GROWTH OF THE WIND POWER INDUSTRY

The spectacular growth of the world wind power market demonstrates the desire of industrialised nations, particularly in the European Union, to exploit the considerable resources available both on land and at sea. In the growing and promising market of large offshore wind power plants, Jeumont Industrie's high performance technology is a major asset for France. The know-how of the CEA in materials, structural mechanics, turbulent flow and electronics can contribute to their optimisation.

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Prototype of the large wind turbine (750 kW) designed by Jeumont Industrie (Framatome group) on the Widehem site (Pas-de-Calais) which will house six in all. This type of wind turbine is produced in series within the framework of the Eole 2005 programme.

With an installed capacity of less than 23 MW at the end of 1999, France has few wind turbines, while the use of wind energy has been growing considerably throughout the European Union for several years (see box D, ***How a conventional wind turbine works***) such as generators, rotor blades or the rings used for rotor rotation, the orientation of the blades and that of the nacelle. There is one small company, Vergnet SA, that is a world leader in the market of small wind turbines not connected to the grid, but there is no French industrial company in the large wind turbine market. With its electromechanical expertise, Jeumont Industrie (100% owned by Framatome) is the only company that has what it takes to become a major manufacturer. In October 1999, on its Widehem site (Pas-de-Calais), it inaugurated a large 750 kW wind turbine prototype with an innovative generator. This machine will be produced in series to equip the plants planned as part of Eole 2005, the national programme that has supported the French wind power industry since 1996 with the aim of installing between a 250 MW and 500 MW capacity in France by 2005. On 31 January 2000, 55 projects were selected totalling 367 MW, of which only 7.65 MW are connected to the grid (in mainland France and Guadeloupe).

Demand for wind-generated power is increasing

The rapid increase in the world market of large land plants is accompanied each year by an increase in the average power of newly installed wind turbines while, at the same time, production costs drop. In Germany, the average power of new machines has increased from 780 kW in 1998 to 935 kW in 1999.

The multiplication of large plants poses the delicate problem of finding suitable large land sites and the necessary limitation of the effect of wind turbines on the natural and human environment, particularly in smaller European countries, such as Denmark and The Netherlands.

In this context, the growing number of offshore wind plants is a much better way to ensure sustained market growth. The resources at sea are greater than on land but, above all, the wind is stronger and more regular and large plants have little or no visual/noise impact on human populations. However, as offshore projects are more expensive than land projects, owing especially to the foundations, the connections to the grid and the difficulties of the machines meeting the demands of a marine environment, their profitability can only be guaranteed by designing large machines of several megawatts.

Major technological developments

Such wind turbines are only in the prototype stage. The technological challenge is thus still waiting to be taken up. But the appearance of "direct drive and variable speed" multi-polar generators could also be a determining factor on the offshore market.

The "direct drive" generators operate at a low rotor speed, which means the heavy and expensive gearbox is not required and the compact machines have reduced maintenance requirements. Furthermore, replacing fixed rotor speed (the most widely used) by variable speed optimises the production of electricity, with the rotor speed constantly adapting to the wind speed. Today, few manufacturers market large wind turbines that integrate both concepts. Three who do are Enercon (Germany), Lagerwey the Windmaster (The Netherlands) and Jeumont Industrie.

The 750 kW "direct drive and variable speed" wind power generator from Jeumont Industrie is equipped with an innovative

Offshore wind turbines off the coast of Denmark.

Iben Østergaard/DTi

generator (using "discoid technology") and an electronic converter that allows coupling to the grid and controls operation at variable rotor speeds. This unique, high performance technology allows more powerful machines to be designed and, with its concept of **aero-dynamic stall** power control (instead of pitch control), it stands out from rival machines.

Support for the French wind power industry

To contribute to the development of the French wind power industry, Ademe (Environmental agency for the control of energy) is spending 1.5 to 2.3 million Euro a year on wind energy research and development between 1999 and 2003, both at national and international level. Among the research areas chosen for this multi-year programme (fundamental research, industrial development of new machines, evaluation of wind energy resources, followed by performance of machines on site), a major area is devoted to the design of a range of 2.5 to 3 MW machines destined for the offshore market and using the technology from Jeumont Industrie, particularly for the generator.

