Institut Thomas More

TRIBUNE

ABOUT WIND POWER BUSINESS

Jean-Pierre SCHAEKEN WILLEMAERS, member of the Thomas More Institute Advisory Board

Wind power is the fastest growing of the European renewables. By the end of 2010, the European wind power installed capacity of 84,278 MW, produced 181 TWh of electricity, meeting 5,3% of overall EU electricity consumption (up from 4,8% in 2009 and 3,8% in 2007). In 2010, 9,883 MW of wind power were installed across Europe, with the EU accounting for 9,259 MW of the total, out of which 8,377 MW onshore and 883 offshore. 2010 was a record year for new power generation installations in the EU, but for the first time since 2007, wind power did not lead the newly installed production capacity, accounting for only 17% of new installations whereas natural gas represented 51%.The offshore wind industry is now also growing extremely quickly. All this has been made possible thanks to massive subsidies under different forms (green certificates, renewables obligation certificates, feed-in tariffs and soon) which have and will be adding heavy charges on the consumers' electricity bills. The question is to know whether Europe can ensure secure (there has been much academic debate on the ability of wind to provide a reliable electricity supply) and affordable electrical energy supplies and implement, simultaneously and rapidly, a "green" policy at reasonable costs, without changing its approach?

Tribune N°31
October 2011

Wind turbine technology

Wind turbines are classified in geared drive or direct drive systems if the drive train is considered.

Geared wind turbines (asynchronous machines)

In traditional geared wind turbines, the blades spin a shaft that is connected through a gearbox to the generator. The gearbox converts the blades speed in the number of rotations needed to generate electricity at the right frequency. Asynchronous machines must work at speed a little bit higher than synchronization (speed of the rotating field) to deliver electricity to the grid. For example, for a 4 pole generator and a 50 HZ grid, the speed will be about 1520 RPM (revolution per minute). This type of wind turbine must be connected to the grid to work because it requires the stator to be magnetized from the grid.

It is however possible to run an asynchronous generator in a stand alone mode if it is provided with a small diesel generator to start the system or with a battery and power electronics.

Geared wind turbines can be equipped with squirrel cage or wound rotor and can operate at fixed (stall control) or variable speed.

The squirrel cage stall control concept performance is optimal only at one wind speed. The two speed stall control concept has been developed to overcome this disadvantage by using a pole changeable SCIG (squirrel cage induction generator with two stator windings). The active stall control is another improvement. It consists of changing the angle of the rotor blades according to the wind speed but it is not a continuous process.

In general the pole pair number is usually equal to 2 or 3 so that the synchronous speed in a 50 HZ grid is 1500 or 1000 RPM.

The SCIG is a well known and robust technology with easy and relatively cheap mass production of the generator. It benefits from a long track record. However this technology suffers from a number of disadvantages:

- The speed is not controllable. Strong wind fluctuations are directly translated into electromechanical torque variations rather than rotational speed variations. This causes fatigue stress. The turbine speed cannot be continuously adjusted to the wind speed to optimize the aerodynamic efficiency.
- As already pointed out, a gearbox is necessary which is relatively maintenance intensive, a possible source of failure and of oil leaks. The multiple wheels and bearings suffer high stress because of wind turbulence and any defect in a single component can bring the turbine to a halt.
- Fixed speed SCIG consumes reactive power and cannot contribute to voltage control.

Gearboxes are found in most wind turbines installed around the world today. However geared wind turbines are basically problematic because they have many moving parts that wear out over time, in particular bearings. In spite of that weak point, it is likely that geared turbines will remain competitive with respect to direct drive technology, at least at low power values[1]

[1] Henrik Stiesdal, CTO of Siemens Wind Power.

and many wind turbine manufacturers stand firmly behind the geared technology reliability even if a 20 year lifetime of continuous operation is questionable.

Doubly fed induction generator

In order to enable variable speed operations, doubly fed induction generators (DFIG) can be used. The stator is directly connected to the grid and the rotor is fed to magnetize the machine[2]. DFIG have thus active windings on both stationary and rotating parts and both windings transfer to the grid. This type of wind turbine is useful in applications that require varying speeds of machine's shaft for a fixed power system frequency. The current DFIG's are equipped with brushes for access to the rotor windings. A better alternative would be a brushless wound rotor.

