The wind turbine -

energy rediscovered

Québec

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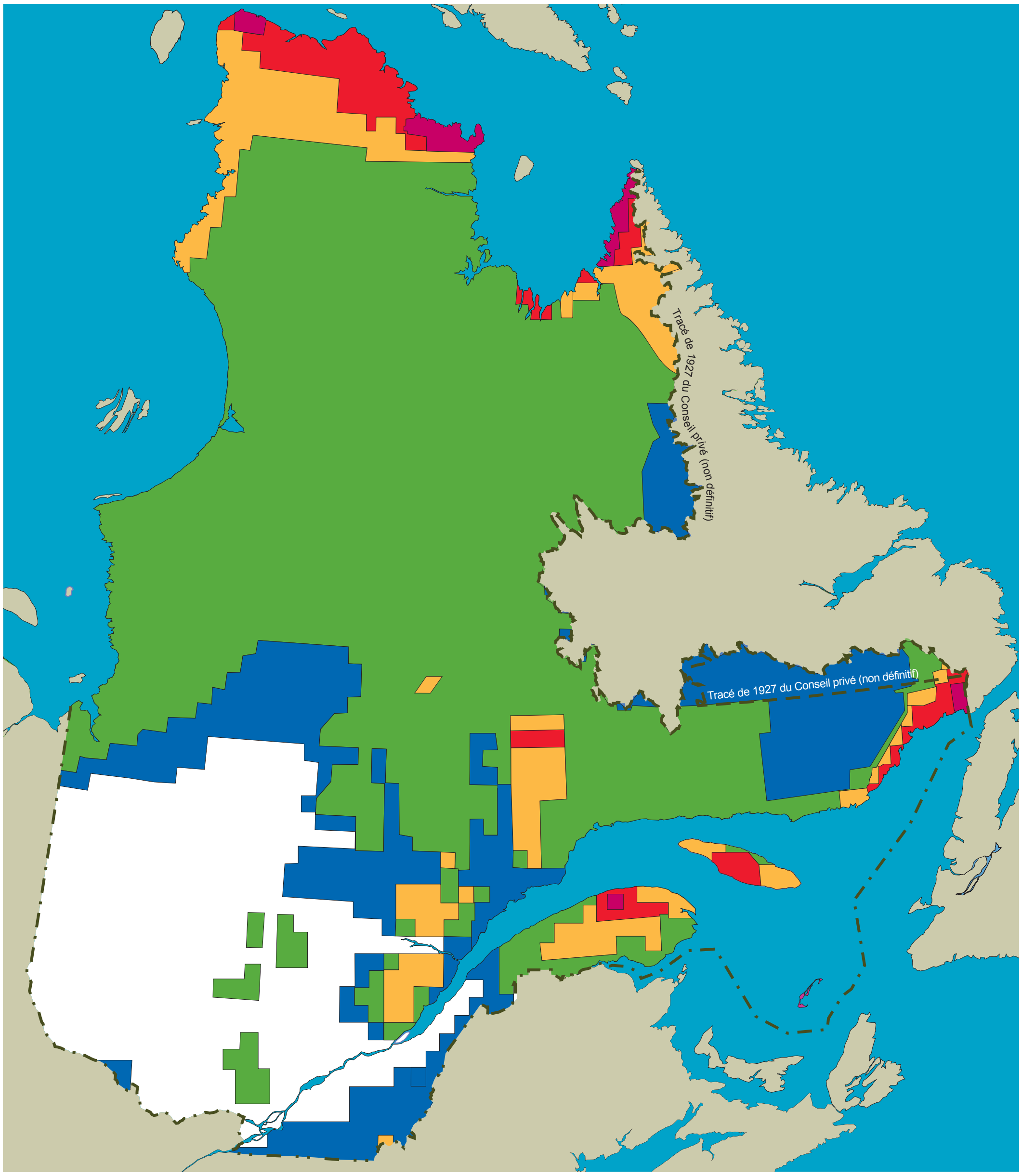
The wind turbine-energy rediscovered

Québec is recognized as a major producer of hydroelectric power. With over 40,000 megawatts of installed capacity, it is the world's third biggest producer of hydroelectricity. However, a "new" form of wind-generated energy is being added to this clean and renewable energy: wind power. Respectful of the environment in its development and operation, wind power has awakened growing interest and is attracting more and more attention to Québec.