The technological innovation will first of all be applied to the power electronics. Jeumont Industrie's technology requires the use of control components or systems that are suitable, efficient and low cost.

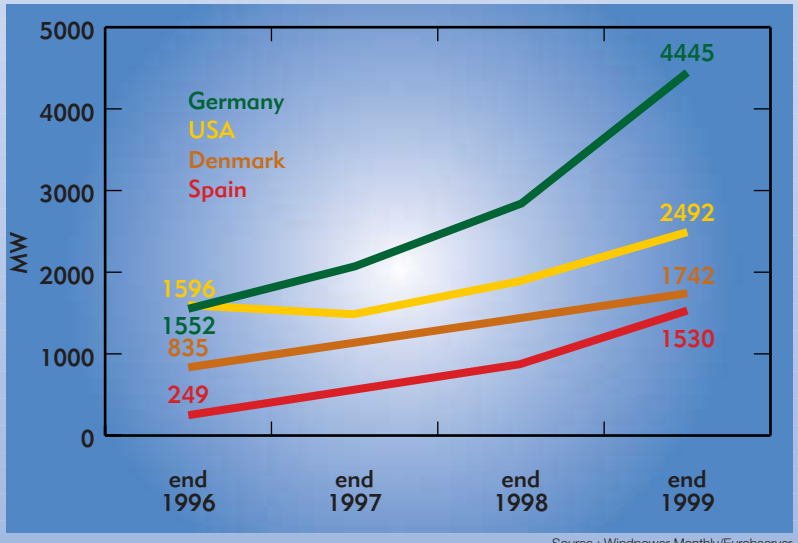
Following this phase, large machines that are economically competitive, lighter, reliable and long lasting in a marine environment will have to be designed. This will mean finding a way to study their dynamic behaviour under the combined effects of swell and wind. Research and development efforts will particularly concentrate on the materials used for the composite blades and the rotating components, which need particular protection against sea, rain and sand corrosion.

Finally, generic studies will be carried out, particularly to take into account the initial results of average sized wind turbines used offshore.

Future wind power market to be blown offshore

Today the world wind power market is essentially a market of 300 kW to 100 MW land plants connected to the electricity grid. It has seen strong growth over the last few years, particularly in the European Union, three of whose member states are among the four world market leaders in terms of installed capacity (see figure). The market is highly competitive and constantly evolving, supported by public grants but close to profitability and largely dominated by European manufacturers, the largest world manufacturer being the Danish company, Vestas.

Small land plants of less than 300 kW not connected to a grid make a profitable, promising niche market destined mainly for rural electrification or telecommunications. The market for large 5 to 100 MW land plants, which use wind power generators of 1.5 MW or more, has seen the greatest growth, but that of large offshore plants, emerging in northern Europe, will probably become THE market of the future.