"Since the late 1990's, some wind turbines over 1.5 MW have been changed to the variable speed concept because of the grid requirement of good power quality… The variable speed control is necessary to maximize the efficiency of the turbine, to dampen the power and torque peaks caused by wind gust, to let the turbine accelerate and to store energy in it during gust. A wind turbine with variable pitch control has a multistage gearbox, a generator and a power electronic converter (rating: 30% of full scale) and a blade pitch system. The frequency of the generator is varied for the grid connection by the converter... This concept has been applied successfully to large wind turbines although the cost of the power electronics is a disadvantage compared to fixed speed systems…

Variable speed pitch control concept has two methods for operation as speed changes and blade pitch changes. Between the cut-in wind speed and related wind speed, the wind turbine of this concept is operated at fixed pitch with a variable rotor speed to maintain an optimal tip speed ratio. When the rated power is reached, the generator torque controls the electrical power output, while the pitch control is used to maintain the rotor speed within acceptable limits. During gusts the generator power can be maintained at a constant level, while the rotor speed increases. The increased energy in the wind is stored in the kinetic energy of the rotor blades. If the wind speed decreases the reduced aerodynamic torque results in a deceleration of the rotor blades while the generator power is kept constant. If the wind speed remains high, the rotor blade pitch can be changed to reduce the efficiency of the rotor blades and torque, once again reducing the rotor speed…

By controlling the rotor active power flow direction, a speed range of about 30% around the synchronous speed can be obtained. Instead of dissipating the rotor energy, it can be fed into the grid. The choice for the rated power of the rotor converter is a trade-off between costs and speed range desired. Moreover, this converter performs reactive power compensation and smooth grid connection. It is the advantage of a DFIG that the speed is variable within a sufficient range with limited converter cost. The stator active and reactive power can be controlled independently by controlling the rotor currents with the converter. Furthermore, the grid-side converter can control its reactive power, independently of the generator operation. This allows the performance of voltage support towards the grid"[3].

[2] It is the only electrical machine that operates at twice synchronous speed for a given frequency of excitation (i.e. 7200 RPM mechanical for 60HZ electrical and one pole pair).

[3] Upwind Concept Report on Generator topologies, mechanical and electromagnetic optimization, deliverable n°D1B2.b.1, December 4, 2007.

Direct drive wind turbines (synchronous generators)

The generator is directly connected to the blade shaft without gearbox. The stator holds a three-phase winding and is provided with many more poles than for an asynchronous generator. The rotor consists of a permanent magnet or a winding which is magnetized by a DC current. The direct drive wind turbine is characterized by a variable rate of rotation increasing with wind speed. The turbine output therefore has changing frequency which cannot be handled by the electrical grid. The current must thus be rectified first i.e. converted in direct current, DC. This conversion can be made using thyristors or power transistors. This DC is then converted to AC (alternative current), using an inverter with exactly the same frequency as the electrical grid. The current must be smoothed out using appropriate inductances and capacitors in an AC filter system.

To produce electricity at low rotary speeds (no gearbox), a substantially larger diameter generator is required which increases the effective rotary speed of the rotor relative to the stator coils so that the required torques can be developed.

A permanent magnet, PM, rotor is particularly suited for such an application. It enables start-ups in stand- alone situations and its efficiency remains high, close to nominal value, even at partial loads which is frequent because of wind inconsistency. On top of that, PM generators eliminate the need for separate excitation, slip rings and rotor windings with associated losses and required less maintenance compared to doubly fed induction generators.

Direct drive generators with permanent magnet, rely on rare earth metals, typically neodymium iron bore (Nd-Fe-B). The magnet materials are becoming subject to supply shortages. China currently controls more than 90% of the rare earth market and in 2011 cuts its export quotas by 35%.

DD (direct drive) generators with PM rotor needs as much as 265kg of rare earth (RE) metal per MW output. Though a big producer of RE metals, "China accounts for only about 40% of the world's RE reserves… China does dominate mining of RE ore and is said to produce 95-97% of the global supply of RE. At one time the US was a major player in rare earth magnet production; today there is very little production and RE oxide mining is just restarting. The scenario may be changing now that China has started limiting exports of RE materials to supply the rapidly growing needs of its own high-tech industries[4].

