figure 19 demonstrates the trend in ROCs issued since 2002-03 by technology type. There is a clear trend across the periods of more ROCs being issued in winter

months. This is predominantly due to the weather conditions being favourable for wind and hydro generation.

Figure 19. Trend in ROCs issued since 2002-03 by technology type in the UK.



Source: Ofgem, 2011

On-shore wind sites has been receiving the largest number of ROCs for the last few years, representing over a third (34.2%) of the total ROCs issued in 2009-10. Off-shore wind attracted a further 12.8% of total ROCs. The majority of ROCs issued in Scotland (56.0%) and the vast majority of ROCs issued in Northern Ireland (90.2%) went to on-shore wind generating stations (Ofgem, 2011).

2. Environmental Transformation Fund

The Environmental Transformation Fund (ETF) is an initiative of the British government, which aims at promoting low-carbon technology and energy efficiency in the United Kingdom and in developing countries. It is split into two elements: a national fund, which supports projects within the United Kingdom, and an international fund, which provides financial assistance to projects that promote climate protection in developing countries.

Procedure: The granting of a subsidy is decided on a case-to-case basis. The UK ETF Strategy 2008 is the main basis of individual decisions on the granting of a subsidy. In many projects, the ETF cooperates with "Carbon Trust“, an independent organisation founded in 2001. The Fund provides for capital grants in order to increase new, low-carbon technologies and it focuses on projects that involve the generation of electricity from renewable sources.

Eligibility: The Fund's support schemes are directed towards enterprises, the public sector and research projects. Applicants negotiate individual contractual agreements within every scheme. These contracts constitute the legal basis for the subsidy. Wind energy is eligible and a focal point of attention of the ETF is offshore wind technology.

Funding: The Fund comes under the item of "business support" of the national budget. ETF funding is thus fully provided by the state.

3. Climate Change Levy

The Climate Change Levy (CCL) is a climate protection tax, which is levied on the consumption of electricity from non-renewable sources by commercial and industrial final consumers and the public sector. It aims at reducing GH gases and promoting energy-efficiency in final consumers.

Funding: The CCL is collected from the electricity suppliers, who pass it on to their consumers through the electricity price. Electricity from renewable sources is exempt from this tax (FA 2000).

4. Feed-in Tariff

The Feed-in Tariff scheme (FITs) is intended to encourage deployment of additional small scale low carbon electricity generation, particularly by individuals, householders, organisations, businesses and communities who have not traditionally engaged in the electricity market. The mechanism is addressed to small operators as an easier to handle alternative to the Renewables Obligation. It is expected that by 2020 the scheme will support over 750,000 small scale low carbon electricity installations. Applications should be directed to the Gas and Electricity Markets Authority (Ofgem) that administers the scheme.

Procedure: The FIT provides support for a set period of time depending on technology (20 years for wind) at a determined level of support. The FIT scheme started in 2010 and currently will close to new entrants in 2021. Automatic reduction of tariffs for new installations is built into the scheme through ‘digression’, where tariffs decrease for new installations from 2012 onwards (Table 14.). Tariffs for all installations will increase with inflation and a payment rate table adjusted to

inflation is published every year before 31 March by the Gas and Electricity Markets Authority (Art.13 FTO). Periodic reviews of FITs will be undertaken and they will coincide with the Renewables Obligation reviews.

Table 14. Generation tariffs in GBP/MWh for wind technology 2010-2021 in the UK.

Capacity (kW)	2010 /11	2011/ 12*	2012 /13	2013 /14	2014 /15	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21
≤ 1,5	345	362	360	380	291	275	26	246	232	219	207
1.5 - 15	267	280	255	243	232	222	212	20,2	193	184	176
15 - 100	241	253	230	219	209	20	191	181	174	166	159
100 - 500	188	197	188	188	188	188	188	188	188	188	188
500 - 1500	94	99	94	94	94	94	94	94	94	94	94
1500 - 5000	45	47	45	45	45	45	45	45	45	45	45

**Tariffs for 2011/12 have been adjusted to inflation, whereas all the other periods rates are still predictions made in 2009.*

Source: Ofgem, 2011b, RESlegal

Eligibility: All installations of promoted technologies (wind, solar PV, biogas, hydro) are eligible as long as their specified maximum capacity is less than 5MW (Art. 3 FTO 2010). Plants between 50 kW and 5 MW are entitled to choose between this system and the Renewable Obligation (Art. 3.1.3 EA 1989).

Funding: The FIT payments, borne by the licensees, are in practice redistributed to the final consumers' energy bills (RES legal).

5. Green Investment Bank

The UK government will set up a green investment bank with £ 3 billion of equity to fund low-carbon transport and energy schemes to help the introduction of renewable energy, especially offshore wind energy. The bank will be able to begin operations in 2012, as recently announced by the Chancellor of the Exchequer, George Osborne, and from 2015, it will be allowed to borrow money (Bloomberg, 2011). Financial products will be created to provide individuals with opportunities to invest in the infrastructure needed to support the new green economy.

6. Low Carbon Buildings Programme

Since April 2006, the LCBP has granted support for householders to cover the upfront costs of purchasing a micro-generation technology, like micro wind turbines. The LCBP initially had a total budget of £28.5 million over 3 years but ran out of funds after 6 months in place due to high demand (Watson, 2008). Further funding was made available for the next 4 years with tighter caps on the money available to each household. In 2010 it closed due to government expense cuts.

7. Offshore Tenders

A new regulatory regime for offshore electricity transmission has been established in 2009. Grants for offshore electricity transmission are licensed on the basis of a competitive Tender Process. Ofgem is responsible for managing this process. Periodically, The Crown Estate invites expressions of interest for a tender round for the development of areas of seabed within UK waters as aggregate dredging areas. Already three tenders rounds have been held so far. The offshore wind capacity awarded in Round 3 could account for over 38% of the country's current overall generation capacity, estimated to be 84 GW (EER, 2010c).

3.5. Analytical comparison

The development of support mechanisms over the last years in Europe led further towards feed-in tariffs (FIT) mechanisms and to a decline of the so-called tradable green certificates (TGC), which became a negligible quantity in last years (EREF, 2009). The TGC scheme has been implemented only by the UK, Poland, Belgium, Sweden and Italy, with the latter having already planned to abandon it, and the European experience suggest that Feed in Tariffs deliver larger and faster penetration of renewables than TGC, at lower or comparable cost (EREF, 2009).

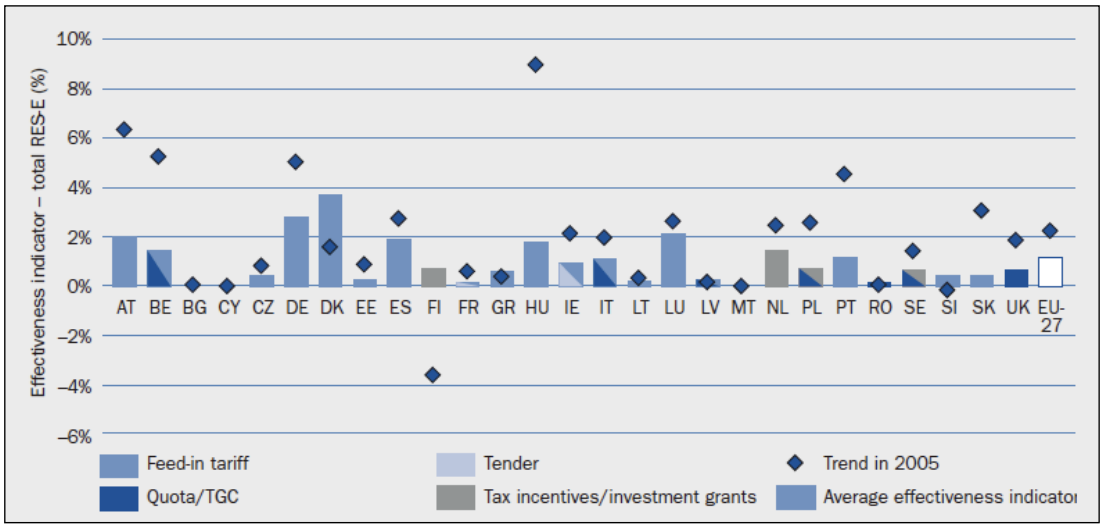
Under the TGC a defined member of the national electricity supply chain has to present a fixed minimum quantity of certificates each year, as set by the public authority. The certificates originate per MWh of RE electricity generated and the certificate price is determined by the market. So the target for RE penetration is fixed and set by the government. In a FIT system on the contrary, public authorities set an effective price but are not limiting the overall quantity of renewable energy installed in the country, and this may lead to greater deployment and growth rates.

Butler (2008), and Toke (2007), carried out a comparison between the market-based RES support scheme in the UK and the price-based supporting mechanism in Germany. Their finding showed that the feed-in tariff reduces costs to consumers, results in larger deployment and ease new technologies into the market place. Dr Dave Toke, from the University of Birmingham, has calculated that the subsidy per kW of capacity installed provided by the RO may actually be 30% higher than that delivered by FIT in Germany. The plausible explanation to lower cost is that long-term price guarantee (provided by the FIT) reduces regulatory and market risk.

GCs systems perform well in terms of effectiveness and social cost effectiveness; however, consumer costs get higher, very large rents are generated and they contribute only marginally to technical change (Bergek, 2010). Such trade-offs need to be taken into account. When the system creates an extra profit for industries, which does not correspond to any extra achievement on their part, the government fails at achieving its targets in an efficient way. As a matter of fact, the wasted part of the scheme turnover could have been used to fund a much higher level of investments in renewable energy technology.

A study carried out by EWEA (2009a) assessed the effectiveness of the various RES-Electricity support programmes in Europe focusing on whether they led to a significant increase in deployment of capacities from RES-E in relation to the additional potential. The effectiveness indicator measured the relationship of the new generated electricity within a certain time period to the potential of the technologies. In order to compare the performance between different countries, the figures were related to the size of the population. The results are shown in Figure 20: countries with FITs as a support scheme achieved higher effectiveness compared to countries with quota/TGC systems or other type of incentives.

Figure 20. Policy effectiveness of total RES-Electricity support for 1998-2005 measured in annual additional electricity generation in comparison to the remaining additional available potential for each EU-27 Member State.



Source: EWEA, 2009b.

Nevertheless a study by Campoccia (2009) that compered the wind energy support systems in Italy (TGC), France (FIT), Spain (FIT) and Germany (FIT), based on the pay-back-period (PBP), the net present value (NPV) and the internal rate of return (IRR), found out that Italy, among the four considered countries, has implemented the most profitable support strategy for wind systems. Both for on-shore and off-shore wind systems, the PBP in the Italian case turned out to be shorter than in the other three countries and the IRR and the NPV are higher.

All three countries analysed, Italy, France and the UK, have FIT schemes in place, while only the UK and Italy also provide for a Green Certificate mechanism.

Both TGC systems have been established at the beginning of the 2000s but with the difference that the British market has always been way more stable than the Italian one. While the price of GCs in the UK has kept roughly constant around £50, in Italy it has oscillated more: at first it increased, then in 2006 an oversupply on the market led to a fall in prices that started in 2007 and has continued till now (Table 15.). The quotas required by the UK are a bit higher than the Italian ones, so while for the years 2010 to 2012 the UK quotas are at 9,7%, 10,4% and 11,4% of RES share, the Italian ones are at 6,05%, 6,83% and 7,58% respectively. These higher quota lead to the creation of a bigger market in the UK as it can be seen in the table 15.

Table 15. A price comparison of Green Certificates (GCs) and Renewable Order Certificates (ROCs) issued to private consumers by the GSE and Ofgem respectively. (≅€/MWh)

	ITALY		United Kingdom	
Period	N° of issued GCs	Average price	N° of issued ROCs	Average price
2002	926.550 (wind: 148.000)	€ 84,16 + VAT	5.583.560 (onshore wind: 1.089.894) (offshore wind: 2.347)	€ 52,61 (£ 45,94)
2003	1.530.900 (wind: 181.200)	€ 82,4 + VAT	7.546.787 (onshore wind: 1.241.034) (offshore wind: 43.812)	€ 51,93 (£ 53,34)
2004	3.081.500 (wind: 464.000)	€ 97,36 + VAT	10.870.929 (onshore wind: 1.728.478) (offshore wind: 282.644)	€ 51,60 (£ 45,05)
2005	4.377.359 (wind: 1.281.550)	€ 108,3 + VAT	13.767.375 (onshore wind: 2.592.267) (offshore wind: 487.083)	€ 48,62 (£ 42,45)
2006	5.969.407 (wind: 2.002.000)	€ 118,9 + VAT	14.964.170 (onshore wind: 4,208,975) (offshore wind: 720,824)	€ 56,57 (£ 49,28)
2007	7.767.978 (wind: 2.653.229)	€ 94,8 + VAT	16.151.978 (onshore wind: 4,814,409) (offshore wind: 963,200)	€ 60,78 (£ 52,95)
2008	10.399.871 (wind: 3.265.130)	€ 92,1 + VAT	18.948.878 (onshore wind: 6,220,107) (offshore wind: 1,497,892)	€ 62,14 (£ 54,37)
2009	17.524.703 (wind: 5.457.420)	€ 88 + VAT	21.227.618 (onshore wind: 7,250,909) (offshore wind: 2,716,787)	€ 60,10 (£ 52,36)

Data sources: GSE, 2010; Aeeg 2009, 2010; Ofgem 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011a.

Feed-in tariff schemes are now in place in all three countries. The major

supporter for TGC schemes, United Kingdom, was the latest to adopt it but offers now a mechanism with the highest tariffs for small wind energy in the world. Both in Italy and the UK feed-in tariffs are very attractive for small wind energy producers while in France they are overall lower but don't discriminate between the generators size. This is because France lacks a GC system for big plants.

Table 16. Feed-in tariffs comparison for wind energy in Italy, France and the UK.

	Onshore	Offshore
ITALY *up to 0,2 MW*	30 €c/kWh	
FRANCE *in ZDE: no limits* *out ZDE: up to 12MW*	First 10y: 8,2 €c/kWh Next 5y: 2,8 - 8,2 €c/kWh	13 €c/kWh 3 - 13 €c/kWh
UK *up to 5 MW*	2010: 5,4 - 41,5 €c/kWh 2021: 5,2 - 23,8 €c/kWh	

Data sources: French Government, 2008; Ofgem 2011b; RES Legal.

So for example a 1,5kW wind power generator would get a support of 41,6 €c/kWh in the UK, 30 €c/kWh in Italy and only 8,2 €c/kWh in France. A 200 kW generator would get 30 €c/kWh in Italy, 22,6 €c/kWh in the UK and only 8,2 €c/kWh in France. Plants bigger than 200kW in Italy and bigger then 5 MW in the UK will enter the Green Certificate market with revenue of ~6-9 €c/kWh, while in France they will get 0,28 €c/kWh.

In Italy higher attention is given to small producers that have two more incentive measures to choose from: 'Net metering' and 'Purchase and sale by the grid operator'.

In France and the UK the focus is more on big producers that have also the chance to participate in tenders. One of the main attraction of tenders from an investor risk perspective is that they are contract of 15-20 years and long contract minimise risk. On the other hand one of the major drawbacks of them is the encouragement to 'play games' within the system: for instance, wind energy is a technology that becomes cheaper with time, therefore a contract holder may delay as long as possible to build a project. It is therefore very important to introduce deadlines and penalties within the mechanism.

All in all it appears that wind energy is more strongly supported in Italy and

the UK than in France. Beside lower support rates, the Grenelle 2 law has recently placed extra administrative burden on French small producers introducing a five wind turbine minimum size for onshore wind farms and an obligation for wind turbines to be classified under rules governing dangerous industries (ICPE).

As shown by all three countries, support schemes need constant evaluation and review not to disturb investment confidence or to endanger the market. Most importantly, they need to be structured in junction with other polices (such as internalisation of external costs and increased research on crucial issues such as grid and storage capabilities), so that eventually renewable energy will be able to walk alone. All support mechanisms provide the necessary, yet temporary, support to enable renewable energy technologies to achieve mainstream status and phase out from the support schemes as eventually full competition with conventional electricity production technologies should be achieved.

4. TECHNOLOGY

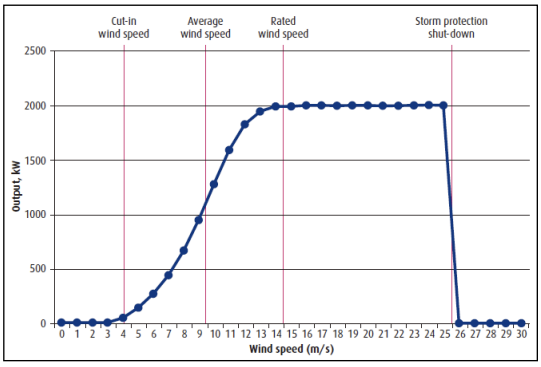
4.1. WIND ENERGY BASICS

Winds are a form of solar energy: they are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetation. The terms wind energy or wind power describe the process by which the wind is used to generate mechanical power or electricity.