Development of wind power is favoured because of its integration into hydroelectric networks, which compensate for the wind's intermittence. The development of the wind subsector can therefore rely on the existence of these networks, making wind turbines an energy source complementary to hydroelectricity. Over 133 wind turbines have already been installed in Québec, making it the leading wind power centre in Canada.



Wind Energy Potential in Québec

Annual Wind Power (at 30 m)

Class	W/m²	Wind Speed (km/h <)
1	0 < 180	18
2	180 < 240	22
3	240 < 320	23
4	320 < 400	25
5	400 < 480	27
6	480 < 640	30
7	640 < 1600	40

Québec: strong wind potential

Québec offers sites with very interesting wind power generating potential. With the financial backing of the Ministère des Ressources naturelles, a study conducted by the Wind Power Research Group at the Université du Québec à Rimouski (UQAR) has produced a preliminary wind map to define the best wind turbine sites in Québec and visually characterize the sectors with potential.

Zones with high wind potential are mainly located in the Appalachian corridor and in the St. Lawrence corridor, especially in the Magdalen Islands, on the Island of Anticosti, on the Middle and Lower North Shore, in the Gaspé and in Northern Québec. These sites could be defined according to a classification method used in several European countries and in the United States. The results are expressed in watts per square metre (W/m2).

In this system, the sites are ranked on a scale of 1 to 7. The sites offering wind potential are at Level 3. Those with good potential are at Level 4 and those with exceptional wind power potential are categorized at Levels 5, 6 and 7.

Compared to California, whose sites rank at Levels 3 and 4 and where the greatest concentration of wind turbines can be found, the Magdalen Islands offer exceptional sites, since most of them are at Level 6 on an annual basis, sometimes reaching Level 7 in winter. The Gulf of St. Lawrence, Island of Anticosti and Middle and Lower North Shore regions, at Levels 4, 5 and 6, are considered to have high potential, especially in the Lourdes-de-Blanc-Sablon sector. As for Northern Québec, wind potential increases north of the 60^{th} parallel, reaching Level 5 in mountainous regions and Level 6 in the coastal zone.

In the Gaspé, the most interesting potential can be found on the north shore of the Gaspé Peninsula with Level 5 and sometimes 6. Measurements on the mountain peaks near Mont Jacques-Cartier have put these zones at Level 6. Finally the higher-altitude sectors located between the Québec City region and the Saguenay offer good potential with Levels 4 and 5.

Studies making it possible to increase knowledge of wind potential in Québec are under way, with a particular focus on determining this potential. Among other aims, these studies seek to collect, analyze and process, with specialized software, data relating to wind potential to complete the wind map of Québec. They also aim seek to measure the shear (difference between the forces exerted by the wind on a anemometer depending on the height), a key parameter for wind power. Finally, these studies are tending to evaluate wind turbine performance in winter periods and gather precise data during the cold season. This research is being conducted under the responsibility of the Ministère des Ressources naturelles, with the collaboration of regional partners. Since 1995, over $2.5 million has been allocated by the Department and its partners to conduct these studies.

NORMAN OUELLET

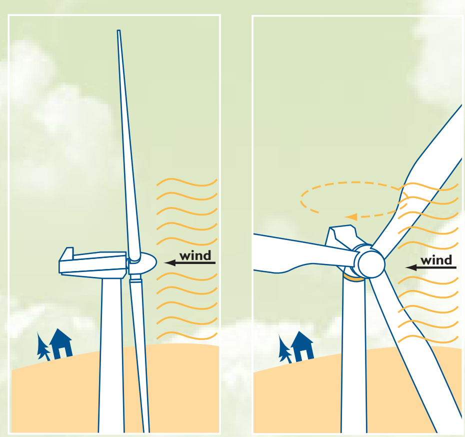
The answer is blowing in the wind

The choice of the site crucial for the wind turbine's effectiveness. An interesting site should show an average wind speed greater than 15 km/h and offer great regularity. In fact, to generate electricity, initial wind speeds of 10 or 14 km/h are necessary to get the wind turbine rotor to turn at an average of 18 to 28 revolutions per minute.