Research for alternatives is another promising area. For example, the US department of Energy (DOE) announced in late June 2011 the funding of six research and development projects at six organizations, focusing on "next generation designs for wind turbine drive trains. Four of the R&D projects will include direct-drive generators of PM or non-PM type"[5].

According to Molycorp Minerals, China is the world's leading consumer of rare earth metals on a global basis, currently consuming approximately 60% of production.

Some experts project that by 2012, China's internal consumption will rise to meet or exceed its production. The world two largest reserves of RE materials outside China, are in Mountain Pass, California and Mount Weld in Australia. Neither of these deposits is currently in production.

The basic disadvantage of indirect grid connection is cost and to some extent availability. Looking at operating statistics from wind turbines using power electronics[6], it seems that the availability rates for these machines tend to be somewhat lower than for conventional ones,

[4] Anders Troedson, Energy and Environment 2011 conference, Las Vegas, US.

[5] "Control Engineering, Rare–earth Magnet Supply and Cost Issues", May 9, 2011.

[6] German ISET Institute.

due to failures in the power electronics. Moreover, energy is lost in AC-DC-AC conversion process and power electronics may introduce distortion of the alternating current in the electrical grid, thus reducing power quality.

Onshore versus offshore wind turbines

"The feasible penetration of wind turbines on agricultural land is higher compared to average feasible penetration on all land cover types. In fact, in countries where wind energy deployment is quite high (Denmark, Germany and the Netherlands), agricultural land area has been most attractive for wind energy deployment… Currently offshore wind farms are, with a few exceptions, placed in shallow waters with depths up to about 25 meters… The offshore wind energy potential between 10 and 30 km from the coast is concentrated in the Baltic sea, the North sea and the Mediterranean… On land only 5% of technical potential is realized in areas with over 3,000 full load hours while at sea this percentage is over 40%. Very windy onshore areas are mainly located in parts of Ireland and the UK. No onshore areas have resource potential exceeding 4,000 full-load hours… For up to 10 km from the coast, the visual impact of wind turbines is significant, as the wind farms can be seen from the coast. In some countries, such as the Netherlands, it is prohibited to build wind farms within 22 km off the coast"[7].

It is obvious that onshore wind energy costs are dominated by turbine costs. For offshore wind, the costs of foundation (tripod, jacket, floating structures and so on) and grid connection can make up a significant share of investment costs[8]. Costs of under water electrical link between offshore wind farms and the continent (excluding transformation stations) could exceed EUR 1 million per km according to the capacity of the line, depth of seabed and so on.

Onshore wind turbines are often installed in distant regions, far from major electricity consumption. Large portions of the electricity produced must therefore be transported over large distances to load centres. This could lead to congestions of existing infrastructure. Therefore at high penetration levels both the transmission and the distribution grids and possibly cross border lines, might require additional extensions or upgrading.

Power flow needs to be continuously balanced between generation and consumption. "This balancing takes place at level of seconds and various types of reserve capacity are used. Estimates for extra reserve requirements due to wind power are in the order of 2-8% of installed wind power capacity at 10% penetration of gross consumption… Related costs of this additional reserve are estimated at a level of 2-4 eurocents/kWh"[9].

Onshore wind farms are subject to restrictions, objections and limited availability of suitable lands due to lack of sufficiently windy areas or too high wind power penetration.

Objections mostly originate from social constraints regarding essentially the visual and noise impacts. In Europe, more and more opponents to wind farms for "NIMBY" reasons, are

[7] *EEA Technical Report n°6*, European Environment Agency, 2009.

[8] Grid connection for offshore farms can reach 30% of total investment costs whereas foundation 25%, according to EEA.

[9] *EEA Technical Report n°6*, "Europe's onshore and offshore wind energy potential", European Environment Agency, 2009.

organized in associations lobbying local policy makers against delivery of construction permits.

The trend towards "direct democracy" in Europe gives those associations a power which could slowdown further onshore wind energy developments. These concerns may partially explain the growing interest for offshore wind farms, but, of course, higher and more constant wind speeds and consequently much higher efficiencies are the main drive for offshore installations.