4.1.1. Wind speed and power output

The economics of a project are crucially dependent on the windiness of the site. The power available from the wind is a function of the cube of the wind speed. Therefore a doubling of the wind speed gives eight times the power output from the turbine. All other things being equal, a turbine at a site with an average wind speed of 5 m/s will produce nearly twice as much power as a turbine at a location with average wind speed of 4 m/s. A change of wind speed of a few per cent thus makes an enormous difference in financial terms for both debt and equity. For these reasons, beyond the atlas wind map, wind resource measurement and analysis programmes must always be taken before developing a wind farm, so to have a robust prediction of the expected energy production over the lifetime.

Wind turbines produce power over a wide range of wind speeds. They cut in at between 3 and 4 m/s, reach their rated output at about 12 m/s and are regulated to produce their maximum output through to 25 m/s, when they typically shut down to protect the drive train, gearbox and structure from potential damage (Figure on the side). The maximum speed of 25 m/s, defined as when tree branches break, correspond to above gale force 9.

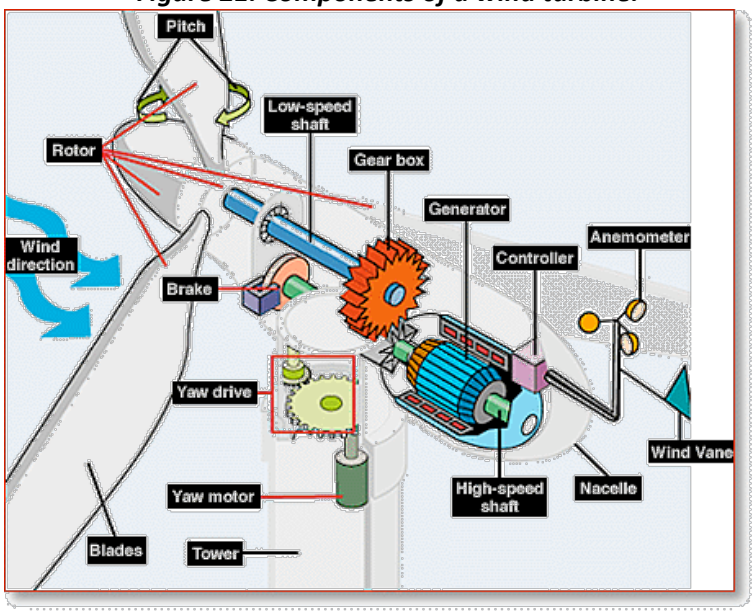


Source: SDC, 2005.

4.1.2. Wind turbines

Wind turbines convert the kinetic energy in the wind into mechanical power: the wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The transformation of the wind kinetic energy into electrical energy requires complex and technologically sophisticated machines. The design and construction of these machines is currently one of the areas of mechanics with the most advanced technologies derived from, or at least comparable to, those of the aviation and aerospace industry. The continuous knowledge development of the aerodynamic field, the use of innovative materials and more sophisticated control systems (usually computerised and remote-controlled) make the machine ageing very quickly in terms of design. The main components of a wind turbine are shown in Figure 21. and described below:

Figure 21. Components of a wind turbine.



Source: US Department of Energy, EERE.

Nacelle: The nacelle sits on top of the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.

Rotor: The blades and the hub together are called the rotor.

Anemometer. Measures the wind speed and transmits wind speed data to the controller.

Controller. The controller starts up the machine at wind speeds of about 3,5 to 7 m/s and shuts off the machine at about 25 m/s to avoid damages. The most commonly used methods of controlling power output are:

Stall control. The twist and thickness of the rotor blade vary along its length in such a way that turbulence occurs behind the blade whenever the wind speed becomes too high. This turbulence means that less of the energy in the air is transferred, minimising power output at higher speeds.

Pitch control. Electronics and hydraulics are used to infinitely adjust the pitch of each blade. This reduces the lift, so that the rotor continues to generate power at nominal capacity even at high wind speeds.

Gear box. Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, which is the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

Generator. Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

High-speed shaft. Drives the generator.

Low-speed shaft. The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

Tower. Towers are made from tubular steel, concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

Wind vane. Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

Yaw drive. Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

Yaw motor. Powers the yaw drive.

Offshore turbines. The main difference with onshore wind towers is the foundations, which are built based on oil platform technologies.

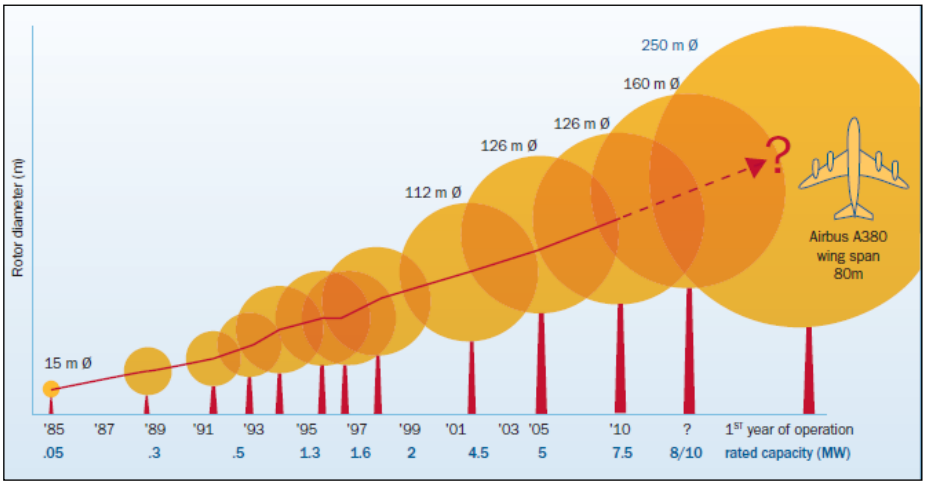
4.1.3. Wind turbine technology development

Wind turbines are getting larger (Fig. 22) because of the desire to increase the power output, to reduce costs and to enhance the harvesting of low-speed wind.

The power output is directly proportional to the swept area of the rotor: larger blades equal larger swept area, which results in higher power output. Furthermore taller towers reach higher wind speeds because of decreased effects from vertical wind shear, due to surface roughness from trees, hills and buildings.

Costs decrease when using larger turbines because of the associated economy of scale. Fewer turbines are needed to make up the wind farm, meaning less maintenance, less roads to the turbines, less cabling between wind turbines, and less interference with agriculture (Hoffman, 2009).

Figure 22. Development of Wind Turbine Sizes



Source: EWEA, 2011c

Larger rotor diameters have been introduced also in order to enhance exploitation of low wind speed sites, as bigger wind turbines can harvest the lower-speeds. This wind turbines can have rotor diameters the size of a football pitch. Siemens, Vestas, and Nordex all recently released new, large wind turbines directed at low-wind markets. Siemens predicts that the low-wind market alone should represent one-third of the total global wind-power market in the coming years as there will be always less accessible high wind speed areas left.

Also blade material development continues to evolve, focusing on the use of composite materials. Traditional rotor blades have been constructed of glass fibre

reinforced polymer (fibre glass). Since then, other composite materials such as carbon-fibre reinforced polymer (CFRP) have been displaying superior properties, as lighter, stiffer and stronger than fibreglass, but remain more expensive. Hybrid blades (fibreglass and CFRP) can be fabricated to reduce this cost. The ratio of the fibrous component compared to the amount of polymer resin is also being tested to achieve the maximum cost reduction and reduced manufacturing time, while still maintaining the quality of the blades.

Other areas of current research that focus on the cost-effectiveness of wind turbines are:

- Advanced independent pitch control.
- Power electronics using silicon carbide (SiC) material which allows for lower losses, higher temperatures and faster switching than standard silicon semi-conductors.
- Hybrid steel/concrete and concrete wind turbine towers which have a projected cost of 33% less than tubular steel towers.
- Fluted steel towers instead of tubular. The innovative self-erecting fluted design is lighter, does not require the use of heavy foundations, and can be shipped to site as flat metal plates. ScanWind from Norway has developed self-erecting towers to minimise crane costs (only a small crane would be needed to start the erection process).

4.1.4. Capacity factor - Minimising the costs

The capacity factor of a wind turbine is the amount of energy delivered during a year divided by the amount of energy that would have been generated if the generator were running at maximum power output throughout the whole year. In general it is an advantage to have a high capacity factor in order to obtain low cost per kW of electricity produced. For this reason many people are very concerned that typical capacity factors for wind turbines are ‘only’ around 20-35%. But differences in capacity factors for wind turbines are useless as indicators of the profitability of wind farms. In fact, the key design criterion for designers of large grid-connected wind turbines is not to maximise the amount of energy extracted from the wind but to minimise the cost per kWh of energy output from the turbine. Since the wind is free, it is not important to draw more or less energy out of it. Since the investment

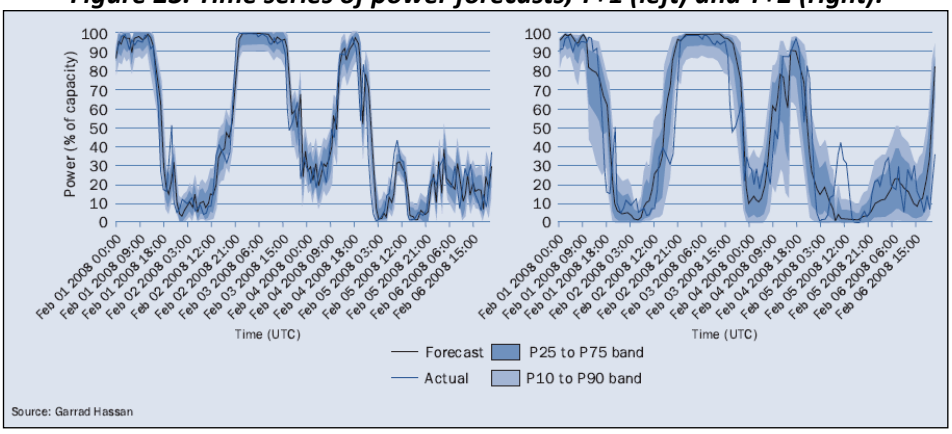
costs are high it is important to keep them to a minimum. Hence it is preferable to have a lower efficiency factor with low lifetime costs than the other way around. Decreasing the size of the generator increases the capacity factor, but this also decreases annual sales. So the costs saved from using a smaller turbine, are too small to even out the lost sale, due to economy of scale.

4.1.5. Forecasting

Sophisticated modelling tools which can provide robust short-term forecast of the output of wind farms are now available. These models are being used by TSOs to facilitate balancing of the grid, by energy traders to trade energy from wind farms on future markets, and by wind farms owners to optimise O&M arrangements.

An example of forecast is shown in Figure 23: the model has predicted the output of the wind farm, both 1 hour (T+1) and 12 hour (T+12) in advance. The forecast has captured the shape of the profile rather well. So that the prediction is rather good for scheduling plant maintenance for example. It looks a bit poorer for purpose of hourly trading.

Figure 23. Time series of power forecasts, T+1 (left) and T+2 (right).



Source: EWEA, 2009c

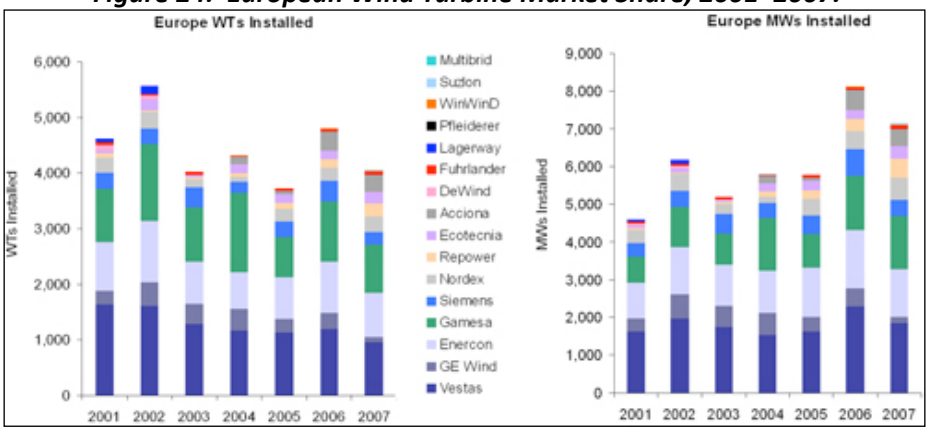
4.2. THE INDUSTRY

The wind power industry consists on five major stages of the value chain:

- Components manufacturing
- Turbine assembly
- Wind farm development
- Installation
- Facility management

The business of wind turbine manufacturing is the most profitable in the value chain. But it is also the one that bears the most additional expenses for research, industrialisation of the product and market development. To remain competitive on the market, a policy of constant and substantial investment on product development is fundamental. Europe hosts quite a strong competition for market share where, to maintain the competitive advantages, a constant improvement of the price/performance ratio is expected. There are roughly a dozen suppliers on the scene, with three major companies dominating the market: Vestas, Enercon and Gamesa (Fig. 24.). Vestas and Siemens dominate the offshore market with a share of 63% and 32% respectively (GWEC, 2010).

Figure 24: European Wind Turbine Market Share, 2001–2007.



Source: Suppliers, Emerging Energy Research

The wind industry is one of the highest-growth industries in Europe, but wind turbine manufacturing is concentrated in those few countries that started to invest in the sector back in the 1970s: Germany, Spain, Sweden and Denmark. For all the countries that approached the market later, like Italy, France and the UK, it was

already too late to gain a share in an already very competitive market. The highly specialisation of the sector and the magnitude of the know-how and technology, makes the turbine manufacturing market very difficult to enter. The know-how needed to design and manufacture wind turbines is fundamental, ranging from mechanical and electrical expertise to aerodynamic knowledge, and building such a background of expertise in a short time is a hard task.

In the rest of the world, a significant production takes place in the United States, India and China. While Europe and the US are consolidating market, India and China are still in an emerging phase, so generally their turbines are of lower quality compared to world leaders' machinery. The technology gap though, is rapidly decreasing and will soon create grater international competition on the mature market.

4.3. THE GRID

Wind power as a generation source has specific characteristics, which include variability and geographical distribution. These raise challenges for the integration of large amounts of wind power into electricity grids. In order to reduce variability, wind plant output should be aggregated to the greatest extent possible. The wind does fluctuate, but if averaged out across the country the fluctuation is much less, and the larger the nation wide network of wind farms, the smaller the variations in electricity generation. A single wind farm can experience power swings from hour to hour of up to 60% of its capacity. On the other hand, the German ISET research institute has shown that the maximum hourly variation across 350 MW of aggregated wind farms in Germany does not exceed 20%. Across a larger area, such as the Nordel system, covering four countries (Finland, Sweden, Norway and Eastern Denmark), the greatest hourly variations would be less than 10%, according to their study (EWEA, 2009c). By aggregating wind power over large regions of Europe, the system could benefit from the complementarities of cyclones and anticyclones over the continent. In order to do so, the present transmission system would need to be upgraded. In December 2010, ten countries bordering the North sea, including the UK and France, signed a project to coordinate investments for a common offshore grid in Europe's northern seas.

4.4. ITALY

4.4.1. The industry

The foundations of Italy's modern wind power industry were laid at the end of the 1970s by a series of research, development and demonstration programs by the major national energy institutions. Starting in 1979, the CNR (National Research Centre) was involved in collecting, classifying and processing wind pattern data supplied by the Air Force Weather Service's 136 monitoring stations. In the same year, ENEL started its Wind for Electricity Project (VELE), and CNEN (National Committee for Nuclear Energy) received its first fund for renewable-sources research, promotion and development. In 1981, CNEN's name was changed to ENEA (National Agency for Alternative Energies), and the organisation was given a fundamental role in promoting wind power in Italy. In 1981, the CNR published the findings from its first investigation of wind resources in Italy. A year later, law 308/1982 introduced the possibility of government funding for projects aimed at generating electricity from renewables. But the available grants were too little to boost development (Pirazzi, 2006). The 1988 National Energy Plan specified for the first time the target capacity of wind-powered generators to be installed in Italy: 300 MW, or 600 MW if large-sized generators became available. Nevertheless the attempt to develop an Italian wind technology sector and to compete with the northern European countries failed. Public institutions and industry lacked the determination and the division of roles and the common opinion was that Italy was not a sufficiently windy country. Moreover, the complexity of wind technology was underestimated. As a result, systems and components were often not designed carefully enough and rigourously tested in the laboratory and in field trials. The development of wind generators jumped from small sizes (up to 70 kW) to medium sizes (200-320 kW) without solving certain technical problems that appeared during testing. As the technical problems remained unsolved, the Italian operators were unable to access the ever more competitive wind-power market. Wind-generator development in Italy entered a difficult new phase when it was decided to focus on a large unit: the 1.5 MW GAMMA 60 (a totally innovative configuration in which the power output would be yaw controlled). In 1992 the GAMMA 60 was installed at an

ENEL site in Sardinia, but, after a short test period and a fire in the shaft, the whole enterprise was abandoned with no practical outcomes.

As a result, in the late nineties, when the wind power industry was already firmly established abroad, Italy had no competitive models of its own.