The average wind speed is a good indication for choosing a site. However, the measurement of the regularity of the winds present and the dispersion of these winds are data that absolutely must be considered. A site's wind potential isn't the only factor to consider when choosing and developing a site. Other aspects such as the use and vocation of the land, access to the power grid, physical constraints of wind turbine development and environmental protection are all elements that influence site selection.

Feathering

In high winds over 80 km/h, the wind turbine must be feathered for safety reasons. Feathering consists of rotating the blade axis by 90°, thus offering the wind a smaller contact surface. Some wind turbines have a variable blade mechanism (the angle of the blade varies), while other have an aerodynamic braking system (only the tip of the blade rotates). These "prebraking" mechanisms are intended to slow the motion of the rotor to prevent the wind turbine structure from becoming unbalanced in high winds.



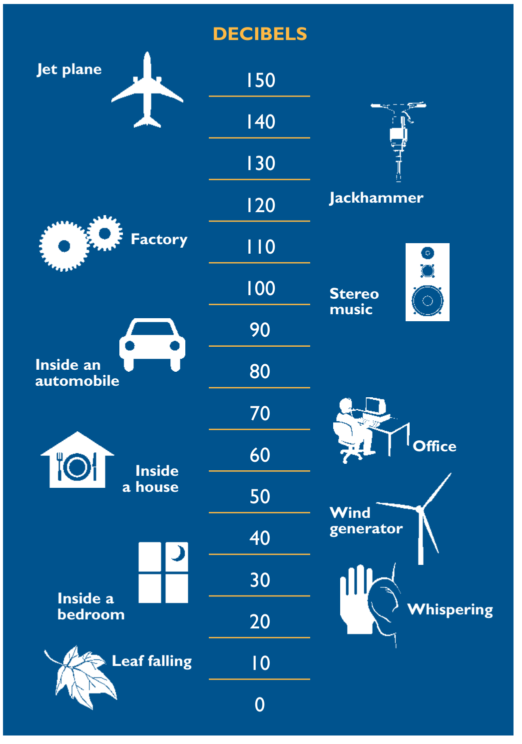
Wind turbines and the environment

In general, wind turbine installation has little environmental impact and causes no irreversible disruption. Nonetheless, it is important to ensure that the chosen site is not located in a bird migration corridor or near breeding or nesting areas to minimize the impacts on wildfowl. Some birds of prey, when hunting, do not perceive the rotors well and may strike them at full speed. However, studies have shown that most birds easily detect a wind turbine's blades when they are in motion and manage to avoid them.

Once installed, the wind turbine takes up little space and does not alter the land's vocation. It is generally compatible with the agricultural or forest uses already present. Moreover, after the wind turbine is dismantled at the end of its useful life, the site reverts to its initial condition immediately.

However, the visual impact is an often mentioned disadvantage. A tower over 55 metres high may have difficulty going unnoticed. The strobe effect observed in winter, when the sun is low and the blades project shadows onto the snow, may be an annoying element in the long run. However, much effort has been invested in giving wind turbines harmonious lines to reduce their visual impact.

Wind turbine noise, mainly generated by air slipping over the blades, is minimal. The technological improvements made to wind turbine components, the improved aerodynamics of the wind turbine as a whole and the soundproofing of the nacelle have reduced the noise generated by the wind turbine considerably. On a scale of 0 to 150 decibels, where 0 corresponds to the sound of a leaf falling from a tree and 150 to the sound of a jet aircraft, the noise produced by a wind turbine at a distance of 300 metres is around 50 decibels. Also, since the human ear is less sensitive to bass sounds, the noise produced by a wind turbine at a 300 metre distance will be comparable to that of a 35 km/h wind blowing through a tree's foliage.



Comparison between wind generators and other sources of noise

The wind turns

In Québec, people began to take a serious interest back in the 70s in wind energy as a power source. During those years, the government corporation Hydro-Québec took an interest in the development of this energy subsector by conducting research projects. More recently, in 1993, Hydro-Québec signed two power purchase contracts with private groups active in the wind power subsector. The purpose of these contracts was the construction and operation of two wind turbine sites with a combined installed power of 100 MW. The Le Nordais wind turbine park was about to happen.