However, this should not obliterate the advantages of onshore versus offshore wind turbines. Indeed the onshore turbines are cheaper than offshore (between EUR 1,000 to 1,500/kW, including foundations against EUR 2,000 to 3,500/kW for offshore units) and so are their connection to the electrical grid, their installation as well as their operation and maintenance. There are other constraints specific to offshore installations like: weather conditions, oil and gas exploration, shipping routes and military use of offshore areas and so on.

Wind turbines manufacturers

There is a fierce competition among wind turbine manufacturers. Those who lack capital, expertise and/or sufficient R&D are very likely to be squeezed out altogether. New entrants based in countries with a large domestic market have a substantial edge on their competitors developing export capabilities to thrive. Instead of devoting sufficient time to improving the design of their machines, some manufacturers concentrate on increasing their selling performances and experience setbacks.

Europeans, once the leaders in wind turbine manufacturing ,are progressively caught up and outrun by Asian companies. For instance, China has captured 4 of the top 10 positions in the ranking of wind turbine manufacturers. Sinovel and Goldwind have become n°2 and 4 rankers in the world with more than 10% of the global market each whereas Dongfang has a 7% market share and United Power is n° 10.

The Danish Vestas remains n°1 (12% market share) in spite of the slowdown in the western markets while the American GE is n°3. There are two Germans in the top 10: Enercon (n°5), a long time market leader in direct drive turbines, and Siemens (n°9). The Spanish Gamesa, once a front runner, regressed to the 6th rank. To retain their ranking or improve on it, manufacturers are developing services and optimizing the component supply chain to meeting the maximum customer's satisfaction.

Vestas and Siemens dominate, for the time being, the offshore projects with roughly equal shares in Europe but with a different design concept. GE notably absent in that segment of the wind energy business, intends to re-enter this market.

Whereas Siemens is betting on gearless wind turbines, Vestas is sticking to geared machines. The former manufacturer is thus confident in the future of an unproven technology in the offshore environment with permanent magnets involving rare earth metals from China although its strong position in the offshore market has been based so far on geared turbines. Vestas on the contrary, prefers a proven technology not depending on Chinese raw material suppliers.

According to the "World Market Update" 2010, direct drive turbines' share of the world total number of wind turbines in 2008, was approximately 12% on a MW basis. By 2010, this share had increased to about 18%. The "World Market Update" estimates that this percentage could continue to rise to 20-25% by 2016. However most manufacturers are still producing both geared and direct drive wind turbines.

Non-Chinese manufacturers have not had to compete, up to now, with Chinese in North America and Europe but, as already said, this situation is expected to change in the near future.

Is the European industrial wind power policy coherent?

To take up the challenges of fossil fuels depletion, security of energy supply, pollution and carbon emissions, was it and is it absolutely necessary to massively subsidize all types of renewable energy production whether their technology is mature or not and without adequate coordination and global strategy?

The European green policy leads to the rapid growth of renewable electricity generation, in particular, wind power and, to a lesser extent, biomass based power production, hydropower capacity extension being limited. Biomass fuelled power plants being not a concern within the scope of this paper, the emphasis will be put on wind power.

Some basic features of wind power like intermittent electricity generation, no reactive power production of a large number of wind turbines, dissemination of wind farms or de-centralized mini power plants located near the consumers and lack of inertia necessary to cope with transient regimes, require technical adjustments and infrastructure management re-thinking. Among the many concerns relating to wind power, electricity-transmission infrastructure is a major one:

- The wide variation of wind power output on relatively short period of time and a large gap between forecasted and actual wind power output imply a high degree of flexibility of the power system and sufficient back-up power. There is a widespread consensus among energy experts that a renewable energy future will not be possible in Europe without big investments[10] and large scale introduction of "smart grids" which involve a great deal of stakeholders[11]. A study commissioned in 2006 by the German Energy Agency (DENA)[12] reported that a very small proportion of the installed wind capacity could contribute to reliable supply. Depending on the time of year, the gain in guaranteed capacity from wind as a proportion of its global capacity was between 5 and 8% for 14,000 MW (2006) and between 5 and 6% for 36,000 MW total projected in 2015. This involves a major additional cost to consumers. According to E-ON (German main utility), the relative contribution of wind power to the guaranteed capacity of their supply system up to 2020, will fall continuously to around 4%. This means that in 2020,

[10] The European Commission estimates that EUR 1 trillion is needed to make Europe's electrical installations and infrastructures fit for the future.
[11] Traditional energy producers, electrical grid operators, regulators, consumers, public authorities, etc.
[12] Deutsche Energie Agentur Gmbh.

with a forecasted wind power of over 48,000 MW in Germany, 2,000 MW of traditional power production can be replaced by wind farms (DENA grid study). Contrary to the Green assertions, the swarming effect does not work as expected. A report by J. Oswald[13] based on data given by E.ON for Germany and Central Europe demonstrates the very limited impact of this effect.