But at that point a new wind-power industry based on imported technologies started to developed in the country. Thanks to the Provision 6/92 (by the Inter-ministerial Committee on Prices - CIP), which introduced a per-kWh price for energy produced from renewable sources, the start-up and rapid development of commercial wind power took place (Pirazzi, 2006). In 1998 the Italian company WEST and Denmark's Vestas formed a joint venture called IWT, whose purpose was to manufacture medium-sized (600 kW) Vestas machines at the WEST plant in Taranto. A few years later Ansaldo WEST gave up the wind business altogether, but in the meantime Vestas had raised the Taranto plant's manufacturing capacity which is today the leader industry in Italy. A great increase in the national development and manufacture of wind-power components also took place over the years.

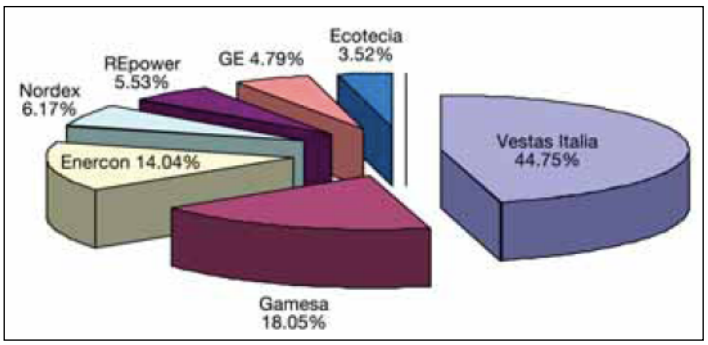
So even if the human and financial resources spent in RD&D from the 1970s to the 1990s produced scanty results for the national industry, they had the important merit of increasing interest in wind power, constituting the basis for commercial development in the mid 1990s.

4.4.2. Manufacturers

As a consequence of the unlucky industrial history in the wind sector, most turbines in Italy are being supplied by foreign manufacturers. Vestas (Denmark), which has production and management facilities in Italy, leads the Italian market with a share of total capacity close to 50% (IEA, 2009a). Gamesa (Spain), Enercon (Germany) and Nordex (Germany) come right after (Fig. 25.).

Despite these four major manufacturers others have entered the Italian market with shares ranging from 3 to 5%: REpower, GE Wind, Ecotecnia. The Italian manufacturers are currently Leitwind, Moncada and smaller firms that supply small-size units (IEA, 2009a).

Figure 25. Market share of wind turbines manufacturers in Italy at the end of 2009.



Source: IEA, 2009a

Vestas group has set a major establishment in Italy since 1998: Vestas Italy runs two commercial offices based in Taranto (Apulia Region) and in Rome. These offices are responsible for the sale, installation, and operations assistance of wind turbines over an area comprising various countries of North Africa and Southern Balkans. The Service and Maintenance Centre at Taranto monitors and assists wind farms spread over this area for a total of more than 1,800 turbines. In addition, two Vestas factories are located at Taranto, one for assembly of medium-sized (V52) and large (V90) machines (Vestas Nacelles), and the other for manufacturing blades (Vestas Blades). Vestas currently employs more than 700 people in Italy.

Leitwind (belonging to Leitner group), based at Vipiteno in South Tyrol, is currently the only Italian large wind turbine manufacturer on the market with installed wind turbines in Italy, Austria, Bulgaria, France, Canada and India.

Moncada Energy Group based at Aragona near Agrigento (Sicily) has invested substantial resources mostly as a wind farm developer, but has also developed an 850-kW wind turbine on its own and is looking to other machines of various sizes. Furthermore, Moncada has received approval to build a 400 kV merchant electrical line across the Adriatic Sea from Albania to Italy. This will enable Moncada to export power from its planned and already authorised 500-MW wind farm in Albania. The interconnecting direct-current (DC) cable between the Italian transmission grid and the Albanian grid will be 154 km long.

4.4.4. R&D

In Italy, there has been no national R, D&D program running on wind energy, but different entities have carried out research on wind. ERSE S.p.A. has continued to work on research programs under contract to the Italian Government in the interest of Italy's whole electricity system. The financial engagement of ERSE on wind energy research was about 2 million euros in 2009 and the 2010 and 2011 budgets are nearly as much (IEA, 2009a). The work of ERSE on wind energy led to a new, interactive Wind Atlas of Italy and a more accurate investigation of offshore wind potential. Regarding offshore wind, since the most plentiful resources are found in waters too deep for the current offshore wind technology, ERSE S.p.A: has taken an interest in the feasibility of building plants on floating foundations.

In September 2008, a small 80-kW wind turbine was installed by the company Blue H on a floating foundation about 20 km off the Apulian coast in 100 to 110 m deep waters where it was tested for a few months. Another prototype with a 2.5 MW turbine will be tested at the same site. In addition, early in 2009, a consortium led by Blue H including companies and research centres has been granted funds by the Italian government under the "Industria 2015" programme for developing a hybrid concrete/steel 3.5 MW floating wind turbine ideal for the deep waters of the Mediterranean Sea (IEA, 2009a).

The University of Trento has been running its own test field in a mountain environment to test and characterise small wind turbines ranging from 1.5 kW to 20 kW. The Polytechnic of Milan, through its Aerospace Engineering Department, has been working with industry, particularly concerning wind turbine aero-elastic modelling and control system design. The department has also been performing tests in their wind tunnel. The University of Naples has been conducting research on anemometers and small-sized wind turbines also by wind tunnel tests. As for offshore wind farms, work has been under way at the University of Bologna, which has a special interest in foundations, and at the Physics Department of the University of Genoa for assessment of offshore wind resources. Other universities have recently engaged in wind R&D activities: offshore wind power (Catania), towers (Forence and Padua), and small turbines (Naples). Feasibility studies have been carried out on offshore wind farms in Sicily jointly by the University of Catania and ENEA.

4.4.5. The grid

The Italian electricity system suffers from inadequate grid infrastructure, which leads to frequent curtailment of wind power production to manage grid congestion. Grid problems concern all projects in Campania, Apulia and Basilicata and some projects in Sardinia, due to the low capacity of the grid, especially on old-fashioned 150 kV lines that are incapable of dispatching all the power produced by the wind farms. In 2008 and 2009, some wind farms operated at 30% less than their normal capacity over the course of the year, some were limited by over 70%, and some were shut down completely because of temporary overloads occurring on electrical lines. Around 500 GWh of wind production was lost in this way during 2009 (IEA, 2009; GWEC 2009).

Terna, the Italian TSO, has been investing heavily (over 500 million € planned) on new grid infrastructures to overcome these problems and support the development of wind capacity. Dedicated substations ("collecting plants"), through which wind generated power can be fed straight from 150 kV lines into the very high voltage (380 kV) system are being built. Moreover, two major links are under construction: the SAPEI DC cable between Sardinia and the mainland and the AC cable between Sicily and Calabria. But the construction of new lines and substations, takes a long time: two to three years and sometimes longer is needed to come into operation, due to lengthy permitting processes.

AEEG (the Italian Regulatory Authority for Electricity and Gas) on the other hand, took action in order to avoid undue damages both to wind investors and to the electrical system at large. Since 1 January 2009, grid-connection of new generating plants are regulated by Deliberation ARG/elt 99/08, which provides for special, more favourable terms for RES plants, with a view to speeding up their connection and alleviating costs to investors. At the same time the Deliberation has allowed grid operators (like Terna) to require that new wind plants provide some ancillary services for the benefit of the electrical system, such as power output modulation, cut-in power ramp control, fault ride-through capability, and regulation of active and reactive power.

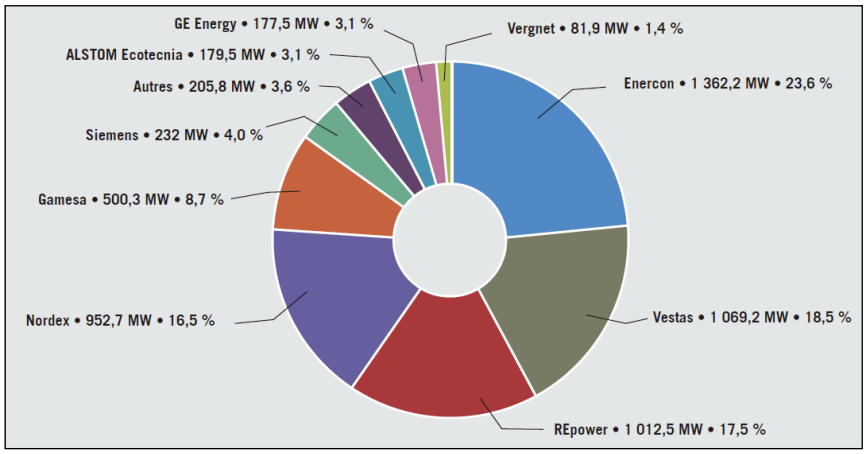
As a result, applications for the connection of renewable energy systems to the transmission or distribution grid must now be given priority treatment and renewable energy systems must be given priority connection (ARG/elt 99/08).

4.5. FRANCE

4.5.1. The Industry

The top four market players in wind turbine manufacturing in France are: Enercon (Germany), Vestas (Denmark), REpower (Germany) and Nordex (Germany). EDF Energies Nouvelles, Eole-RES and GDF-Suez are the leading project developers.

Figure 26. Market share of wind turbines manufacturers in France at the end of 2010.



Source: SER, 2010.

Vergent is the only real French player but the national industrial market is expanding: French power engineering multinational ALSTOM bought the Spanish ECOTECNIA recently, while French Nuclear Power giant, AREVA, took over 51% of German MULTIBRID's shares in September 2007 (Avis, 2008).

In general, French companies in the wind sector continue to grow, especially manufacturers, suppliers and subcontractors. French subcontractors (like Aerocomposite Occitane, Rollix Defontaine, Carbone Lorraine, AREVA T&D, CDE SA, SIAG, SPIE, Laurent SA) engage in the wind industry by providing components of any kind. Many consulting firms, engineering, construction or transportation companies benefit from the growth in the wind industrial sector: over 150 companies have already been identified as sub-contractors active in the wind industry, working for major manufacturers (SER, 2010c).

4.5.2. VERGNET - World leader in farwind market

Vergnet is the only French industrial group in the wind sector and, thanks to constant innovation (representing 30% of the last 5 years revenues) the group is the

technology leader in the “Farwind” market. For over fifteen years, it has been designing, manufacturing and marketing turbines for Farwind areas, namely areas with reduced infrastructure or with extreme climatic conditions, that make the installation, operation and maintenance of conventional wind farms difficult. Its special turbines (from 275 kW to 1 MW) can be installed without cranes, can be shipped in standard containers, and have the peculiarity of bending to the ground in very little time in case of cyclone emergency or for major maintenance operation. Today Vergnet has the only 1 MW wind turbine in the world designed to meet the specific needs of the Farwind market. This is also the largest wind turbine ever designed and produced in France.

More than 650 Vergnet wind turbines are currently in service in the Caribbean area, in Africa and in the Pacific and Indian Ocean while the group's growth prospects look very optimistic. In France, Vergnet is ready to meet commitments under the Grenelle Law by providing wind systems incorporating storage features. As to the export, the group has signed a contract, with the national Ethiopian Electricity company EEPCo, for the supply and installation of 120 1-MW wind turbines over 3 years (for € 210 million) (SER, 2010a).

The company has a nacelles assembly plant in Ormes, near Orléans; a blades factory in Béziers; 3 subsidiaries for O&M in Guadeloupe, Réunion and Nouméa. The group now employs 250 people and expects an increase in staff and production capacity with eventual production of 150 turbines per year (SER, 2010a).

4.5.3. The grid

Adequate grid connection capacity remains a problem in some areas of France, where grid connection capacities are running low and grid needs to be reinforced. Although, some commitment has been made towards reinforcing the French grid to accommodate more wind development. The regional schemes of electricity grid connection, planned in the Grenelle 2, aim to address these problems (GWEC, 2009).

In France, the use of the grid for the transmission of electricity from renewable sources is subject to the general legislation on energy and shall be granted according to the principle of non-discrimination. There are no special provisions for electricity from renewable sources.

4.6. UNITED KINGDOM

4.6.1. The industry

The UK, like Italy and France, largely missed out on the early growth phase of the wind industry in the 1980s. As the manufacturing market is too hard to penetrate now, turbines are mainly imported from the continent (Fig 27.) With the exception of Clipper Windpower, major turbine manufacturers are all located outside of the UK, which poses challenges for the UK supply chain (IEA, 2008).

The British slow development in the wind sector might have been due to the lack of proper support schemes (such as feed-in tariffs), as the introduction of the Renewables Obligation scheme in 2002, boosted investments and deployment making the UK one of the leading countries in world for wind power development. So that today, even if the manufacturing sector is still missing, large parts of the wind industry chain have become important and established business in the UK, such as development, technical consulting and construction and installation.

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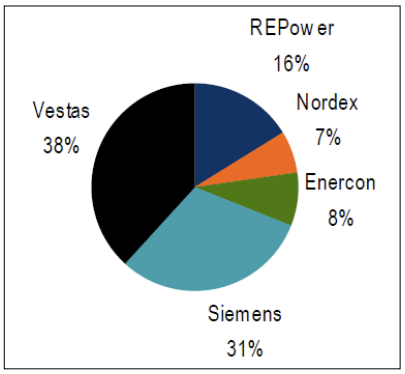
Figure 27. Turbine manufacturers market share in the UK, 2007.



Source: Merrill Lynch, 2007.

The UK wind industry will develop especially in the offshore wind sector, being the leading country in offshore wind farms deployment, and likely to remain so for some years to come.

Micro-generation in individual homes has also been a central subject for policy and industry attention in recent years: the UK see it as a strategy to reduce household carbon emissions up to 15% by 2050, while meeting 40% of the electricity demand.

Figure 28 shows the current and planned high deployment of wind power in the UK, that will contribute to increasingly strengthen the national industry. Altogether, at the end of 2010, around 1,300 MW of offshore wind power was generating electricity in the UK, making it the country with the largest portfolio of offshore wind projects.

Figure 28. Operational and planned wind farms in the UK, at the end of 2010.

Operational wind farms

Onshore			Offshore		
England	107	839.44 MW	England	10	1,181.20 MW
Northern Ireland	28	324.73 MW	Scotland	1	10.00 MW
Scotland	112	2,379.18 MW	Wales	2	150.00 MW
Wales	33	382.55 MW		**13**	**1,341.20 MW**
	280	**3,925.90 MW**			

Total operational wind farms: 293 (5,267.10 MW)

Wind farms currently under construction

Onshore			Offshore		
England	8	127.55 MW	England	7	2,238.00 MW
Northern Ireland	2	42.60 MW		**7**	**2,238.00 MW**
Scotland	25	1,413.02 MW			
Wales	2	32.40 MW			
	37	**1,615.57 MW**			

Total wind farms currently under construction: 44 (3,853.57 MW)

Consented projects

Onshore			Offshore		
England	89	1,197.66 MW	England	4	1,232.10 MW
Northern Ireland	22	400.40 MW	Wales	1	576.00 MW
				5	**1,808.10 MW**

Source: Renewable UK

4.6.2. The grid

In the United Kingdom, access of renewable energy systems to the grid is subject to the general provisions of energy law. RES are not given priority.

Grid capacity is often limited in those areas where there is good wind supply and site approval is achievable. Getting significant transmission capacity built out to remote locations can take up to 10 years (Boettcher, 2008). The dominant view is that gaining access to grid connectivity and the actual connection of wind farms will remain a challenge.

However when it comes to penetration problems, the UK enjoys a good correlation between electricity demand and weather, especially cold weather. The country experiences significantly higher electricity demand during winter than in summer. Moreover electricity demand is higher during the day and early evening and lower overnight and in the early hours of morning: Sinden (2007) found that this pattern of electricity demand is similar to the pattern of the wind volatility in the UK.

4.7. Analytical comparison

None of the countries among Italy, France and the UK has developed a national industry in wind turbine manufacturing. They all missed out on the early growth phase of the wind industry in the 1980s and when they approached the market they lacked technology and experience and couldn't confront the competitiveness. This explains why they are now lagging behind Spain and Germany, with less than half of their installed capacity but with good future prospect development.

Despite lacking a national wind turbine manufacturing industry though, all three countries have attracted foreign manufacturers and have developed all sectors of the wind industry parallel to the machine manufacturing: from components manufacturing to engineering, project development and consultancy.

France stands out for being world leader in farwind turbine manufacturing, and for having taken over large shares of foreigner manufacturing companies, like Ecotecnia and Multibrid.

As to the grid, all countries are still experiencing problems and working toward an improvement and upgrade of the connection lines. A more coordinated deployment policy across European countries to encourage investment in the best wind sites while developing a European grid that links the key windy areas, would be a great benefit.

5. ECONOMIC ANALYSIS

5.1. EUROPEAN MARKET

Generating electricity from the wind makes economic sense: the wind is a free and renewable fuel which will never run out. The European wind energy industry - manufacturing and operating turbines - is growing fast and is set to expand as Europe and the rest of the world look for cleaner and more sustainable ways to generate electricity. Turbines are becoming cheaper and more powerful, with larger blade lengths which can utilise more wind and therefore produce more electricity, bringing down the cost of renewable generation. On top of that, wind reduces the exposure of our economies to fuel price volatility, which represents an important economic benefit. Europe relies on relatively low capital intensity fossil-fuel fired power plants at the moment, with a very high risk component as fuel prices are very volatile and unpredictable. A diversified generating technology portfolio, containing more capital intensive and low-risk wind power, may indeed be a wiser choice for society than relying on fuel intensive high-risk fossil technology.