Le Nordais

The Le Nordais wind turbine park contains two of the best wind power sites in Canada. Erected at the cost of $160 million, this is the biggest wind turbine park ever built in Canada and one of the most impressive in the world. It has allowed Québec to move into the leading position in Canada as a generator of wind power. The construction of this park required the participation of over 250 workers for 9 months.

Le Nordais has over 133 wind turbines divided between Cap-Chat (76) and Matane (57). The rated power of each of these 133 wind turbines is 750 kW.

DIANE BARRY

One million loonies

The price of a wind turbine generating 600 kW is about one million Canadian dollars. This investment breaks down as follows: 75% of the million is used for installation capital; 5% goes to cover insurance and administration expenses; and 20% of the total is invested in maintenance and operating costs.

Just one of these 750 kW wind turbines could generate 6.5 million kilowatt-hours (kWh), assuming that it operates at full capacity under ideal wind conditions, 24 hours a day, 365 days a year.

However, under actual conditions, a large wind turbine with 750 kW of power will generate about 1.6 million kWh a year, given the intermittent and variable nature of the wind. If we consider that the average annual consumption of a typical Québec home is 20,000 kWh, each wind turbine in the Le Nordais park could provide energy to nearly 80 homes.

DONALD MALTAIS

Under the French Regime, building a mill was one of the first obligations of the seigneur to his tenants. During that era, there were over a hundred mills in the St. Lawrence Valley, of which more than fifteen still survive.

Going with the wind …

People have sought to exploit the wind for a very long time. The first windmills appeared in the 12th century to replace draft animals for the hard work of grinding grain and pumping water. Later, around the 15th century, the use of windmills was extended to other applications, such as sawing wood. In the 19th century, paper and oil manufacturing and grinding of certain materials became additional uses for mills and it was only in the late 19th century, in Denmark, that the windmill was first used to generate electricity. Throughout the 20th century, several hundred windmills intended to generate power were put into operation in Europe and the United States. The oil crisis of the 1970s revived interest in these power generating systems, which had declined in popularity in the early 1960s.

The wind turbine industry

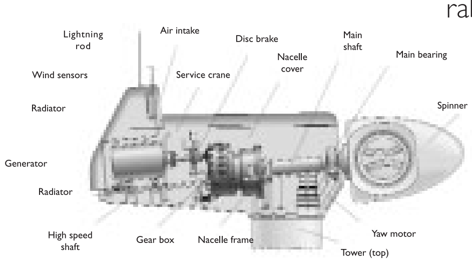
There are two types of wind turbines – vertical axis and horizontal axis wind turbines. The first kind derive their name from the fact that their axis of transmission is perpendicular to the ground, and thus vertical. Horizontal axis wind turbines are more often used nowadays. Their axis of transmission is parallel to the ground and therefore follows the horizon.

DIANE BARRY

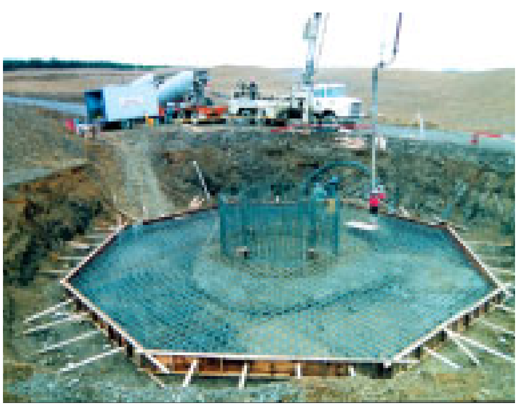
Wind turbines can also be subdivided depending on whether they are fixed speed, the most common model, or variable speed. On some models, the rotation speed of the rotor (the set of blades) is governed by simple aerodynamic stalling. For other models, a variable pitch mechanism governs the speed according to the winds.

By varying the angle of inclination of the blades, the lift of the wind on these blades is reduced. This system prevents the rotors from turning too quickly, without stopping them completely, to avoid premature rotor wear.