- The physical location of wind farms is often distant from existing transmission infrastructures. As a consequence, additional and upgraded grids are required to connect the production facilities with the consumption areas. In addition, developing cross border connections will provide the means to integrate a greater quantity of renewable plants. In Germany, wind power production is clustered in the Northern part of the country whereas consumers are more concentrated in West or South Germany. This requires investments in North-South infrastructures. In the meantime, the current is transiting through neighbouring countries like Belgium, with the consequential strengthening of their grids. Most bottlenecks in the energy market occur at national borders but not necessarily because of lack of inter-connection capacity but also because of congestion of the domestic networks on one or both sides of the border.

The consequence of the poorly coordinated and insufficiently looked-in European energy policy, is that the development of the renewable energy industry continues to be hindered today by outdated grids and grid congestion, delays to planning permission and insufficient funding. It is not clear how quickly these problems can be solved.

As subsidies are provided to attract investments in renewable energy, similarly TSO's and DSO's should be proposed incentives to develop transmission and distribution systems meeting the current and future power generation and consumption requirements.

Wind power , the fastest growing of the European renewable, accounts for the second largest share of renewable electricity in Europe (after hydropower) of which Germany and Spain have approximately 50% of the installed capacity.

But can Europe ensure secure and affordable electrical energy supplies and implement simultaneously and rapidly a green policy at reasonable costs, without changing its approach?

A number of parameters raise questions about the success of the European strategy:

- The financial and economical crisis has had and will have a negative impact on the European renewable energy policies in terms of financial incentive schemes and of investments. Some governments already took harsh measures like Spain which decided, among others, to cut subsidies for wind power by 35% between 2010 and end 2012. Other European governments followed suit as the Dutch.
- The NIMBY phenomenon is another case in point. Lobbies are more and more efficient. The France-Spain high voltage interconnector through the Pyrenees is a good example of this trend. Opponents to the link, eager to protect their environment, on both sides of the border, succeeded in blocking the project during many years until they obtained an acceptable solution but at a high cost: the burial of a portion of the HV line. Besides the media hype, not a week goes by in Europe without demonstrations of citizens against the installation of wind farms (not necessarily successful). What is at stake is not only the noise and visual impacts but also the consequential electricity price increases due to the support schemes granted to the renewable power producers.
- The deficit of power transmission capacity, domestic as well as between countries, as a consequence of poor European energy policies. Would it not be more rational, before rushing into massive financial incentives, to take time for analyzing the consequences of

[13] Oswald J., et al., *Will British Weather provide reliable electricity?*, Energy Policy, 2008.

the renewable strategy and its impact on HV power transmission and power distribution.

- The uncertainties about the European objectives relating to GHG emission policies, the national legislations including construction and operation permits and administrative constraints.

On the other hand, it appears that a thriving European wind power industry depends on exportation. But on the world market, Europe will have to face aggressive contenders like China which benefits from a huge domestic market and cheap equipment… up to now.

A brief outline of the renewable energy policies of some EU Member States

Germany

In 2010, the installed capacity of wind capacity was approximately 27,000 GW with a production of about 7% of Germany total electricity power. As of 2011, the Federal Government is working on a new plan concerning renewable energy commercialization, with a particular focus on offshore installations. The replacement of first generation wind turbines with modern multi-megawatt machines is under way.

The Federal Government hopes to increase the amount of electrical energy coming from renewable sources, as a percentage of all energy generated, from 17% to 40% by 2020 and it foresees most of this increase from huge offshore farms. However expansion of offshore wind projects are behind schedule.

Apparently, the government plans to raise the feed-in tariffs paid to the operators of offshore wind farms from EUR 0.15 to EUR 0.18/kWh. The guarantee of higher profits does not reduce the risks investors assume in setting up an offshore farm. The technology has yet to be proven. In recent years, major companies have suffered a number of setbacks.