The tendency to select technologies that are less capital-intensive and riskier than wind energy can be exacerbated by the lack of financial resources at the time of making the investment. The upfront/capital costs of a wind farm constitute around 80% of the total outlay, while for other technologies, like natural gas, they remain in the range of 40% to 60%. If the financial market is not well informed about the benefits of wind and about the uncertainty of the alternative options, obtaining the financial resources needed at the initial stage of the project can be difficult and will favour less capital-intensive technologies.

The wind energy sector also benefits the economy creating employment, markets and export opportunities for Europe, which is already the global leader in wind energy technology. As an established market for wind energy, Europe accounts for over half of the total wind capacity installed worldwide. Nevertheless by 2020 it will be outclassed by Asia Pacific and North America that will become the global wind growth leaders. By 2020, Europe is expected to account for 27% of new

capacity added worldwide, compared to 31% for North America and 42% for Asia-Pacific (EER, 2009b). Following this trend, large European utilities are revising their investment plans and increasing the weight of non-European wind assets in their portfolios. Some European utilities' non-European portfolios account for over 25% of their installed capacity (E.ON, EDF, EDP, ENEL, Iberdrola) (EER, 2009b). They have already established a solid presence in growing markets such as the US. China's market, despite its enormous resource potential, is more difficult to penetrate as regulations are limiting wind development opportunities for foreign players.

The new capacity added in the world in 2010 represents investments worth €47.3 billion (GWEC, 2011*).

5.2. COSTS OF WIND ENERGY

The cost of generating electricity from wind energy comprises of:

- Capital costs (turbine costs, foundations, electrical installations, connections to the electrical grid, consultancy fees, land costs, financing, security and road construction) (5.2.1.)
- Running costs, such as fuel and operation and maintenance (O&M) (5.2.2.) and
- The cost of financing (how the capital cost is repaid) (5.2.3.)

These costs may vary depending on the entity of two main classes of influence:

- technical factors (such as wind speed and the nature of the turbines), (5.2.4) and
- financial perspective of those that commission the projects (required rate of return on the capital, time over which the capital is repaid) (5.2.3.).

5.2.1. Capital costs (turbines)

The total cost per kW of installed wind power capacity differs significantly between countries. Especially for foundation and grid connection, costs vary depending on turbine size, distance from grids, land ownership structure and the nature of the soil. Costs typically vary from around **1,000 - 1,350 €/kW** for onshore wind farms (EWEA, 2009b; EEA 2009). Approximately 75% of the total cost of energy for a wind turbine is related to upfront costs such as the cost of the turbine, foundation, electrical equipment and grid-connection (EEA, 2009). Usually banks and finance institutions require a pay-back of 7-10 years. After the investment is paid off, the cost of producing electricity from wind energy is lower than any other fuel-based technology, as the fuel has no cost and O&M costs are very low.

The typical cost structure for a 2 MW turbine is shown in Table 17 below.

Table 17. Cost structure of a typical 2 MW wind turbine installed in Europe

	INVESTMENT €/kW	SHARE OF TOTAL COST %
Turbine (ex works)	928	75.6
Grid connection	109	8.9
Foundation	80	6.5
Land rent	48	3.9
Electric installation	18	1.5
Consultancy	15	1.2
Financial costs	15	1.2
Road construction	11	0.9
Control systems	4	0.3
TOTAL	1,227	100

Source: EWEA, 2009b.

Wind turbines, including the costs associated with blades, towers, transportation and installation, constitute the largest cost component of a wind farm, typically accounting for around 75% of the capital cost. The geography in terms of site accessibility and the geotechnical conditions on the site of the wind farm obviously plays a crucial role in determining the cost of road construction, cabling and so on. On average, grid connection accounts for around 9% and foundation for around 7% (EWEA, 2009b).

Offshore costs depend largely on weather and wave conditions, water depth and distance from the coast. Offshore wind capacity is still around 50% more expensive than onshore wind due to foundations, transformer stations and sea transmission cables that are considerably more expensive. On average, investment costs for a new offshore wind farm are in the range of **2,000 - 2,200 €/kW** for a near-shore, shallow water facility (EWEA, 2009b). But costs can increase dramatically with water depth and distance from the coast (Table 17.).

Table 18. Increase in offshore investment cost as function of distance to the coast .

		Distance to coast (km)							
		0–10	10–20	20–30	30–40	40–50	50–100	100–200	> 200
Cost (EUR/kW)	Turbine	772	772	772	772	772	772	772	772
	Foundation	352	352	352	352	352	352	352	352
	Installation	465	476	488	500	511	607	816	964
	Grid connection	133	159	185	211	236	314	507	702
	Others	79	81	82	84	85	87	88	89
	Total cost (EUR/kW)	1 800	1 839	1 878	1 918	1 956	2 131	2 534	2 878
	Scale factor	1	1.022	1.043	1.065	1.086	1.183	1.408	1.598

Source: EEA. 2009.

There are economies of scale in the construction of wind farms, both in terms of total size of the wind farms (the number of turbines sharing a common substation and sharing development and construction costs) – and in terms of turbines' size. Larger turbines generally have comparatively lower installation costs per swept rotor areas. Moreover the cost of some components such as electronic controllers and foundations varies less than proportionately with the size of the wind turbine.

The recent increase in turbine prices is a global phenomenon, which stems mainly from a strong and increasing demand for wind power in many countries, as well as rising raw material cost and constraints on the supply side: turbine manufacturers, but also deficit in sub-supplier production of wind turbine components, caused by the staggering increase in demand.

5.2.2. Running costs (O&M)

Due to the relative infancy of the wind energy industry, there are still only a limited number of turbines that have gone through their whole life period of 20 year, thus estimates of O&M costs are still uncertain, especially around the end of a turbine's lifetime. O&M costs are generally estimated to be around **1,2 - 1,5 €c/kWh** of wind power produced over the total lifetime of a turbine. There is a trend towards lower O&M costs for new and larger machines (EWEA, 2009b). O&M costs increase with the age of the turbine. During the first few years the warranty of the turbine implies a low level of O&M expenses for the owner. After the 10th year, larger repairs and reinvestments begin to appear and they become the dominant costs during the last ten years of the turbine's life (EWEA, 2009b; EER, 2010b).

Turbine owners face key O&M decisions between years two and five of operation (Fig. 29.), when failure rates are constant, but long-term performance remains uncertain (EER, 2010b). Figure 30 shows the failure rate of various components and their average downtime before reparation.

Figure 29. Turbine life cycle.

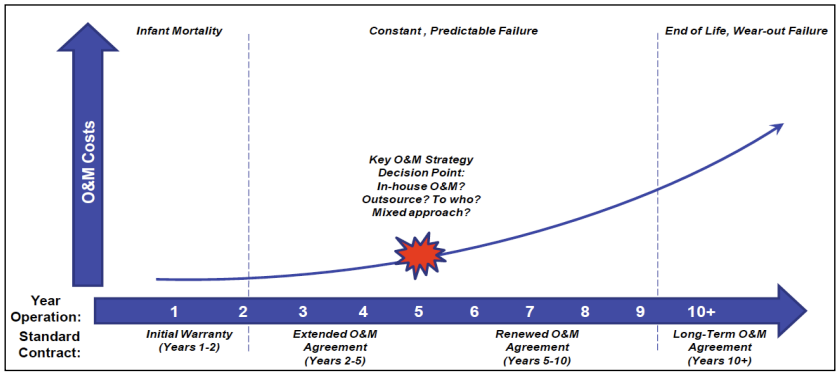
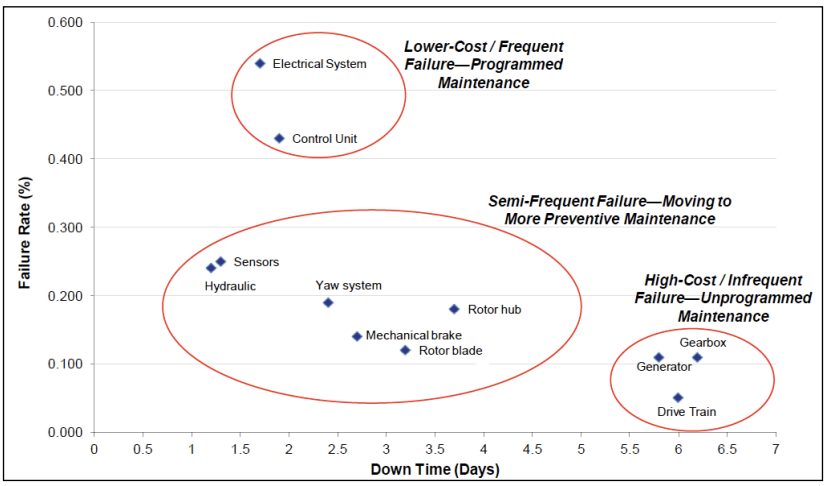


Figure 30. Turbine's components failure

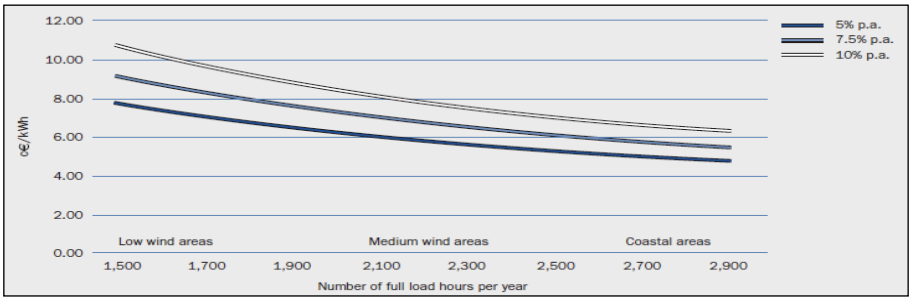


Source (Fig. 21 and 22): EER, 2010b

5.2.3. The cost of financing & financial perspective

As wind turbines are very capital intensive, the costs of capital (discount or interest rate) is an important factor for the cost of wind generated power. Interest rate may vary significantly across European countries. Assuming a case where investment costs are on average 1,225 €/kW, and O&M costs are of 1.45 €c/kWh (as an average over the 20 years lifetime of the turbine), the effects of different discount rates per annum (varying from 5 to 10%) on the cost of wind power are reported in Figure 31:

Figure 31. The costs of wind power as a function of wind speed and discount rate.



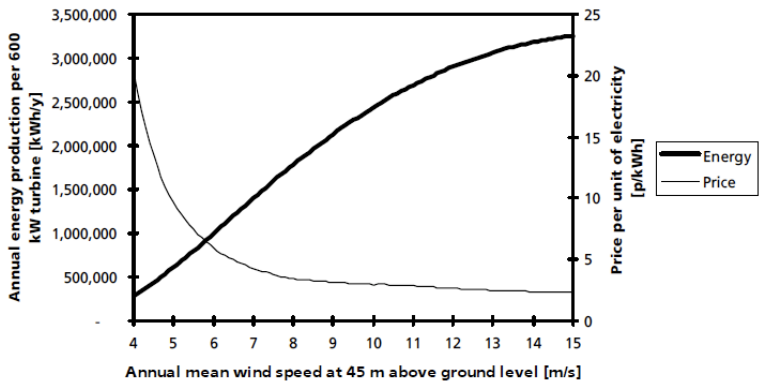
Source: EWEA, 2009b

The costs ranges between around **6-8 €c/kWh** at medium wind positions, indicating that a doubling of the interest rate induces an increase in production costs of 2 €c/kWh or 33%. In low wind areas, the costs are significantly higher, at around **8-11 €c/kWh**, while in coastal areas the production costs range between **5-7 €c/kWh**. In Europe coastal positions such as these are mostly to be found in the UK, Ireland, France, Denmark and Norway. Medium wind areas are generally found at inland terrain in mid- and southern Europe: Italy, France, Spain, Holland and Germany. In many cases, local conditions significantly influence the average wind speed at the site anyway. Therefore, strong fluctuations in the wind regime are to be expected, even for neighbouring areas.

5.2.4. Technical factors: wind speed

The energy costs of a wind farm also depend on the amount of electricity generated, which is strongly influenced by the wind speed at the site. Fig. 32 shows the variation in annual energy output with wind speed for a typical 600kW wind turbine and the effect this has on the cost of energy (all other things being equal).

Figure 32. Variation of electricity generation & price with wind speed for a 600kW turbine.

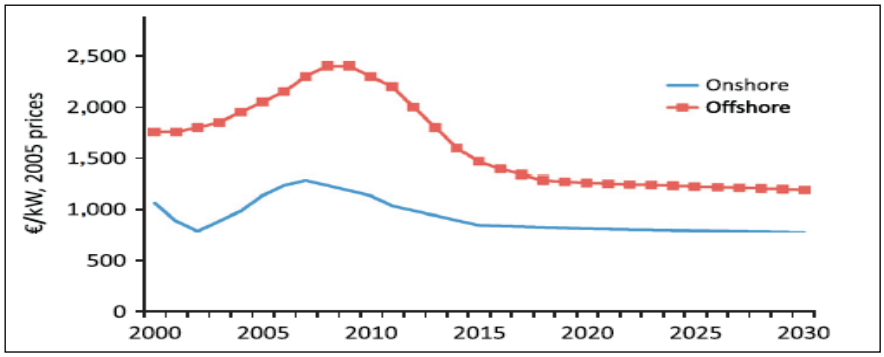


Source: DTI, 2001.

5.2.5. Project cost development

A past, current and future trend of wind capacity costs is shown in Fig. 33. In the period 2001 to 2004, the global market for wind power capacity grew less than expected and created a surplus in wind turbine production capacity. Consequently, the price of wind power capacity went down dramatically – to as low as €700-800/kW for some projects. In the four years from 2005 to 2008 the global market for wind turbines increased by 30-40% annually, and demand for wind turbines surged. This, combined with increasing raw material prices, led to an increas in wind farm prices (onshore wind farm prices starting at €1,300/kW and offshore prices of €2,300/kW). The steep increase in offshore cost reflects the limited number of manufacturers in the offshore market, the current absence of economies of scale due to low market deployment, and the bottlenecks in the supply chain.

Figure 33. Past and predicted wind capacity costs of onshore and offshore wind (€/kW).



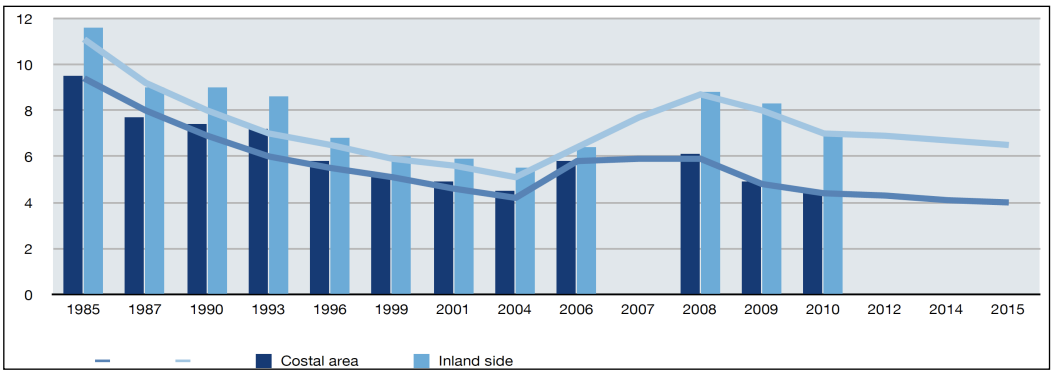
Source: EWEA, 2009b

The subsequent establishment of a strong wind industry, technology development and the constant increase in turbine size contributed to lower production costs of wind generated power and this trend is expected to continue for a few more years. But it is unlikely that costs will decrease dramatically due to technology advancements. Furthermore, as the commodity market of steel, copper, and other important materials will remain strong for several years, due to the high demand for these products in Asia, future wind energy costs reductions due to these commodity prices receding is improbable (Hoffman, 2009).

5.2.6. Energy production cost development

The same pattern took place in the cost of energy produced from the wind, mirroring the changes in project cost developments. Figure 34. illustrates energy past and predicted costs of wind energy production. Until 2008 the figures come from a Danish farm, then the estimates until 2015 are based on data from EWEA (2009b), the WEF (2009, 2010) and BNEF (2011).

Figure 34. Future development of wind turbine economics until 2015 (€c/kWh).



Data source: EWEA, 2009b; WEF 2009, 2010; BNEF, 2011.

Between 2005 and 2008 manufacturers and technology providers had been working to drive down their costs, however, the soaring demand for equipment from project developers meant that turbine prices were on an upward trend, thus these cost reductions were evened and not passed on to clients. All that changed in 2009, when in onshore wind turbine prices fell to their lowest levels for many years, finishing 2009 up to 20% below 2008 levels. This was, however, somewhat offset by higher financing costs, leaving the levelized total cost (Figure 30.) only 10% down

(WEF, 2010). Offshore wind costs on the contrary continued to rise as projects moved into deeper waters (facing increasingly complex construction and capital costs), and as the rush in project financing – particularly in the United Kingdom – has brought into sharp focus the predicted bottlenecks in installation ships and high voltage cables (WEF, 2010).