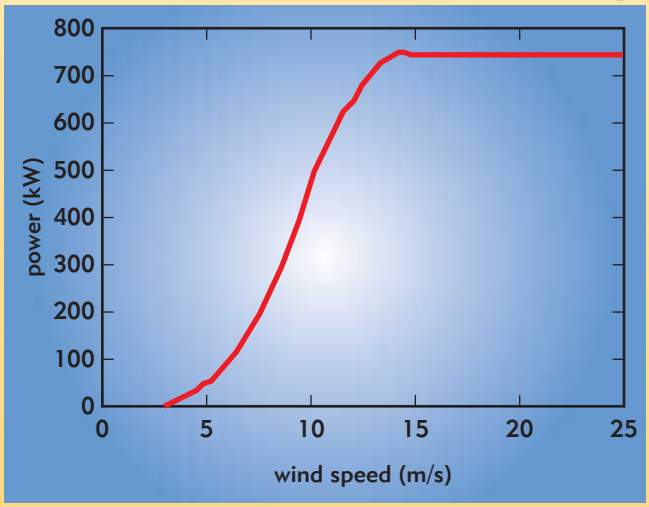
Source : Windpower Monthly/Eurobserver

How a conventional wind turbine works

D

A wind turbine is made up of a rotor and a nacelle mounted on a tower. The rotor usually comprises 3 blades, rather than one or two, in order to reduce mechanical stress on the machine and improve visual appearance, and turns at a constant speed of about 30 revolutions per minute. The nacelle houses an asynchronous generator that operates at a speed of 1 500 revolutions per minute. The generator is coupled to the rotor by a gearbox and the energy produced is fed to the grid by a voltage transformer at the base of the tower, which then increases the voltage to grid level. In all commercial wind turbines the gearbox and the generator are horizontally aligned. Although a vertical axis rotor design does exist (called the Darrieus rotor), it has not lived up to expectations in terms of development.

The wind turbine has an instantaneous power proportional to the surface swept by the rotor and to the cube of the wind speed. The idea is to capture the strongest winds several tens of metres from the ground at the top of the tower. The turbine reaches its nominal power at a wind speed of around 14 m/s (see figure). Above that, the rotor speed must be restricted and the wind turbine must be stopped automatically if the wind speed exceeds 25 m/s (90 km/h).



There are two power regulation techniques: pitch control (the blades can turn around their longitudinal axis in order to reduce lift and hence motor torque) and **aerodynamic stall control** (the blades are designed in such a way that the action of the wind is limited when its speed exceeds its nominal value).

The CEA's scientific and technological offer

In February 2000, the CEA submitted a service offer to Ademe so that it could participate in national industrial wind power projects co-financed by Ademe and in particular involving Jeumont Industrie. The CEA proposal includes a coherent and comprehensive range of multi-disciplinary skills and calculation and testing means. Its expertise is especially strong in the areas of ageing and generation of composite blade materials, structural mechanics of wind turbines, turbulent air flow and liquid-structure interactions, instrumentation and power electronics.

This proposal shows the desire of the CEA to contribute to the development of large French wind turbines targeting the offshore market and, more generally, bring its scientific and technological know-how to bear in matters relating to wind turbines once the institutional and industrial demand exists.

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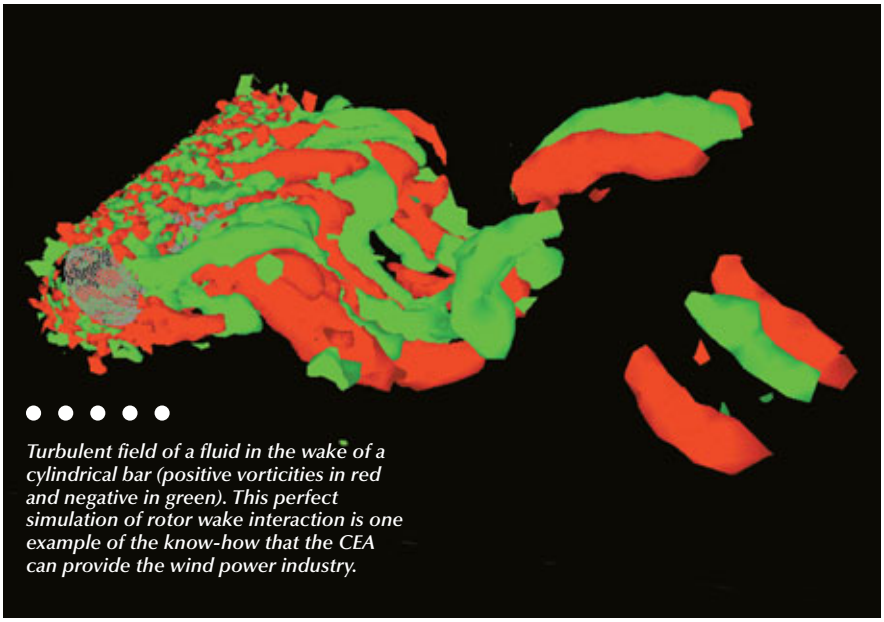

Turbulent field of a fluid in the wake of a cylindrical bar (positive vorticities in red and negative in green). This perfect simulation of rotor wake interaction is one example of the know-how that the CEA can provide the wind power industry.

CEA/DRN