The United Kingdom

Wind power in the UK is nearing 6,000 MW and is the second largest source of renewable energy after biomass.

In 2011, onshore wind costs are below new nuclear but, on the contrary, offshore wind costs are much higher than early estimates according to the engineering consultancy Mott Mac Donald (about 17 p/kWh).

Wind farms are made profitable by subsidies through Renewable Obligation Certificates which provide over half of wind farms revenue. To meet the ambitious target of generating 15% of all UK's energy from renewable energy by 2020 means that 35-45% of electricity will have to come from green sources on the grounds it will take longer to deploy renewable heat systems.

The Scottish government wants to generate the equivalent of 100% of its electricity consumption from renewables by 2020. But since Scotland aims to export as much electricity as it consumes, in practice this means that 50% of the electricity production for domestic use should come from renewable sources. In 2009, Scotland already generated 27.4% of its consumption from "green" plants. Over half of this was hydropower, most of the rest wind and wave power.

Spain

"Spain is among the countries most reliant on renewable energy, a policy that has made it less dependent on fossil fuel producers but has resulted in higher energy prices, stoking up inflation and hitting the economy's international competitiveness at a time when domestic demand has weakened.

Spain's government is seeking to press ahead with planned cuts in costly renewable energy subsidies as part of ongoing austerity moves. The plan is designed to make annual savings of around EUR 100 million (solar plus wind). Solar power currently accounts for around 3% of Spain's power generation and about half of renewable energy subsidies! Wind power accounts for 13% of generation"[14].

According to the Spanish industry group AEE, the total wind power capacity at the end of 2010 was about 20,500 MW. It generated 16.6% of all electricity produced in Spain that year.

Subsidies have made Spain a leading producer of renewable energy but have added billions to the debt pile of a government fighting to persuade financial markets its public finances are in order. In July 2010, the government reached a preliminary agreement with wind industry in which premiums paid to wind producers above market prices would be cut by 35% in 2013. Since then however, the government has failed to reach cross-party agreement on an "energy pact" to determine the future of subsidies and Spain's generation mix.

France

The so-called "Grenelle de l'Environnement"[15] fixed a 23% share of renewable energies of the overall French energy consumption within 2020. To attain this goal, France needs 25,000 MW of wind power of which 6,000 MW offshore. Current wind power capacity of 5,600 MW, versus 63,130 MW nuclear and 24,178 MW hydropower, supplies only 2% of France power demand.

The long term profitability of offshore wind power generation is a cause for concern because of the special operating conditions at sea and the maintenance costs. The state has fixed the tariff for the offshore production at EUR 16 to 17/MWh.

The Netherlands

The energy policy of the current Dutch government, which was formed in October 2010, represents a radical change with the past. It also represents a break with the policies of neighbouring countries like Germany.

---

[14] MERCOM, *Market intelligence report*, December 2010.

[15] Initiated in 2007, the « Grenelle de l'Environnement » aimed at designing a roadmap in favor of ecology and sustainable development. Between 2008 and 2010, the French Parliament voted the legislation concerning the corresponding commitments.

The Dutch government wants to achieve its renewable energy in the most cost-effective ways. This is reflected in a policy of limiting subsidies to relatively cheap installations, such as onshore wind power and bio-gas. Their plan is for the subsidies to be cut from EUR 4 billion to EUR 1.5 billion.

However the Netherlands does not intend to discontinue investments in new thermal power plants.

"According to the grid power operator TenneT, Dutch national power output is expected to increase by 50%, or 14 GW, by 2018 which would make the Netherlands a prospective power exporter from a country once dependent on imports…The Netherlands is expected to see its installed capacity reach 40 GW in 2018 from 26 GW at present, with about 5.7 GW from renewable energy sources"[16].

Ireland

"The Irish government wants to increase the share of wind power in the country's electricity production capacity to over 40% by 2020, more than double the current rate. The problem is that these plans come at a time when demand has been falling as a result of the economic crisis, so that their realization would lead to a huge over capacity... Maximum load in January 2011 was some 300 MW below that of January 2010.