Electricity from onshore wind was generated at prices of **6,2-9 €c/kWh** in 2008, at prices of **4,9-8,3 €c/kWh** in 2009 and at a price of **4,3-7 €c/kWh** in 2010 (WEF 2009, 2010; BNEF 2011). The cost of electricity from offshore wind was around **11-15 €c/kWh** in 2008 and **9-17 €c/kWh** in 2009. The range became larger due to considerable differences in the project conditions but it is worth noting that the lower cost indicates a fall by nearly 25% from 2008. The cost will come down rapidly as more project experience is gained (WEF 2009, 2010).

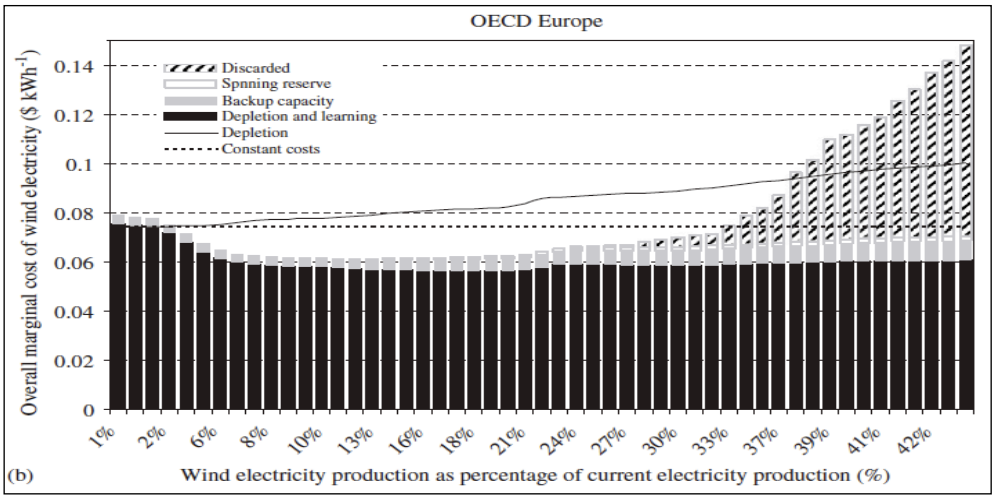
From 2010 until 2015, a learning rate of 10% is assumed (Figure 26.), implying that each time the total installed capacity doubles, the costs per kWh of wind generated power decreases by 10% (EWEA, 2009b). The growth rate of installed capacity is assumed to double cumulative installations every three years.

With increasing penetration wind production costs may further fall thanks to upscaling and technological learning, however one has to take into account also the counteracting effects that bring the cost up again. Three main factors are of concern to the wind costs (Hoogwijk, 2007):

1. The need to generate wind electricity at less favourable sites: this effect may cause a cost increase of 25–50%, counteracting the larger part of the expected gains from technological learning.
2. The need for additional back-up capacity.
3. Discarded wind electricity because of supply–demand mismatch. This occurs after about 20% wind electricity production as percentage of current electricity production. If wind electricity production exceeds about 30% of current electricity produced, discarded electricity is found to be the most significant factor for cost increase, accounting for 50% of the overall wind electricity cost.

Figure 35. shows the marginal cost development of wind electricity in OECD Europe with increasing wind electricity penetration subdivided in different cost components. Options to store the discarded electricity, which could substantially reduce these costs, are not considered in this study.

Figure 35. Marginal cost development of wind electricity in OECD Europe with increasing wind electricity penetration (0.06 $ = 4 €c).



Source: (Hoogwijk, 2007)

5.2.6. Additional costs

The output of wind power technology is variable in nature as it fluctuates depending on the availability of the wind which cannot be controlled. Growing shares of wind energy will require modifications to the operation of the system and market, and eventually additional flexible reserves, in order to ensure that system security is not impaired. To accommodate intermittent generation it may be necessary to retain a significant proportion of conventional plant to ensure security of supply (e.g. under conditions of high demand and low wind). Hence, the capacity value of intermittent generation will be limited as it will not be possible to displace conventional generation capacity on a "megawatt for megawatt" basis (Strbac, 2007). Also, intermittent generation is not easy to predict, hence various forms of additional reserves will be needed to maintain the balance between supply and demand at all times. The various costs associated with integrating increased levels of variable generation into the system can be grouped into three major categories:

- Network costs (large upfront capital investments): the construction of high-voltage transmission lines may be necessary to link such resources to the existing grid.
- Balancing costs (operational costs): need for ancillary services to meet supply with demand.
- Capacity adequacy costs: maintaining sufficient capacity in the grid to handle peak loads and maintaining system security for which an adequate amount of backup generation capacity is required.

The Table below (Table 19.) reports some estimations of interconnection costs in Europe as an average of various renewable sources.

Table 19. Integration costs of variable renewables in the European Union, 2035.

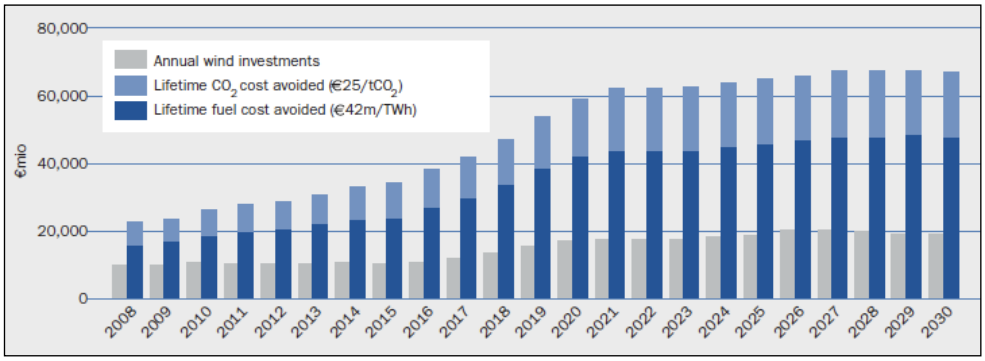
	Interconnectio	Balancing	Adequacy	Total
Unit costs (€c/kWh)	0,63	0,13 - 0,25	0 - 0,3	1,1
Total costs (€ billion)	5,2	1,7	2,3	9,2

Data source: IEA, 2010c.

5.2.8. Avoided costs

Wind energy can be very profitable as it avoids considerable costs of avoided fossil fuels and CO2 emissions. Most importantly, investments in wind energy capacity in a given year will continue to avoid fuel cost and carbon cost throughout the 20 (onshore) to 25 (offshore) year lifetime of the wind turbines. Figure 36. comperes wind investments with wind avoided costs from CO2 and fossil fuel assuming a price of CO2 allowances of €25/t and a price of $90 per barrel. It also assumes that on average 690 g CO2 per kWh produced are avoided per year. As a result the €152 billion invested in wind power between 2008 and 2020 will avoid **€135 billion** worth of CO2 and **€328 billion** in fuel cost (€42 million worth of fuel is avoided for each TWh of wind power produced), with a net gain over the whole period of €311 billion.

Figure 36. Wind investments compared with life time avoided fuel and CO2 costs (Oil = $90/barrel; CO2 = €25/t)



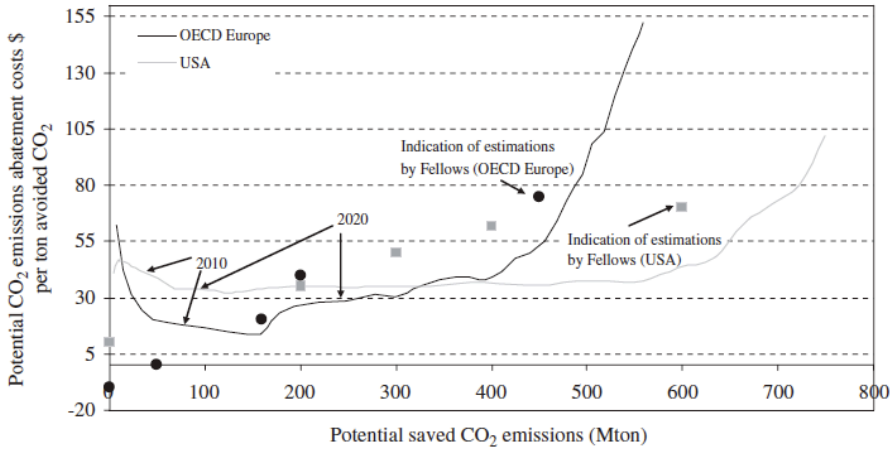
Source: EWEA, 2009b.

For the period 2008 - 2030, EWEA (2009b) has calculated avoided costs that sum up to €783 billion with the above mentioned assumptions. Assuming different CO2 and fuel prices can have a dramatic impact on the result though. Assuming low

carbon prices (€10/ton) and low fuel prices ($50/barrel) throughout the same period the wind power investment would avoid €466 billion. With high prices of CO2 (€40/ton) and fuel ($120/barrel) wind power would avoid costs equivalent to more than 1 trillion from 2000 to 2030.

Figure 37 reports the CO2 emissions avoided as a result of fuels savings according to a study by Hoogwijk (2007).

Figure 37. Potential CO2 abatement cost for wind electricity with increasing wind power penetration in OECD Europe.



Source: Hoogwijk, 2007

At first, abatement costs decline due to technological learning to about €9,5 per ton CO2 avoided in Europe. In 2010, (with an installed capacity of 75GW) emission of about 76 Mton CO2 can be avoided in Europe at average costs of about €12 per ton, while in 2020, around 230 Mton of CO2 can be avoided at €30 per ton.

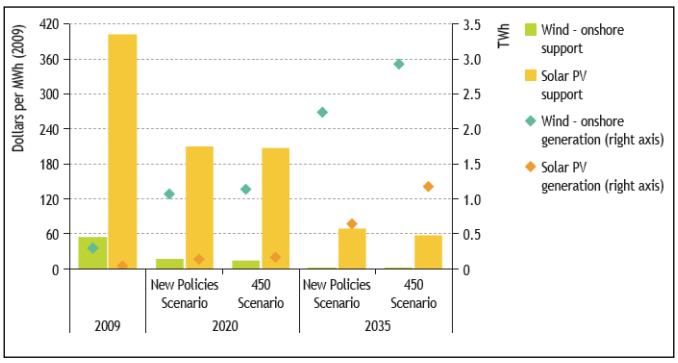
5.2.9. Competitiveness

The generating costs of wind power technologies per unit of output are diminishing, due to increased deployment, which accelerates technological progress and increases economies of scale (IEA, 2010c). Onshore wind power is relatively close to being competitive with non-renewable sources in several countries and learning will usefully reduce costs. As wind energy is a very capital intensive technology, once the investment is covered, the cost of producing electricity is generally lower than the electricity price.

The cost of support for wind is expected to diminish globally from $16 (€11) billion in 2009 to $4 (€3) billion in 2035, even though electricity output from onshore wind farms increases by a factor of ten over the same period (see figure

38). As a result, support costs per unit of onshore wind power generation fall to a global average of $2 (€1.3) per MWh by 2035, down from $52 (€35) per MWh in 2009 (IEA, 2010c). In the European Union onshore wind power is expected to become competitive around 2020 (IEA, 2010c).

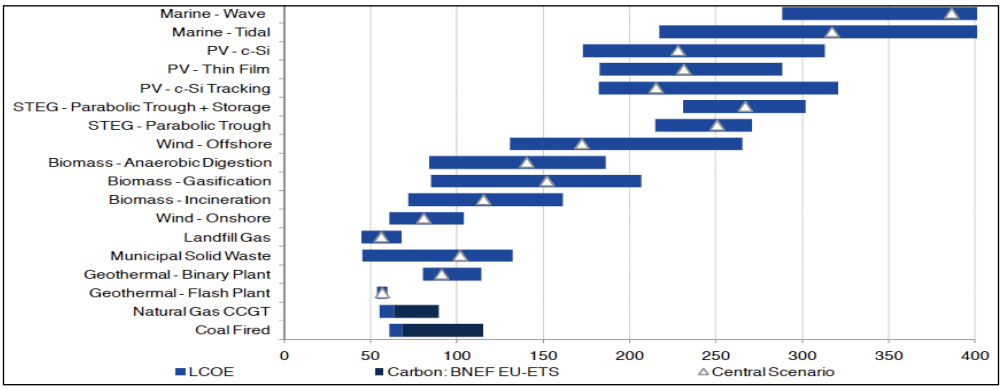
Fig. 38. Global government support and generation from onshore wind and solar PV.



Source: IEA, 2010.

Wind energy is one of the most competitive green energy available et the moment as shown by the Levelized Cost of Energy (LCOE) in figure 39. LCOE takes into account all costs – equipment and financing – amortised over the lifetime of the project. It examines the costs associated with generating clean energy from various technologies and it offers a useful means for comparing the underlying economics of power projects that use different technologies. The LCOE for each clean energy sector can vary widely by region or project (Fig. 39) as LCOE is determined by various factors – such as capital cost, shipping, labour, availability of renewable resources, leverage and interest rates. Today, onshore wind, geothermal and bioenergy projects are most likely to be directly competitive with thermal generation on an unsubsidised basis (BNEF, 2011).

Figure 39. Levelized Cost of Energy (LCOE), Q4 2010, US$/MWh



Source: BNEF, 2011

5.3. INFLUENCE ON ELECTRICITY PRICE

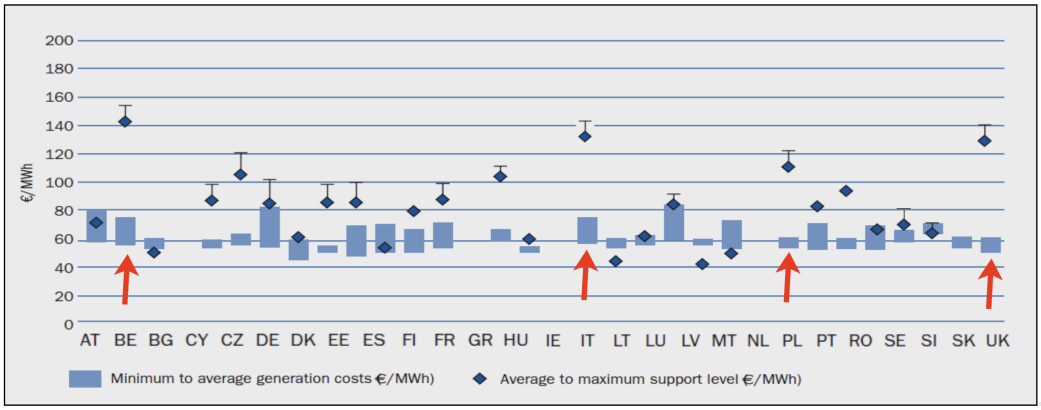
5.3.1. Government support

Unregulated markets will not automatically ensure that goods or services are produced or distributed efficiently or that goods are of a socially acceptable quality. Likewise, unregulated markets do not ensure that production occurs in socially and environmentally acceptable ways. In many cases market regulation is essential because of so-called external effects, or spill-over effects, which are costs or benefits that are not traded or included in the price of a product, since they accrue to third parties which are not involved in the transaction. Typical examples are air pollution, greenhouse gas emissions or (conversely) environmental benefits from renewable power generation. For these reasons renewable energies markets have to be supported until they can stand on the market on their own. Most countries have opted to support the use of renewable energy through regulating either price (FIT) or quantity (TGC) of electricity from renewable sources. So either the supplier of wind energy is paid an above-market price for the energy and the market determines the quantity, or the supplier is guaranteed a share of the energy supply while the market determines the energy price. Thus both classes of schemes are market-based in relation to either price or quantity.

A study carried out by the EWEA (2009b) in 2006 has tried to determine the economic efficiency of these support schemes focusing on what was the absolute support level compared to the actual generation costs of wind power generators, and on how the net support level of wind power generation was consistent with the corresponding effectiveness indicator. Three aspects have been of interest for the study: the absolute support levels; the total costs to society; and the dynamics of the technology.

The support level and generation costs turned out to be almost equal in the majority of the EU-27. So countries with rather high average generation costs also showed a higher support level. But a clear deviation from this rule was found in the four quota systems - Belgium, Poland, Italy and the UK - for which the support is significantly higher than the generation costs (Fig. 40.). The rationale for the higher support level may differ, but the main reasons are risk premiums and inadequate validity times of certificates for Italy and Belgium.

Figure 40. Onshore wind: support level ranges (average to maximum support) in EU countries in 2006 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).



Source: Ragwitz, 2007; EWEA, 2009b.

So the European experience suggests that a feed-in tariff offers more cost-effective support than a tradable green certificate, because it is less risky and allows these capital-intensive projects to be viable with a lower cost of capital. The problem with feed-in tariffs is the need to set the tariff at an appropriate level, and the risk that it will be too generous, creating excessive rents for well-sited generators, or too mean in other cases, stifling development.

Both for green certificates and FITs, which are the most popular RES support schemes in Europe, the cost is passed on directly to the end-user, resulting in higher electricity tariffs for the consumer. Over the period 2009-2035 the government support are expected to correspond to an addition of 7% on average to the wholesale electricity price in the EU (IEA, 2010c).