Wind turbines can be big or small, depending on their use. To generate electricity intended for a power distribution network, it is cheaper to resort to large wind turbines to benefit from economies of sale. In these cases, the typical wind turbine most often installed to date consists of a steel structure, the tower, weighing nearly 64 tonnes, on which a nacelle, or machine cabin, rests. This nacelle, which weighs about 34 tonnes, is comparable to a machine room containing the generator or generators, the braking system, the gearbox and other equipment. The blades, which today are made of fiberglass and carbon fiber, complete the unit. These blades are between 20 and 30 metres long and weigh about 20 tonnes. Finally, the tower, nearly 50 metres high, is anchored to a concrete base. This foundation, made of 400 tonnes of cement and iron reinforcing rods, is a crucial component, because it will hold the wind turbine in place and ensure its solidity.



Technical characteristics of nacelle

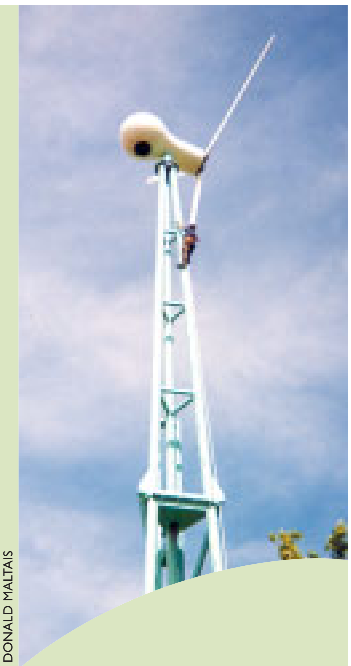


N E G MICON

Small wind turbines

Thanks to small wind turbines, farms or residences remote from power grids can obtain some degree of energy self-sufficiency. To meet part of their heating needs or power certain low-capacity electrical equipment, the energy generated by small wind turbines can be useful as an auxiliary source for other forms of energy such as solar power or a diesel generator.

Designed in Québec, the Plastiques Gagnon ltée wind turbine is the result of a coordinated effort between the owners of this regional company in the Lower St. Lawrence and the Wind Power Research Group at the Université du Québec à Rimouski (UQAR). Active in the plastic moulding field, Plastiques Gagnon ltée has been interested in production of small, moderately-priced wind turbines requiring no specific maintenance to meet domestic needs. The Plastiques Gagnon ltée wind turbine is primarily directed at the residential market or isolated sites requiring energy self-sufficiency.



DONALD MALTAIS

Domestic wind turbines, generally 8 to 12 metres high, are constructed differently from large wind turbines. A small wind turbine has between two and five blades, and sometimes more. The rotors of these wind turbines can be fastened to the front or back of the nacelle. They are said to be "under the wind". They have no drift. They are driven in the direction of the wind by the drag generated by the movement of the blades.

Most small wind turbines do not have a gearbox. The rotor is connected directly to an alternator, which generates a 24-volt direct current, supplying power to lamps or small electrical appliances running on low voltages.

It is estimated that a usable site for a small wind turbine should offer wind speeds of 15 km/h or more to be efficient. Since wind conditions vary greatly during the year, it is essential to rely on an energy storage method such as batteries similar to those used in cars or trucks.

And the wind begat electricity

By heating the atmosphere unevenly, the sun creates warm air and cold air masses. The movement of these air masses, caused by the difference in barometric pressure between two regions of the atmosphere, produces winds. These winds exert forces which in turn drive the wind turbine's moving surfaces directly exposed to wind. These surfaces are generally blades, or rotors.