In March 2011, the total electricity production capacity in Ireland was about 8,570 MW of which about 1,400 MW consists of wind power and 240 MW consists of other forms of renewable energy. Wind farms supplied some 10,5% of electricity consumption in 2009… What has to be added to this is the extra cost to the grid. The obvious problem here is that the bulk of the new wind capacity is on the other side of the country from the main areas of demand, most notably Dublin. Eirgrid's development plan suggests that virtually every province of Ireland will require expansion of the grid with an additional 1,100 km of new lines and upgrading on 2,200 km. An early Eirgrid study put the cost of this at EUR 4 billion. Wind power suffers from System-Non-Synchronization penetration since it is much more difficult to keep a large number of wind turbines in phase with each other than large conventional plants"[17].

Wind integration versus CO_2 emission

Wind power is not as low carbon (life cycle carbon print, especially for offshore wind power) and CO_2 emission free as their supporters suggest. Indeed the introduction of wind power in conventional energy systems requires reserve capacity and back-up thermal power plants (if a "green" energy back-up like hydropower is not available) to secure the electricity supply in case of reduced wind or lack of it. Conventional generation is ramped down to make room for wind generation and is then ramped up as wind production subsides. This leads to heat rate rises (lower efficiencies and increase of fuel consumption). Larger amounts of intermittent renewable energy will only exacerbate this drawback although technical developments are

[16] Energy Market Price, August 19, 2011.
[17] *European Energy Review*, March 10, 2011.

expected to reduce the negative impact of wind power back-up.

On the other hand, there could be a mismatch between wind power availability and electricity demand. Thus the CO_2 saving through onshore wind power is to some extent balanced out by extra CO_2 emissions from back-up thermal power[18]. In that respect offshore wind power is a better choice although manufacturing and installation is far from being CO_2 emission free.

It is interesting to note that the European countries that most promoted wind power are the biggest GHG (greenhouse gas) emitters in Europe because of their conventional power generation: Germany, Denmark and Spain.

In spite of all this, wind power benefits from the privilege that their forecast power generation entails no penalty if it is not available. The operators of wind turbines believe that they cannot be held accountable for whether the wind blows and for their inaccuracies in their forecasting capability.

So far the claims that onshore wind farms strongly contribute to CO_2 emission reduction, have not be substantiated by analysis based on measured data in spite of the fact that such evidence is of the essence to justify the European "green" policy and, in particular, the priority given to wind power over conventional power plants. The burden of the green policy on the European citizens and businesses in terms of higher electricity prices, noise and visual nuisances and so on, should have prompted the policy makers to check that the objectives of their legislation are realistic and attainable.

Conclusions

The technology of wind turbines is evolving rapidly accommodating an even wider range of sites and wind speeds. More and more powerful wind turbines are offered for offshore applications (up to 6 MW and very soon above 7 MW) while onshore, the turbine size is more in the 1.5 to 3 MW range although there is some interest for mid-size (below 1 MW) and small machines, essentially for local communities and small businesses applications. Enercon, the market leader in Germany, recently installed in Magdeburg-Rothensee, the world's most powerful wind turbine: 7.5 MW with a hub height of 135 m and a rotor diameter of 126 m (total height: 198 m).

There is a fierce competition among wind turbine manufacturers. The Europeans, once the leaders on this market, are progressively caught up and even outrun by Asian companies. For instance, Chinese capture 4 of the top 10 positions in the ranking of wind turbine manufacturers. Sinovel and Goldwind have become n°2 and 4 rankers. However the Danish Vestas remains n° 1, but for how long?

Some manufacturers are betting on gearless (direct drive) wind turbines involving fewer moving parts and hence easier maintenance and improved reliability but more expensive and if equipped with a permanent magnet rotor requiring today rare earth for its construction, depending on China that presently holds a quasi monopoly of the supply of this material. Other manufacturers are sticking to their geared technology like Vestas. However a number of manufacturers are producing both geared and direct drive wind turbines to diversify their

[18] Oswald J., et al., *Will British Weather provide reliable electricity?*, Energy Policy, 2008.

risks. Both types of turbine have their advantages and drawbacks which have an impact on the financing conditions.

Financiers are wary of the perceived added risk associated with direct drive machine cost and related technology implications as well as of offshore applications difficult environment. Indeed proven technology and availability of components and spare parts at reasonable prices, are of the essence.