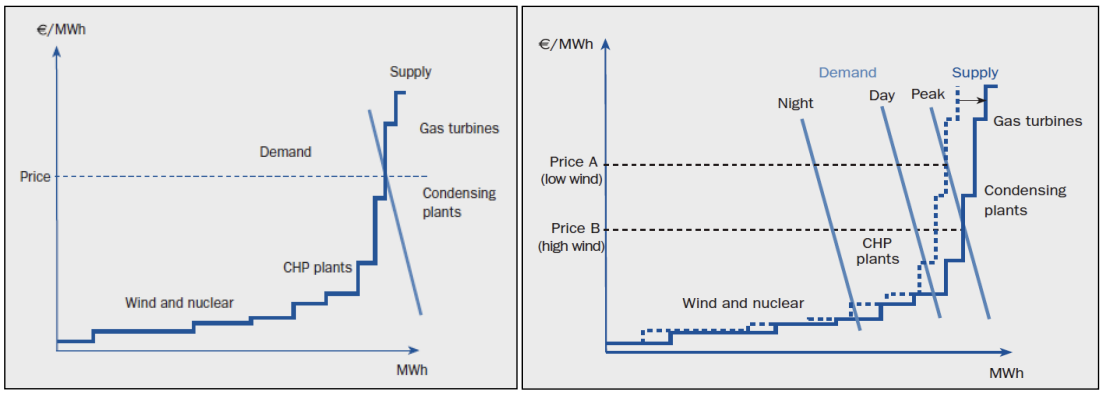
5.3.2. The spot market

In the long term though, wind power will help reduce power price by influencing the power spot price. As part of the gradual liberalisation of the EU electricity industry, power markets are increasingly organised in a similar way, where a number of closely related services are provided. This is the case of power markets in Italy (GME) France (Powernext and EEX), and the UK (N2Ex). GME, EEX and N2Ex are all power spot markets or 'day-ahead' markets, where the price of power is determined by supply and demand. Power producers and consumers submit their bids to the market 12 to 36 hours in advance of delivery, stating the quantities of electricity supplied or demanded and the corresponding price. Then, for each hour,

the price that clears the market (balancing supply with demand) is determined at the power exchange. In principle, all power producers and consumers can trade at the exchange, but in reality, only big consumers (distribution and trading companies and large industries) and generators act on the market, while the smaller companies (as is the case for wind turbines) form trading cooperatives, or engage with larger traders to act on their behalf.

As wind power has zero fuel costs it has a low marginal cost that makes it enter the supply curve near the bottom (Fig. 41). When wind power supply increases, it shifts the power supply curve to the right, resulting in a lower power price, which depend on the elasticity of the power demand. In general, the price of power is expected to be lower during periods with high wind than in periods with low wind. However, the impact of wind power depends on the time of the day. If there is plenty of wind power at midday, during the peak power demand, most of the available generation will be used and consequently wind power will have a strong impact on the spot power price (reducing it from A to B in Fig. 41). On the other hand if there is plenty of wind power during the night, when power demand is low, the impact on the spot price is low (as the supply curve is very flat at that time).

Figure 41. Supply and Demand Curve for the Power Exchange. How wind power influences the power spot price. The NordPool Spot Market (Elspot) as an example.



Source: Risø DTU

The bids from nuclear and wind power enter the supply curve at the lowest level, due to their low marginal costs, followed by combined heat and power plants; while condensing plants are those with the highest marginal costs of power production. Note that hydropower is not identified on the figure, since bids from hydro tend to be strategic and depend on precipitation and the level of water in reservoirs.

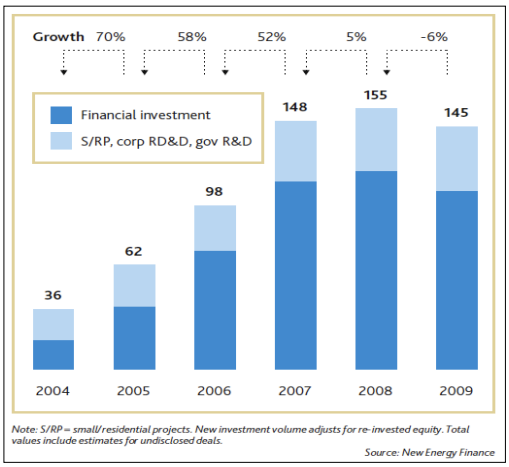
Only a percentage of total electricity production is traded on the spot market. The remaining share is sold through long-term, bilateral contracts, but the spot price has a considerable impact on prices agreed in such contracts.

5.4. INVESTMENTS AND THE FINANCIAL CRISIS

Despite continuous growth in the sector, the 2009 economic and financial crisis represented a significant challenge for the wind power industry. Because renewable energy projects are very capital intensive, the availability and cost of financing is essential for a project's economic viability. High interest rates, short maturities and changing debt-to-equity requirements have a direct impact on the price, and thus on the attractiveness of renewable energy projects compared to other types of power generation.

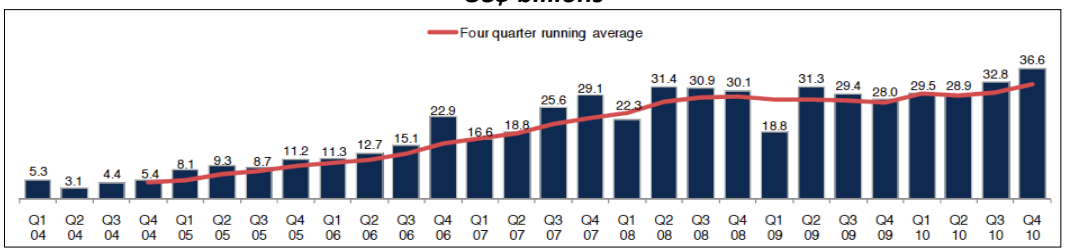
According to Bloomberg New Energy Finance, by early 2009, global investment in renewable energy (excluding government and corporate R&D) was down 50% from its peak in 2008 (WEF, 2010). Liquidity problems made banks either stop lending for infrastructure altogether or demand tougher terms, including shorter pay-back conditions. The amount of equity a project developer had to provide to secure a loan increased dramatically in comparison with the pre-crisis days, when projects could be financed with as much as 90% debt. And finally, the year ended with no multi-national agreement being reached in Copenhagen on carbon reduction targets, which many considered necessary to boost investor confidence and drive clean energy technologies forward. By the end of 2009, however, the sector had come back, and Bloomberg New Energy Finance reported US$ 145 billion (€102 billion) in total investment in clean energy: only a 6.5% drop from 2008 (Fig. 34). In 2010 the sector stabilised again (Fig. 43.).

Figure 42. Total global annual investment in clean energy 2004 to 2009, US$ billions



Source: WEF, 2010

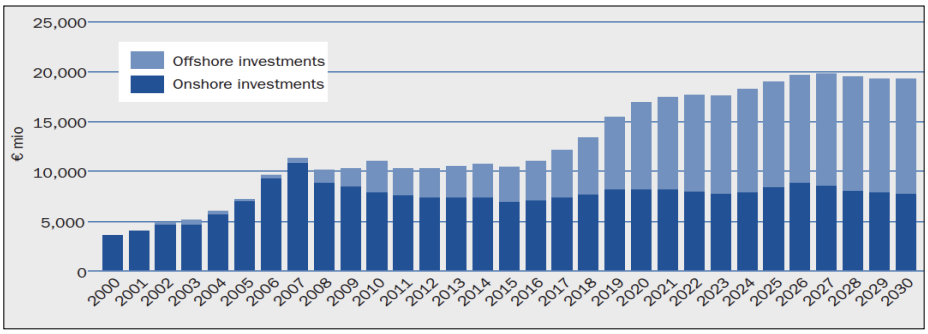
Figure 43. Global Asset Financing for New Build Clean Energy Assets, 2004-2010, US$ billions



Source: BNEF, 2011.

In order to calculate future wind energy investments in the EU, it is necessary to make assumptions regarding the future development of investment costs and installed capacity. Assuming that installed wind power capacity cost approximately 1,000 €/kW; that this cost will drop to 826 €/kW in 2020; and that 180 GW will be installed in 2020; the European Wind Energy Association (EWEA 2009b) estimates that the market will be stable at around €10 billion per year up to 2015, with a gradually increasing share of investments going to offshore. By 2020, the annual market for wind power capacity will have grown to €17 billion annually with approximately half of the investments going to offshore (figure 44.).

Figure 44. Wind energy investments 2000-2030 (€ mio)



Source: EWEA, 2009b

5.5. EMPLOYMENT

The employment effect is a crucial factor to weigh costs and benefits of wind power. Given the high unemployment rates that many countries are facing since the financial crunch, any technology which demands a substantial level of both skilled and unskilled labour is of considerable economic importance, and likely to feature strongly in any political decision-making over different energy options.

According to EWEA estimations (Table 20.), the EU wind energy sector directly employed approximately 108,600 people in 2007. Including indirect employment, the people employed were **151,000** in 2007 (of which 2,800 for offshore wind), showing an increase of 125% compared to 2002 (EWEA,2008). Turbines and components manufacturers represent the widest employment sectors, with a share of 59% of the total offer.

Table 20. EU employment in the wind energy sector in 2007.

	Share of direct employment	Direct employment	Indirect employment	
Wind turbine (WT) manufacturing	37.0%	40,182.0	42,716.0	
Component manufacture	22.0%	23,892.0		
Wind farm development	16.0%	17,376.0		
Installation, operation and maintenance	11.0%	11,946.0		
IPP/utilities	9.0%	9,774.0		
Consultants	3.0%	3,258.0		
R&D/universities	1.0%	1,086.0		
Financial	0.3%	325.8		
Others	0.7%	760.2		
Total	100.0%	108,600.0	42,716.0	151,316.0

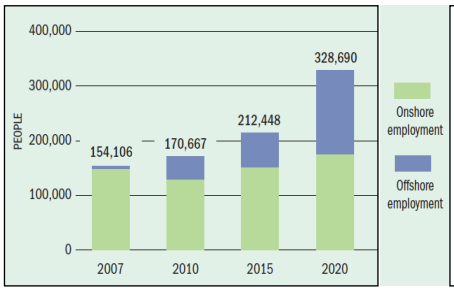
Source: EWEA, 2008

These results are in line with the ones of the Global Wind Energy Council (GWEC, 2008) that assumed that in 2007 wind energy created 15 jobs per MW of annual installation through turbine and component manufacturing, wind farm development, installation and indirect employment. Operations and maintenance work contributed an additional 0.33 jobs per MW of total installed capacity. Based on these assumptions, the total direct and indirect wind energy employment in the EU was estimated at **147,000** for 2007, with around 18,500 jobs related to O&M. This would indicate that 45% of global wind energy employment (329.000 jobs) was in Europe. However, some uncertainty must be assumed, since more wind turbine components are exported from Europe to the rest of the world than imported into the EU, indicating higher EU employment. At the same time, Europe imports more raw materials (i.e. steel and energy) than it exports, indicating a lower level of employment compered to the GWEC figure. As to confirm the margin of liability of

these numbers, a year later, in 2008, Blanco (2009) estimated that the wind energy sector employed around **104,350** people directly.

Assuming that 180 GW of wind energy will be operating in the EU in 2020, wind energy employment will more than double from 154,000 in 2007 to almost 330,000 in 2020 (Fig. 45.). Over that period the offshore market will be the biggest driver of employment growth in manufacturing.

Figure 45. Wind Energy Sector Employment (EU 2007-2020)



	Annual capacity (MW)			Cumulative capacity (MW)			Employment		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
2007	8,344	210	8,554	55,500	1,100	56,535	147,736	6,370	154,106
2010	6,873	1,331	8,205	76,500	3,500	80,000	129,271	41,396	170,667
2015	8,086	2,300	10,386	112,500	12,000	124,500	151,047	61,401	212,448
2020	9,949	6,805	16,754	145,000	35,000	180,000	176,199	152,491	328,690

Source: EWEA, 2008

The GWEC (2010) is more optimistic. It assumes that the annual market for wind energy created employment at the rate of 14 jobs per installed MW in 2010, through direct and indirect employment. As production processes are optimised, this level will decrease, falling to 13 jobs per MW by 2020 and 12 by 2025. In addition, employment in regular O&M work at wind farms will contribute a further 0.33 jobs for every megawatt of cumulative capacity. Under these assumptions, **524,000 jobs** will be created in Europe by 2020 (GWEC, 2010).

However the employment issue is related more to workers shortage rather than the other way around right now. The extraordinary performance of the wind energy sector since the end of the 1990s (from 2000 to 2007, wind energy installations in the EU increased by 339%) resulted in the multiplication of job offers in all the sub-sectors, especially in manufacturing and development, but ended up facing a shortage of skilled workers on the labour market. The wind sector growth was too fast to enable the labour market to be ready with the right required profiles. The shortage has been indeed more pointed for those positions that require a high degree of experience and responsibility, like engineers for manufacture, O&M, and site management activities; or project managers that posses both knowledge of the country legislation at issue, and wind energy expertise (Blanco, 2009).

5.6. ITALY

5.6.1. Investments

Italy saw 124% growth in clean energy investments in 2010 (the third highest among G-20 members), with € 9,7 billion invested in RES. 62% of this investment (€ 3 billion) were directed toward wind energy projects (PEW, 2011).

Market characteristics. Owners of wind farms are mostly private medium-large companies, utilities, and sometimes small local firms that have joined forces with larger ones. Neither single farmers nor citizens, including cooperatives, are yet owners of medium or large wind turbines. Only small turbines are currently owned (and to a lesser extent managed) by landowners. In the near future, thanks to the incentives, this tendency should change, with a growing number of single wind turbines up to 1 MW in capacity being located and run on private properties (IEA, 2008).

5.6.2. Wind energy cost

As a typical example the average installed plant cost of a land-based wind farm at a site of medium complexity, with 15 km of roads and 12 km of electric line for connection to the high-voltage grid, was around 1,340 €/kW in 2009 (IEA, 2009a), with turbines representing 70% of the cost. The sale of energy production yielded an average price of 6,7 €c/kWh in 2009. The additional income from the sale of TGCs was, on average, nearly 8,8 €c/kWh in the 2009 trading, totalling 15,5 €c/kWh (IEA, 2009a). Owners of wind plants between 1 kW and 200 kW can opt either for a fixed tariff of 30 €c/kWh for energy fed into the grid (clearly better suited for them) or for exchange contracts (net metering). In the latter case, their income equals the avoided price of the electricity they would have bought as customers, which is rather variable, but could be put on average at 20 €c/kWh (IEA, 2009a). With high conventional energy prices in Italy, wind energy can easily become profitable (see Table 23).

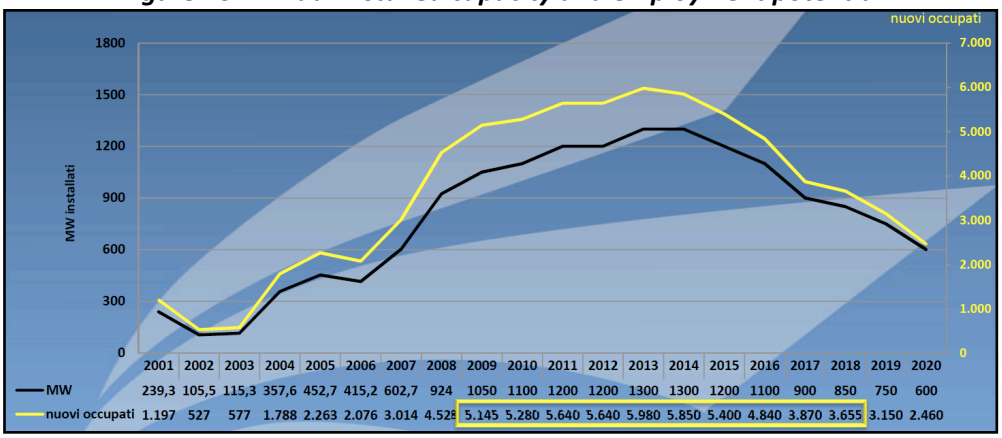
5.6.3. Benefits to the national economy - employment

Because of the increasing annual growth of wind power capacity, the

economic turnover of the wind sector rose significantly in Italy in the past years. The steady growth of the Italian market has encouraged a number of international turbine manufacturers to expand operations to Italy. Several local wind turbine manufacturers entered the sector, some of which have specialised in small-scale and off-grid applications, and a combination of local and foreign developers arose. The most positive effect of this progress is the growing number of employees involved in the sector. EWEA (2008) estimated that the wind sector created 2500 direct jobs in 2007 and this number grew to 3000 direct jobs in 2008 (Blanco, 2009).

ANEV (National Wind Energy Association) together with UIL (Italian Work Union) prepared a study in 2008 that provides a scientific insight into the wind sector employment potential in Italy. The report indicates that in 2007 the wind sector created 3,544 direct jobs and 13,630 positions considering also the indirect jobs (Anev; UIL 2008). They projected an average increase of more than 5,000 new jobs annually between 2009 and 2018 (Fig. 46), with an almost constant annual growth and a gradual decrease for the next decade. This projection corresponds to an average growth of installed capacity to over 1,100 MW per year.

Figure 46. Annual installed capacity and employment potential



Source: Anev, UIL, (2008)

In case of realisation of the planned 16,2 GW (27,2 TWh) of wind capacity, the employment potential for 2020 would be of 66,010 direct and indirect jobs (of which 19.000 direct jobs). The benefits of employment will be enjoyed mostly in the central and southern regions of Italy.