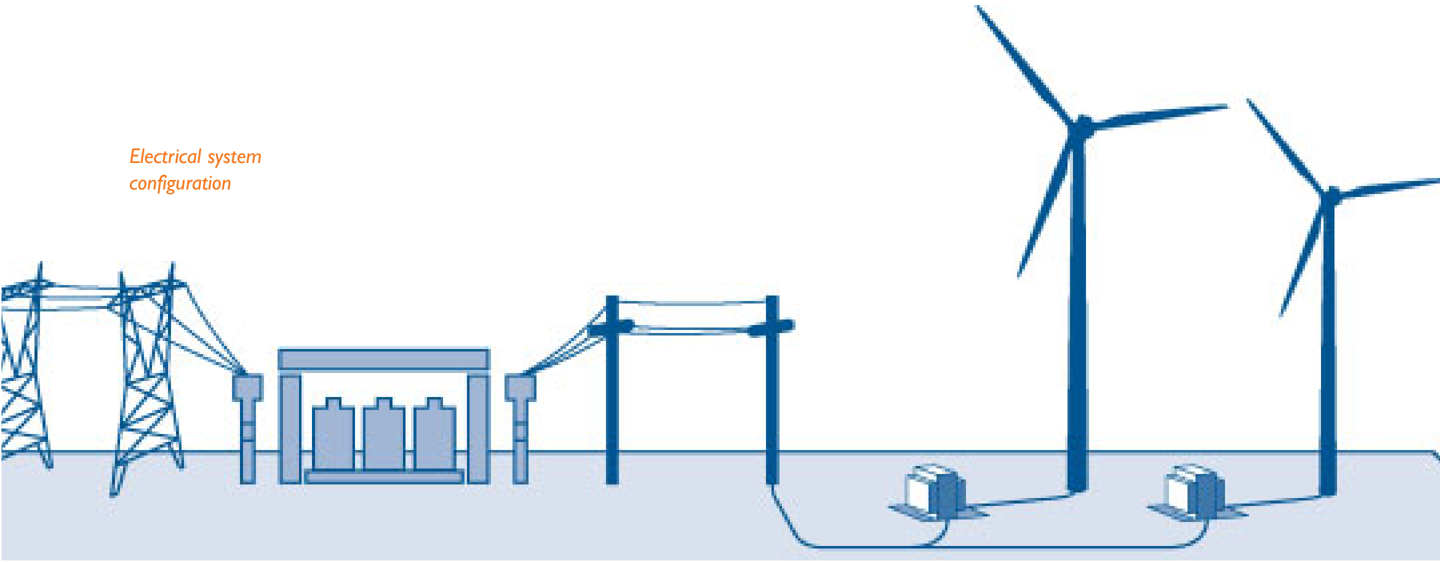
When the wind begins to blow, the force exerted on all of the blades by this displacement of air generates a rotating motion. This rotation is transformed into mechanical energy which produces electricity when coupled with a generator. Thanks to gears located inside the nacelle, this mechanical energy is increased tenfold and routed to a generator through a multiplier. Finally, power cables inside the structure transmit the generated power to a transformer.

Aeolus, god of the Winds

*The word "eolian" means **relating to the wind.** In other words, a wind turbine, known in French as an "éolienne" from the Roman wind god Aeolus, is a **machine which captures wind energy**. A wind turbine could also be defined as a set of components **which transform the kinetic energy of the wind into mechanical or electrical energy**. This energy can therefore have different applications, such as driving mills or water pumping stations, or generating electricity.*

To maximize a wind turbine's efficiency, it must be the right height, 30 metres or more in the case of a large wind turbine, and positioned facing the wind. To maintain the nacelle in the wind's axis, a wind vane determines the direction and an instrument called an anemometer measures the air displacement speed. These two devices are fastened to the nacelle and allow the nacelle to be controlled electronically by orienting it in the direction the wind is blowing, at the right time.

Electrical system configuration



The main uses of wind energy

In some countries, like those in the Third World, the windmill is mainly used to pump water mechanically. This is an economical and still widely used method, both for agricultural purposes and to meet domestic consumption needs. In Québec, the wind power produced by the Le Nordais park is integrated with Hydro-Québec's generating capacity and grid. This integration into the power system optimizes the generating capacity of hydro-electric plants by saving dam water.

Wind power can also supply electricity to places not served by the traditional power transmission networks. Thanks to self-sufficient power generation, the wind turbine particularly meets the power requirements of ocean drilling platforms, weather stations, microwave relays, chalets or remote residences.


DIANE BARRY

Did you know that…

The wind power subsector involves a considerable technical advantage. Thanks to its modular characteristics, a wind turbine can be erected quickly, allowing it to meet needs and adapt the prevailing energy context.

In regions far from major centres and not connected to the grid, wind power makes it possible to limit use of other sources, such as fuel (diesel) to generate electricity. These regions are mainly supplied with electricity by diesel-operated systems. In these cases, a wind turbine saves non-renewable energy. However, it is necessary to have equivalent power generating capacity to guarantee a permanent source of electric power. This combination of two systems, known as "coupling", allows electrical needs to be covered in relays.