Some basic features of wind power like intermittent electricity generation, no reactive power production for a large number of wind turbines, dissemination of wind farms and of decentralized mini power plants as well as turbine's lack of inertia needed to cope with transient regimes, require major and costly technological changes in the electrical infrastructure and in their management.

On the other hand, a study commissioned , in 2006, by the German Energy Agency (DENA) reported that only a very small proportion of the installed wind capacity could contribute to reliable supply. This situation is expected to worsen.

Moreover, wind power production is not necessarily located close to the consumers. In Germany, for instance, wind power generation is clustered in the Northern part of the country whereas consumers are more concentrated in south- and west-Germany. This requires infrastructure investments because the current network was not designed for such flows.

Europe has been and is still a strong supporter of growing the share of power production from renewable sources as the 20/20/20 scheme clearly illustrates. The problem is that the European energy and environment policies are poorly coordinated and not sufficiently looked in.

Is this policy sustainable in the current context and in the coming years without changing its approach? A number of parameters have a negative impact on the European strategy and could seriously mitigate its outcome, like: the financial and economical crisis; the NIMBY phenomenon[19]; the deficit of power transmission capacity within the Member States and between them[20]; the uncertainties about the European objectives relating, for instance, to GHG emission policy; the national legislations including permitting procedures; administration constraints and the global competition, as explained in this paper.

At last but not least, it should be kept in mind that one of the main reasons for Europe to promote renewable energies and, in particular, wind power is the reduction of CO_2 emission. The fact is that wind energy is not at present as clean and CO_2 emission free as their supporters suggest. Indeed the introduction of wind power in the conventional energy systems requires, inter alia, reserve capacity and back up thermal power stations where hydropower or other "green" energy is not or not sufficiently available, to secure the electricity supply in case of low wind or lack of it. Those power stations have to operate at lower load capacity and thus at lower efficiency to make room for wind generation and are ramped up and down according to wind conditions. All that increases the heat rate and hence GHG emission[21].

So far, the claim that onshore large wind farms strongly contribute to CO_2 emission reduction, has not been substantiated by analysis based on measured data in spite of the fact that such survey is of the essence to justify costly financial support schemes for not always mature renewable electrical generation.

The financial burden of the "green"policy on the European businesses and citizens in terms of

---

[19] "Never In My Back Yard".

[20] The Commission itself recognizes that the transition from the current grid infrastructure to an infrastructure base on smart metering and smart grid technologies is not progressing as fast as it needs to be.

[21] GreenHouse Gas.

higher electricity prices, visual and sound impacts and so on should have prompted the policy makers to first check that that the objectives of their legislation are realistic, attainable and do not jeopardize the European competitiveness.

A problem with massive subsidization of renewable energy is that a number of developers/investors focus on maximizing the return on investment and not on long term operation with, as a consequence, minimizing the O&M[22] costs. On the equipment supply side, the policy of too many manufacturers is to enhance sales at all costs without taking sufficiently into account the after sales services. This leads, among others, to long delivery times of spare parts which makes O&M very difficult. Sales top, Service flop! In such conditions, what is the lifetime of wind turbines: 10 years or less?

Jean-Pierre SCHAEKEN WILLEMAERS

[22] Operation and Maintenance.

Jean-Pierre SCHAEKEN WILLEMAERS holds a Master's Degree in electrical and mechanical engineering and graduated in nuclear engineering and economics (University of Louvain, Belgium). He began his career as a Lecturer at the University of Louvain. He then held different executive positions in the industry sector as he worked for the Suez-Tractebel group. He was a Sales & Marketing Director and a Member of the Executive Committee of Tractebel Engineering before being appointed Executive Vice-President of Suez Tractebel EGI (Electricity & Gas International). He has been in charge of several subsidiaries in Europe (Germany, Italy, Hungary) and Central Asia. He is currently a Vice-Chairman and an Executive Board Member of Unit International SA, a Board Member of Unit Invest NV and of a number of Industrial Companies. He is also a member of the Thomas More Institute advisory board.

Institut Thomas More
20, rue Laffitte – 75 009 Paris
Tel. +33 (0)1 49 49 03 30
Fax.+33 (0)1 49 49 03 33
www.institut-thomas-more.org
info@institut-thomas-more.org