The report has also forecasted that by 2020, with 16 GW of installed capacity, 107 million barrels of oil will be saved and 23,4 million tons of CO2 will be avoided.

5.7. FRANCE

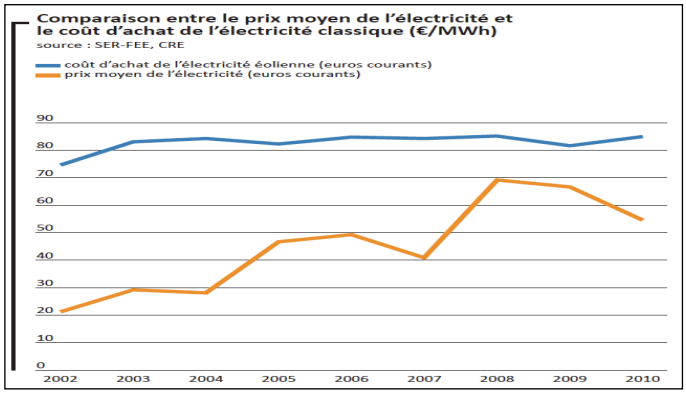
5.7.1. Investments

In 2010, France saw clean energy investments increase 26% over 2009 to reach €2,8 billion, allowing the country to break the ranks of the G-20's top-10 countries for investment at 9th place. Of this budget, €1,9 billion went to wind energy projects (PEW, 2011).

5.7.2. Wind energy costs

Each kWh of electricity produced by a wind farm is bought by EDF at 8.2 €c/kWh for 10 years and between 2.8 and 8.2 €c/kWh for the next 5 years depending on the productivity of the park. The tariff was set by the Government to allow projects to find funding. Between 2003 and 2009, electricity prices grew by an average of 20% per year and then decreased in 2010 due to the economic crisis. The cost of wind power though has remained stable because it is independent from fossil fuels (Fig. 47).

Figure 47. Comparison between average electricity price (orange line) and purchase cost of wind generated electricity (blue line) in France (€/MWh).



Source: FEE, 2010.

The difference between the purchase price of wind energy and the market price of energy decreases from year to year except in exceptional circumstances as in 2010. In a few years, the price of wind power could be less than the price of electricity on the market. Wind power is thus one means of competitive production to help protect consumers from the rising price of fossil fuels.

The extra cost of wind power purchased by EDF is reflected in the electricity

bill of each consumer, under the expenses of the CSEP (Contribution Public Service of Electricity) which includes wind support, the obligation to purchase electricity produced by the cogeneration (electricity and heat), equalisation rate and social costs. The amount of CSEP in 2010 was 0,45 €c/kWh and wind energy accounted for only 13% of this amount, namely a charge of 0.06 €c/kWh per capita. This means that for the average French household consuming 2,500 kWh per year, the wind support charge is around €1.5 annually.

5.7.3. Benefits to the national economy - employment

The rapid growth of wind energy installations has led to an industry based on developers of different sizes, component manufacturers (transformers, cranes, masts, and electronic equipment), engineering and consulting companies. France is now the leader in the manufacturing of anti-cyclone wind turbines, which do not need cranes for installation. The interest of the national power company in renewable energy investments and the settlement of the main international groups reflect a changing mentality, and points to the consolidation of a national industry with strong potential.

ADEME, the French National Energy Agency, reported 7,140 jobs in the manufacturing of wind turbines and major sub-components in 2007 with 500 companies operating wind energy farms. The wind energy sector now employs around 11,000 people spread over more than 180 companies. ADEME also estimates the creation of up to 16,000 direct jobs in 2012 (ADEME, 2009; SER, 2010c), while in 2020, the wind energy sector will be able to employ around 60,000 people (SER, 2010c). The installation and maintenance of parks require call on local businesses and jobs are thus created directly in areas where the wind turbines are located.

The growth of wind energy is such, that professionals face significant challenges recruiting the necessary staff for development and exploitation. For this reason, many training programmes have been established, particularly for maintenance of the new production facilities. Several high schools (Bazin de Charleville-Mezieres, the Lycée de Nimes Dhuoda..) recently implemented a training programme for wind technology maintenance and many other wind-specific courses start to be available in many universities (SER, FEE, 2010).

5.8. UNITED KINGDOM

5.8.1. Investments

Financing for wind farms in the UK is obtained largely from the balance sheets of corporate investors and banks, although there is a small amount of private investments (IEA, 2008). After achieving a fifth-place ranking for clean energy investments in 2009, the United Kingdom dropped out of the G-20 top 10 in 2010. Investment levels in 2009 were driven by large volume financing for offshore wind energy and the government's commitment to strong action on climate change. But 2010 brought a new government in charge, and investors appear to believe that there is a high level of uncertainty about the direction of clean energy policy-making in the country. The UK saw a decline in clean energy investment as sharp as 70%. Investments for clean energy in 2010 totalled €2,3 billion, (compared with 2009 levels over €7,7 billion). Still, 52% of them went to wind energy (PEW, 2011).

5.8.2. Wind energy costs

In the UK, the price a wind generator receives for electricity generated will depend on the contract terms that he can negotiate with an electricity supplier, taking into consideration:

- the wholesale market price for electricity
- any embedded generation benefits
- the CCL exemption
- the value of the Renewables Obligation Certificates.

The costs of wind farm generation in the UK has been estimated at around 5€c/kWh for onshore wind and at around 7€c/kWh for offshore wind *(RAEng, 2004, Strbac, 2007)*. The wholesale market price for electricity is around 5 €c/kWh (RWE website) and in January 2009, ROCs were traded at 6 €c/kWh.

An assessment of the costs and benefits of wind generation on the GB electricity system, assuming different levels of wind power capacity, has been carried out by Strbac (2007). Overall, he concluded that the system will be able to accommodate significant increases in intermittent power generation with a relatively small increase in overall costs of supply. These additional costs will be

primarily driven by the capital cost of wind generation, while the benefits in terms of the cost of fuel saved will be directly influenced by fuel prices. The average values of the various components of additional costs and benefits of integrating 25 GW of wind in the GB electricity system are summarised in Table 21. The net additional costs amounted to around 0.28 p/kWh which is 5% of the 2007 british electricity price. The UK Sustainable Development Commission, with a different study, came to the same result (SDC, 2005).

Table 21. Estimates of additional cost (+) and benefits (-) of integrating 25GW of wind in GB system.

Component	p/kWh
Fuel cost savings	−0.288
Capacity benefits	−0.038
Cost of wind generation	0.465
Balancing cost	0.054
Network cost	0.094
Overall	0.28

Source: Strbac, 2007.

However the BERR (2008), referring to all renewable energies and without taking into account the fuel saved, stated that current climate change policies make up around 14% of average domestic electricity bills while on the industrial side, for an average medium-sized consumer, the RO, ETS, and Climate Change Levy together contribute around 21% to industrial electricity bills (BERR, 2008). In Table 22 figures are reported on the RE impact on the electricity bill in the UK, based on a scenario where a 15% renewable energy target is achieved in 2020, with shares of renewable energy in heat at 14%, electricity at 32% and transport at 10%.

Table 22: Impact on annual electricity bills, from measures to achieve 32% RE electricity.

	Domestic Bills	Industrial Bills
2010-2014	-1 to 4 % (-£3 to £13)	-1 to 4% (-£4 K to £19 K)
2015-2019	1 to 5% (£3 to £19)	1 to 6% (£4 K to £28 K)
2020-2024	9 to 15% (£32 to £53)	10 to 16% (£46 K to £78 K)
2025-2029	10 to 14% (£33 to £48)	11 to 16% (£48 K to £70 K)

Source: BERR, 2008

There will be no immediate impact on bills, but it will increase as 2020 approaches and the renewable deployment rises, particularly post 2015, and will continue beyond 2020 (BERR, 2008).

Micro-generation. The application of micro wind turbines in urban environment is encouraged in the UK via a grant scheme which provides a proportion of the initial capital costs. Micro wind turbines for domestic applications account for approximately 17% of all state grant aid for domestic micro generation (Peacock, 2008). Nevertheless, under current conditions (taking into account the LCBP and CCL programmes), payback times for a 1.5 kW micro-wind turbine are between 7 and 19 years for households and between 7 and 13 years for a company, through a lease contract (Watson, 2008). A more dramatic study by Peacock (2008) suggests that payback time sometimes exceed 20 years, namely the turbine lifetime and that reductions in cost in the order of 60% would be required to produce payback times within the assumed lifetime period. Hence investments in micro-generation are in most cases unlikely to be attractive for households or companies. Industry experts expressed the view that payback times should be well below 10 years and probably be less than 5 years before significant uptake takes place (Watson, 2008).

5.8.3. Benefits to the national economy - employment

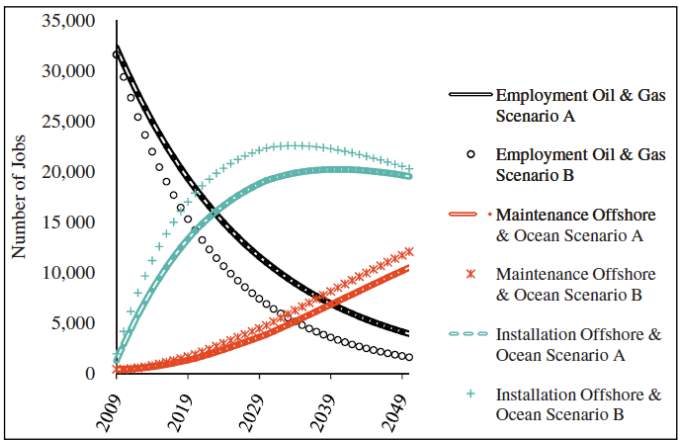
In the UK, the importance of offshore wind energy and small-scale wind turbines is reflected by the many businesses working in these segments of the industry; the country also host some of the largest wind energy engineering and consultancy companies, and large wind energy operators and developers. Some of them with a solid international position (Blanco, 2009).

In 2007, 4,000 direct jobs were estimated to be created by the wind sector (EWEA, 2008), while In 2008, the number increased to 4,500 direct jobs (Blanco, 2009; EWEA 2008). The level of employment in the UK wind industry stood at approximately 5,000 jobs in 2010: of these jobs, a large percentage are located in parts of the value chain where business models are local in nature, such as development or construction and installation (Boettcher, 2008). If the UK is to meet its RE targets for 2020, it is estimated that it will require 122,000 to 130,000 jobs - although not all of them will necessarily be in the UK (IEA, 2008).

This source of employment could turn out to be crucial in the UK, as the decline in production of oil in the North Sea comes with a decline in the number of people employed in oil related jobs: the gap that this could create in the UK's economy shouldn't be undermined. Allowing these jobs to disappear could have a

dramatic effect in the communities where they are located and in other areas to which these jobs extend through direct and indirect supply chains. Offshore wind deployment is therefore seen as a way to employ this large pool of talent that is concentrated in the east and north parts of the country, particularly in Scotland. A study carried out by Esteban (2011) estimates that by 2050 the oil and gas industry would only have between 1,600 and 4,000 employees left, but the offshore renewable sector (wind, tides and waves) would be employing 10,000–12,000 people in maintenance and 19,000–20,000 people in the installation of new devices (Figure 48.).

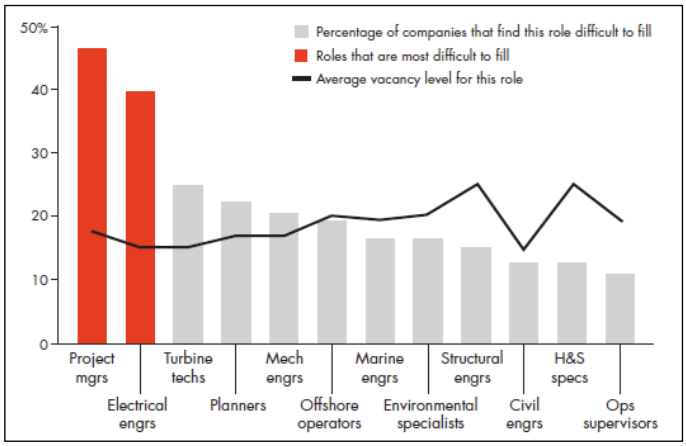
Fig. 48. Employment levels in the offshore industry for two different Scenarios.



Source: Esteban, 2001

As a general trend also the UK faces the issue of labour scarcity, seeing British wind energy companies with vacancy levels of above 5% . In certain specialist roles, the shortage is even higher (Fig. 49) (Boettcher, 2008).

Figure 49: Specialist roles particularly challenging to fill.



Source: Boettcher, 2008

5.6. Analytical comparison

Investments

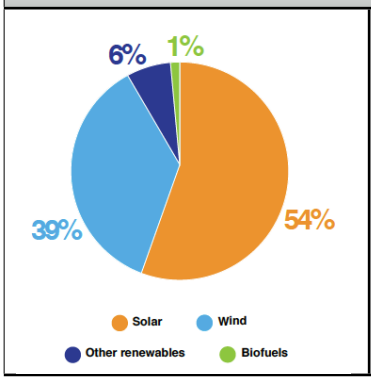
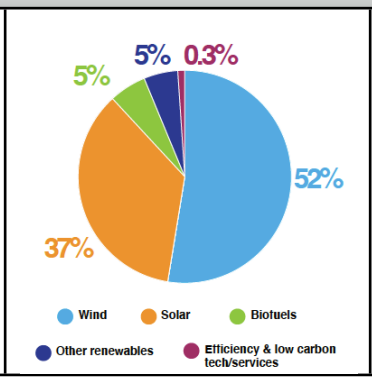
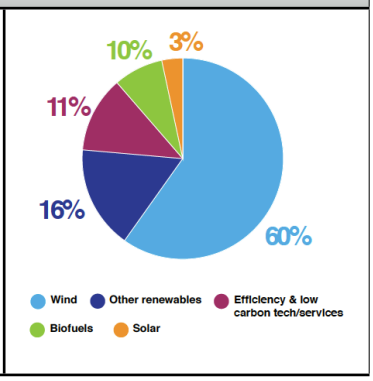
Over the past several years, the progress that has been made in cutting clean energy equipment costs has attracted considerable attention. As investors and lenders grow more comfortable with the risk profile of clean energy projects, they are more likely to offer capital at lower cost. In addition, financiers are finding new and creative ways to bring down the overall cost of capital by reducing/spreading risk. To date, the European experience has proven nearly beyond doubt that generous feed-in tariffs are the most effective policies for spurring large amounts of renewable energy development very quickly. By offering developers nearly guaranteed relatively high returns, investors do promptly respond.

However, such policies can lead to overpayment for clean megawatt-hours and ultimately to backlash from either the public and/or policy-makers. As an example, in 2008, Spain offered among the most generous feed-in tariffs in Europe and saw a massive spike in new installations. But as budget concerns mounted in 2009 and into 2010, the country cut back its support (45% cut of photovoltaic grants) and saw development come to a near complete halt (BNEF, 2011). The Spanish experience raised concerns that governments elsewhere facing fiscal pinches might also seek to cut support tariffs.

Like Spain, also the United Kingdom, with a new Conservative-Liberal Democrat coalition to power, embarked on a new era of fiscal austerity in 2010. In February 2011, however, the government said that it would be scaling back its feed-in tariff for large-scale projects. Italy has also just had a similar warning, when the Legislative Decree 28/11 announced a suspension of the whole frame of support schemes for renewable energies in favour of a new cheaper frame to be disclosed and started next September.

All in all, the financing of wind projects has been extensive and has proved very effective till now, boosting wind energy deployment all across Europe. Nevertheless the sector is facing some financial uncertainties at the moment - due to the recent credit crunch - that may turn into the withdrawn of support, or may come back to a more flourishing time. Table 23 compares investment data from Italy, France and the UK.

Table 23. Investment in clean energy 2009, 2010; share of investment by sector 2005-2010.

ITALY	FRANCE	UK
INVESTMENT IN CLEAN ENERGY (2009)		
Total: € 4,2 billion	Total: € 2,2 billion	Total: € 7,5 billion
INVESTMENT IN CLEAN ENERGY (2010)		
Total: € 9,5 billion	Total: € 2,8 billion	Total: € 2,3 billion
Wind: € 3 billion	Wind: € 1,9 billion	Wind: € 1,4 billion
DISTRIBUTION OF INVESTMENT BY SECTOR (2005-2010)		
		

Data source: PEW, 2011

While from 2009 to 2010 Italy has more than double its investments in RE, the UK has cut them by 70%, probably because it was the country hit the worse by the financial crisis. France has never invested much and has kept a consistent trend. Nevertheless as the UK addresses 60% of its investment to wind energy, while Italy only a 40%, the support for the wind sector turns out to be not that unequal in the three countries.

Electricity price

Between 2003 and 2009, electricity prices on the European market grew by an average of 20% per year. However, they decreased in 2010 due to economic conditions. The cost of wind power on the other hand has remain quite stable because it is independent from fossil fuels. Table 24 reports the different electricity price in the three countries, the wholesale price and the respective profit from the sale of wind energy under different support mechanisms.

Table 24. Electricity prices in Italy, France and the UK.