A breath of fresh air

The main advantage of wind power is the fact that, like hydroelectricity, it is clean and renewable. When it replaces the generating capacity of power plants running on oil, wind power reduces air pollution by preventing emissions of carbon dioxide, sulphur dioxide and nitrogen oxides and the release of soot particles. The installation of 1 MW of wind power (1 MW represents the energy consumed by about a hundred homes) would avoid the discharge of several thousand tonnes of these products per year[1] and thus reduce greenhouse gas emissions. A medium-size wind turbine (750 kW) prevents the emission of over 15,000 to 30,000 tonnes of CO_2 normally produced by conventional sources (gas or coal) during a useful life of 20 years.

Various ecological concerns have motivated some countries to consider wind power as a possible replacement for part of their fossil fuels, such as petroleum. The growing interest in this energy, and the incentive programs for its development, are evidence of a growing awareness of the environment, and particularly of air quality. The Kyoto Protocol on greenhouse gas emissions is one example. This Protocol promotes the use of renewable energy by inducing the signatory countries to reduce their consumption of fossil fuels such as petroleum, natural gas and coal. Generating electricity by wind turbines can be considered a very effective way of fighting air pollution and global warming.

DIANE BARRY

From Kyoto to Bonn, via Québec

Following the Kyoto Conference with the aim of improving air quality, Canada has made the commitment to reduce its greenhouse gas emissions by about 6% by 2012, a commitment it reiterated at the meeting held in Bonn in summer 2001.

In a similar vein, the Québec government, in its "2000-2002 Action Plan on Climate Change" intends to promote renewable energy to reduce greenhouse gas emissions. Thus, in addition to hydroelectric resources, the development of other forms of renewable energy, including wind power, is among the government's priorities for the years ahead.

[1] 2000 tonnes of CO_2, 13 tonnes of SO_2, 10 tonnes of NO_x and 1,3 tonne of soot particules.

DIANE BARRY

From atop its tower, the wind turbine looks towards the future

Some expert reports, including the one produced by BTM Consult (a Danish firm of independent consultants specializing in renewable energy), reveal that the wind power subsector is growing fastest worldwide. Indeed, while it was predicted in the early 1990s that about 4,000 MW would be available at the approach of the year 2000, over 18,000 MW of wind power was installed by the beginning of 2001 in over 50 countries, representing a growth rate of over 30% per year.

The wind turbine industry has therefore gone far beyond the stage of small-scale operation. The two biggest wind turbine manufacturers currently report sales of nearly $400 million. Denmark, the leading world exporter, had over 15,000 direct and indirect jobs in 1999 related to wind turbine manufacturing. This number of jobs should double by 2003.

The International Energy Agency (IAE) considers the wind power subsector to be destined for the highest growth rate over the next few years, with an average of 14%, compared to 0.6% for hydraulic power. In the past three years, the demand for wind power on the international market has grown by over 30% per year.

However, because of its higher cost per kilowatt-hour, the development of the wind power market in Québec will remain partially dependent for some time yet on the support it receives. This is why the Québec government intends to continue its efforts to encourage the development of this energy subsector, through the introduction of a tax incentive strategy.

Support for wind power

Since 1996, the Ministère des Ressources naturelles has invested over $2 million in measuring Québec's wind power potential. The first three measurement phases conducted in the Gaspé Peninsula and on part of the Middle North Shore have made it possible to clarify the wind power potential present in these sectors further. Over 30 towers were erected, allowing wind speed and wind direction to be specified and thus determine the density of wind power on the measured sites. These 40-metre towers also clarified the actual wind power potential present at the height of the current wind turbine rotors. Thanks to the measurements taken at 20 and 40 metre altitudes, it was possible to measure wind shear, a value used in establishing the wind's vertical profile and the intensity of turbulence on the site, two essential parameters when constructing wind turbine parks.

Also, thanks to its energy technology development assistance program known as PADTE, the Ministère des Ressources naturelles, since 1992, has provided $1.9 million in financial assistance for over 30 projects, particularly those related to wind turbine infrastructures, development of electronic controls and evaluation of the behaviour of wind turbines in a cold climate.

Thanks to over $5.4 million in government financial assistance, the Ministère des Ressources naturelles has contributed to the establishment of the Le Nordais wind turbine park.

Ressources naturelles Québec