	Italy (€c/kWh)	**France** (€c/kWh)	**UK** (€c/kWh)
Domestic Electricity prices	20,85	13,05	14,47
Industrial Electricity prices			
2,000 MWh/year	13,27	6,52	10,64
24,000 MWh/year	10,71	5,59	9,22
Wholesale Electricity price	6,7	4,2	5
Wind energy purchase cost	6,7(sale)+8,8(TGC) = **15,5** (FIT) = **30** (net metering) = **20,85**	**8,2** (FIT)	5(sale)+6(TGC)=**11** (FIT) = **5,4 - 41,5**
Wind energy cost	**4,3-7 €c/kWh**		

Data source: Europe's Energy Portal; IEA 2009a; RWE; EDF.

Wind energy generation and penetration influence the electricity price in two opposite directions: on one hand it increases the price due to support mechanisms, whose cost is passed down from the producers to the consumers; on the other hand it decreases prices by displacing costly fossil fuels resources. The overall effect is still debated and it will also depend on the development of fossil fuels prices in the future. There are many studies though, supporting the view that increased levels of wind generation reduces the costs of electricity production, the price of wholesale energy and therefore the costs to consumers, even in the short term, when renewables still require a subsidy, as the reduction in consumer costs is greater than the subsidy paid. This is asserted by a report commissioned by the Irish Wind Energy Association in conjunction with Wind Skillnet (IWEA, 2011) and by an independent report by Pöyry (2010), commissioned by EWEA.

Whatever the truth in the short term, the benefit from wind energy is quite a guarantee in the long term, given the trend of fossil fuels prices and the fact that soon wind energy will phase out from support schemes.

Employment

Table 25 brings together the employment estimations and predictions for the three countries and for Europe. Nevertheless it is inappropriate to compare them on an equal basis given that they all come from different sources and have been

computed in different ways and with different methodologies. Therefore this is only a very indicative view of the various countries' trends.

Table 25. Numbers of jobs created by the wind sector: estimations and future projection.

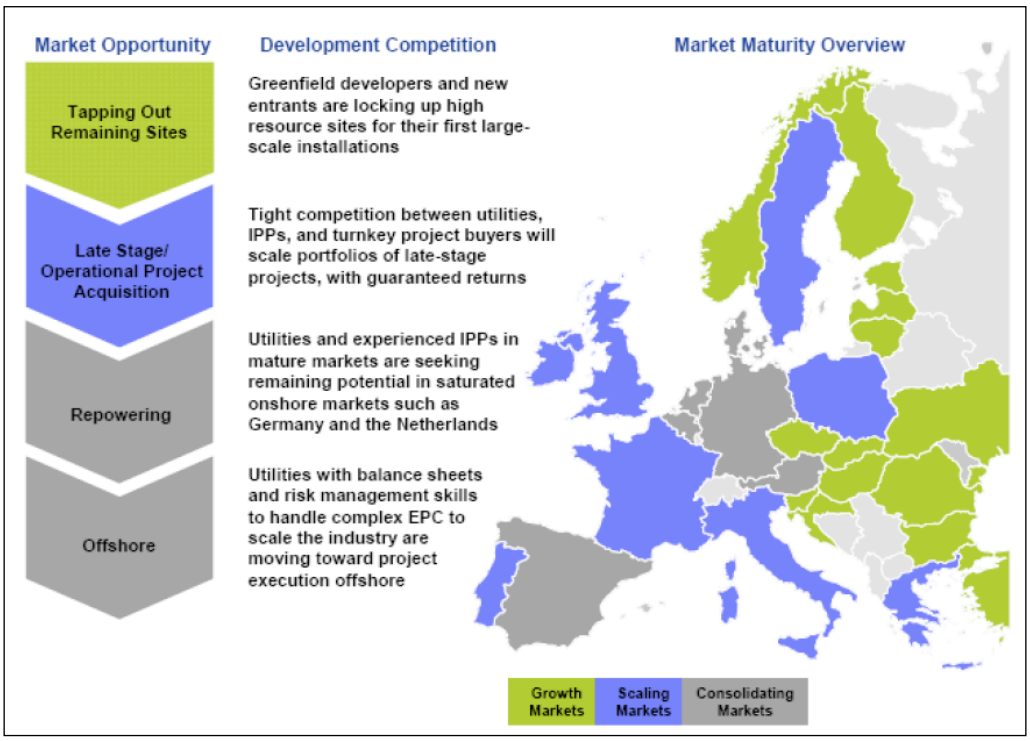
	Italy	France	UK	Europe
2007 (direct)	3.000	7.000	4.000	151.000
2010 (direct)	5.000	11.000	5.000	170.000
2020 (direct & indirect)	66.000	60.000	126.000	330-520.000

Data source: EWEA 2008; GWEC 2010; ANEV 2008; SER 2010; ADEME 2009.

Market

Europe's onshore wind power sector can be divided into three main market types - consolidating, scaling, and growth markets - reflecting each market's maturity as development and intensity of competition within the country. Scaling markets, led by the UK, Italy, France, Spain and Portugal, are characterised by strong remaining resources coupled with stable regulatory frameworks that will facilitate project development. As such, these markets will experience high project volume in the near term, and are expected to be Europe's main driver of growth (EER, 2009a).

Figure 50. European markets situation and development.



Source: EER, 2009a

6. CONCLUSIONS

European wind power has known a fast development in the last decades reaching, in 2010, a capacity of 84 GW, from only 2.5 GW in 1995 (EC, 2011). But the way to reach the projected 230 GW in 2020 is still long and the deployment has to keep the pace, but will it?

The 'economically competitive potential' of wind energy in 2020 is estimated to be three times greater than the expected European electricity demand.

The drivers that propelled the sector for the past years are still at work – climate change, long term carbon price exposure, fuel-price risk, energy security, fossil fuel depletion, energy access and the European energy targets.

Wind - an indigenous power source that comes from free - also provides jobs and creates export opportunities for Europe, the global leader in wind energy technology.

Nevertheless, the financial crisis has crept in, in 2009, making this fast wind energy development hesitating for a bit and creating uncertainties about the lasting of government support schemes and, accordingly, private investments. Renewable electricity standards are an important signal to investors that there will be long-term demand for renewable energy, making investment in the sector attractive.

Italy, France and the UK, although vaunting very different wind energy potentials, have known, so far, a very similar pattern of wind energy deployment and market growth. They are three scaling markets, that have recently experienced an incredible and fast deployment of wind power, driven by solid policy support.

Each country has taken different policy directions in promoting renewable energy sources: Italy and the UK implemented a Tradable Green Certificate (TGC) scheme, whereas France developed a feed-in tariff mechanism. The European experience suggests that Feed in Tariffs (FIT) deliver larger and faster penetration of renewables, at lower or comparable cost than TGC. In effect the three countries have experienced almost the same wind energy capacity deployment so far, but Italy and the UK have invested almost double the money than France in support mechanisms. Italy has also experienced system failures in the TGC scheme that had

to be revised to avoid market distortions.

Beyond cost effectiveness, both TGC and FIT schemes have strongly boosted wind energy deployment in all countries, nevertheless, the UK and Italy, have seen their support schemes shaking, lately. The United Kingdom, with the new government, has embarked on a new era of fiscal austerity, averting investors from the wind sector with a result of a decline in investment as sharp as 70 percent last year. Similarly, the Italian government has recently announced the closure of all current renewable incentives, in favour of a new (not yet defined) restructured and cheaper support policy, which has considerably alarmed investors. The financial crisis has thus played quite a bad influence on the wind sector, still holding the market in the uncertainty.

None of the countries among Italy, France and the UK has developed a national industry in wind turbine manufacturing as they approached the scene too late, lacking technological competitiveness to enter the market. This is the main reason why the three countries are lagging behind the European leaders, not having a consolidated market yet. Nonetheless, they have attracted foreign manufacturers and have developed all sectors of the wind industry parallel to the machine manufacturing: from components manufacturing to engineering, project development and consultancy. Moreover many foreign companies have manufacturing establishments in the countries. All of that indicating the strong potential of these scaling markets. France is the only country that stands out for national manufacturing as world leader of “farwind” (or anti-cyclone) turbines.

Concerning the grid, all countries are still experiencing problems and working toward an improvement and upgrade of the connection lines. Most of the time wind power integration into to the main grid requires major changes to the lines, which take some time and involve additional - balancing and back-up - costs, representing an obstacle for wind energy deployment.

As for energy production costs, thanks to technological improvement, there is still room to drive them down, but the high price of materials will inhibit an endless decline. The profitability of wind energy will become more evident in the future, with the projected increase of fossil fuels prices, and with the phasing out of wind technology from support schemes: both events that will help drive down the costs of electricity prices.

Generally the major impediment to the achievement of the European 2020 targets seems to be the financial crisis irruption. Even though wind technology has almost reached maturity, it still does need a few years of support before confronting the market in open competition, thus investments are very important.

Beside the unstable economic frame though, which could recover soon, it appears that all three countries have strong and solid bases in terms of policy configuration, industry development, and commitment to the improvement of the grid and administrative issues. A restructure of the support mechanism toward a most cost effective option could help Italy and the UK to overpass the financial difficulties, while streamlining the strict legal frame in France could help unbridle deployment at a faster rate.

Looking at the bigger picture, the European targets could be easily reached if Europe had a common energy policy: the discrepancy in the wind resource across countries could be exploited through a more coordinated deployment policy that encourages investments in the best wind sites and then distributes power from lower to higher demand spots, solving also part of the intermittence problem. The European SET-plan (Strategic Energy Technology plan) is leading in this direction. Probably not by 2020, but in a near future the picture could start changing.

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Appendix A

LEGAL BACKGROUND to the promotion of renewable energy

ITALY

- **Decree No. 633/1972**
  provides for a *reduction in the VAT* for photovoltaic and wind energy systems (table A, Part 3, 127). Last amended on 30.08.1993
- **Law No 241/1990**
  introduces the *Service Conference tool* to bring together all the administrative bodies and entities potentially concerned by the evaluation and authorisation of a project, in order to examine all the interests at play at the same time and to facilitate coordination among the various entities involved. As part of the Conference, a single authorisation is issued for the construction and operation of electricity production plants fed by renewable sources and the connected works.
- **Legislative Decree No 79/1999** - "Decreto Bersani"
  (implements the European Directive 96/92/EC) with common rules for the single market of electricity. The decree is also the legal basis for the promotion of renewable energy through the *quota system*. It also includes provisions on access to the grid. Last amended on 15.08.2009
- **Constitutional Law No 3/2001**
  alters the division of *responsibilities between the State and the regions* within the renewable energy sector: the State has legislative power whilst the regions have administrative power.
- **Legislative Decree No 387/03**
  (implements the European Directive 2001/77/EC) It set out a national framework for the promotion of renewable energy sources, particularly for production from microgeneration plants. *Article 12* provides for a simplified authorisation procedure for plants using renewable sources: a *single authorisation,* that considerably reduces the administrative procedure time. This document in fact concludes a procedure lasting a maximum of 180 days. In the wind sector this simplified procedure applies to wind plants with a generation capacity below 60 kW. Last amended on:15.08.2009
- **Decree of 14 March 2003**
  regulates the trade of green certificates via the GME (electric market manager).
- **Decree-Law No 239/03 and Law No 239/04**
  defines the authorisation procedure for electricity transmission and distribution networks. The construction and operation of electrical power lines which form part of the national electricity transport network are subject to a *single authorisation*, issued by the Ministry for Economic Development in consultation with the Ministry for the Environment, Land and Sea, provided that the agreement of the regions concerned is obtained.

- **Act No. 244/2007 (Budget Act of 2008)**

  Generators of less than 0,2 MW electricity per year from wind energy are entitled to a guaranteed *feed-in tariff* as an alternative to green certificates (Art. 2 par. 143-176).

  Last amended on 15.08.2009
- **DM 18/12/2008 (Decreto Rinnovabili)**

  on the promotion of renewable electricity generation according to Art. 2 par. 150 of L 244/07

  It introduces changes to the existing support system for electricity from renewable sources. The most important changes are related to the green certificates and the all-inclusive tariff.
- **Article 11 of Legislative Decree No 115/2008**

  introduces further simplification and rationalisation measures for individual wind turbines with a maximum height no greater than 1.5 metres and a diameter no greater than 1 metre.
- **Law No 99/2009**

  introduces simplification measures for operations on electrical power lines which involve changes to lengths no greater than 1,500 linear metres which use the same line, or which do not move away from the original line for more than 40 linear metres.
- **Law No 13/2009**

  provides that the 2020 targets will be divided between the Italian regions, assuming that different energy sources will be developed in the various regions.
- **Legislative Decree 28/11**

  (Implementation of directive 2009/28/CE modifying and repealing directives 2001/77/CE and 2003/30/CE). It provides for the gradual abandonment of the green certificates system, which, starting from 1 January 2015, will be replaced by a new system of incentives that will vary depending on the size of plant: feed-in tariffs for plants of less than 5 MW and incentives based on downward auction for plants greater than 5 MW. Valid for installations connected to the national grid after May 31, 2011.

FRANCE

Loi n°2000-108

Act on the modernisation and development of public electricity supply. It establishes the legal framework for the purchase of and payment for electricity from renewable sources (Art. 10), the conditions regarding tenders (Art. 8) and provisions on the funding of the support system (Art. 5). It introduced the Investment plan of the French government (PPI) which specifies production capacity targets, graded according to primary energy source, production technology and geographic zone. The plan currently in force sets the following target capacities to be installed by 2015 for wind energy: 17,000 MW of which 13,000 onshore and 4,000 offshore. Last amended on 24.10.201.

- **Décret n°2000-1196**

  The decree establishes different categories of systems for the generation of electricity from renewable sources and imposes different capacity limits for the eligibility for the feed-in tariff (Art. 2). Last amended on 06.09.2007

- **Instruction fiscale 3 C-2-01 N° 119**

  This regulation sets out detailed provisions on a reduced VAT rate for certain renewable energy systems, including wind plants.

- **Décret n°2002-1434**

  The decree sets the conditions for tenders for the construction of renewable energy systems (Art. 8). Last amended on 01.12.2009

- **Loi n°2005-781**

  Act establishing an energy policy programme. France supports renewable energy to ensure its energy independence and economic competitiveness (Art. 2). Last amended on 14.07.201.

- **Arrêté du 9 février 2005**

  Article 1 lists wind energy as eligible for the Crédit d'Impôt and specifies technical and performance requirements.

- **Arrêté du 13 novembre 2007**

  Article 1 modifies the list of renewable energy systems eligible for the Crédit d'Impôt and the technical and performance requirements set out in Arrêté du 9 février 2005.

- **Loi n°2008-1425 (Finance Act 2009)**

  Article 109 of Loi n°2008-1425 introduced amendments on the tax credit (Crédit d'Impôt) to promote electricity from renewable sources.

- **Arrêté du 17 novembre 2008**

  Order establishing conditions for the purchase of electricity generated from wind energy. It aims at promoting wind energy through a feed-in tariff.

- **Grenelle Law II 2010**

  Set the basis of the national commitment to the environment and to renewable energy development. It defines qualitative and quantitative regional targets based on the renewable energy potential of each region, taking into account the national objectives for 2020. It provides for a regional wind power plan to define the parts of the territory suitable for the development of wind energy and sets a regional plan for the connection of renewable energies to the grid.

UNITED KINGDOM

- **The Electricity Act 1989, c.29 (EA 1989)**
  It introduces the quota obligation and the certificate system, authorising the issuing of the Renewables Obligation Orders. The Act also includes general provisions on the access of electricity to the grid.
  Last amended on 22.07.2008
- **The Utilities Act, c.27 (UA 2000)**
  Amendment to the electricity Act 1989. It is the legal basis which authorises the introduction of the quota and certificate systems giving the Secretary of State the power to require electricity suppliers to supply a certain proportion of their total sales in the United Kingdom from electricity generated from renewable sources. Last amended on 26.05.2008
- **The Finance Act 2000, c.17 (FA 2000)**
  The FA 2000 introduced the Climate Change Levy (CCL) for the very first time, providing fiscal benefits for the use of electricity from renewable sources. It removes coal mine methane from the list of renewable energy sources. Last amended on 02.07.2008.
  Regulations 2001, No 838
  It establishes detailed regulations on the Climate Change levy (CLL) and lays down the exemption of electricity from renewable sources from the levy. Last amended on 21.07.2008
- **The Energy Act 2004, c. 20 (EnA 2004)**
  Sections 115, 116, 118 and 119 fundamentally amend the rules and regulations of the EA 1989. Especially important are the amendments to the sections that represent the legal basis for the quota and certificate systems. Last amended on 06.04.2008.
- **The Renewables Obligation Order 2006, No. 1004 (ROO 2006)**
  The order aims at promoting renewable energy sources in England and Wales.
- **The Renewables Obligation (Scotland) Order 2007, No. 267 (ROO SCO)**
  The Order aims at promoting renewable energy sources within the territory of Scotland.
- **The Renewables Obligation Order 2007, No. 104 (ROO NI)**
  The Order aims at promoting renewable energy sources within the territory of Northern Ireland.
- **The UK Environmental Transformations Fund (ETF) Strategy 2008**
  It is a strategy paper of the British government, which lays down the basic principles for the promotion of individual projects by the ETF. The strategy paper is not legally binding, as the fund does not have binding general guidelines. However, binding rules are individually negotiated and established for the various ETF schemes.