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Wind energy development in the Caribbean

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Abstract

The Caribbean has the potential for a significant increase in wind powered electricity production. A number of wind farm projects are being implemented, making wind potentially the fastest growing renewable energy technology in the region over the next two decades. Wind promises to provide more than 10 per cent of the electricity in many Caribbean countries by the year 2020.

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1. Introduction

Wind energy is an attractive, clean, indigenous energy source for those Caribbean countries that have the required wind regime. The primary regional wind systems are the NE trades that form a relatively stable wind regime. Wind speeds are greatest in the eastern Caribbean; they are lower in the western Caribbean and the Bahamas. Coastal sites on the islands tend to have strong diurnal variations in wind speed with the strongest winds occurring between 9:00 am and 4:00 pm, whilst there is little wind during the rest of the 24 hour day.

The cost of wind turbines and ancillary equipment has fallen significantly over the past decade and this trend is continuing. The cost of electricity produced from wind energy has fallen even faster, not only because of lower wind turbine prices, but also because of higher turbine efficiency and availability, larger turbines intercepting increased wind speeds, and lower operation and maintenance costs. Wind turbine prices fell by about 36 per cent between 1990 and 2000, and the cost of electricity produced from wind power has been reduced by approximately 50 per cent in the same period.

The price of wind turbines of about 45 meters rotor diameter is presently approximately US$770/kW. Turbines have gradually increased in size over time. The larger the turbines, the less are required for a given size wind farm. This allows savings in site costs as well as maintenance and operation costs. By moving turbine size from the 250 kW size range to 1 MW size machines, site construction costs can be reduced by up to 30 per cent.

Construction costs, electrical equipment and transmission costs vary between wind farm sites and between countries depending on many factors, including location, and the number and size of the turbines. Together, these factors can account for between 25 and 40 per cent of project costs.

Operational costs also vary according to turbine size. Costs range from about US$25/kW/year for 250 kW machines, to about US$14/kW/year for 750 kW turbines. Average energy prices from a 10 MW wind farm with 500 kW turbines, corresponding to plant cost of $900/kW, are approximately 10 cents/kWh at 5 m/s wind speed; decreasing to 3.6 cents/kWh at a wind speed of 10 m/sec. This assumes depreciation over 20 years at a 7.5 per cent discount rate [1].

2. Caribbean projects

Demonstration projects have been built initially under US and CDB funding. One was the installation of a 120 kW vertical axis wind turbine in Antigua, and the other an 85 kW horizontal axis turbine in Montserrat. After these, other demonstration projects were considered for Barbados, Curacao and Grand Turk as well as Monsterrat. This resulted in a 3 MW wind farm in Curacao and a small wind farm of 215 kW maximum rating in Monsterrat. The plans for the construction of a wind farm in Grand Turk were shelved for economic reasons. The Barbados project failed due to lack of support after implementation.

Wind turbines for grid electricity generation are presently operational in four Caribbean islands — Cuba, Curacao, Guadeloupe and Jamaica. The wind turbines on Montserrat have recently been put out of operation by volcanic activity on the island. Countries which have had wind turbines installed but are not operational are Antigua, Barbados, Montserrat and Trinidad and Tobago. Windpower is used for water pumping in Aruba, Bonaire, Cuba, Curacao, Dominican Republic, Guyana and Jamaica.

The potential for windpower in the Caribbean is relatively large. The Caribbean is currently estimated to be producing 3187 GWh annually (excluding Cuba, Curacao, Jamaica, Puerto Rico, Haiti, Dominican Republic and Trinidad and Tobago), or an average of 363 MWh every hour. This represents a peak in the neighbourhood of 550 MW [2].

If we assume a penetration of 10%, the market in the small eastern Caribbean islands is about 55 MW.

2.1. Curacao

In 1983 KODELA, the utility company, installed the first wind turbine on the plains of Hato. The initial investment of US$1 million also included infrastructure for a future 25 MW of expansion. However, when oil prices dropped in 1986 the expanded project was no longer viable. Between 1986 and 1991 wind turbine manufacturers made significant strides in improving efficiency and lowering costs. This first wind turbine encouraged KODELA to improve on the standard European design in terms of corrosion and high wind speed resistance, and to build what is still the largest wind farm in the Caribbean.

This is the 3 MW Tera Cora wind farm installed on Curacao in 1993. It has been an unqualified success, performing well above expectations. The plant consists of 12 Nedwind 250 kW turbines.

Wind speeds measured at the wind farm site over the past five years have averaged 8.6 m/s (19.2 mph). The site on the San Pedro plain has an excellent wind regime with little diurnal variation

so the wind farm really operates as a base-load plant. The 12 turbines stand on simple reinforced concrete foundations, spaced 125 metres apart in a line following the natural contour of the land. The three-bladed rotors have a diameter of 25.3 metres; hub height is 30 metres.

KODELA finalized arrangements for the installation of a further 9 MW of wind capacity in late 2000 using 500 kW turbines from Nedwind.

The grid in Curacao has to serve a peak of 95 MW. When a total of 12 MW of windpower is introduced into the grid later this year the wind penetration factor will be high. Availability from the present 3 MW wind farm has been approximately 94%, and figures for the turbines' performance indicate a 38 percent capacity factor. The Curacao experience has shown that a firm capacity credit can be awarded to a Caribbean wind farm and demonstrates that wind can provide firm power generating capacity for utility companies [3].

Other islands in the Netherlands Antilles, such as Aruba and Bonaire, also have strong possibilities for wind energy, with localities having wind speeds in excess of 8 m/s at 21 metres above ground [4].

2.2. Guadeloupe

There are two wind farms on the small islands near Guadeloupe, French Antilles. On Desirade island, a wind farm of 144 kw was installed in 1993. Additions in 1996 raised the output to 500 kW; so that it now provides 90% of the island's needs.

A new wind farm at Petite Place on Marie–Galante Island is comprised of 25 wind turbines of 60 kW capacity, for a total of 1.5 MW. Its production is 4.8 GWh/year, representing 30% of the electricity needs of the island. A second wind farm, planned for the year 2000, will raise the contribution of wind energy on Marie–Galante to 60% of energy demand. The wind turbines are provided by the Vergnet Company and have been designed for hurricane resistance. They are able to resist winds of more than 200 km/h and, in case of a major hurricane, the turbines can be promptly dismantled and laid on the ground. No particular equipment is needed for the installation and maintenance of these machines. They are mounted on posts that are lowered with just a winch or an attached motorized hoisting gear.

Other wind projects planned for Guadeloupe, if implemented, would provide a total new capacity of 6.3 MW [5].

Although adequate windpower exists in the Caribbean, insufficient use is made of wind energy at this time. A primary reason for the slow implementation of wind energy projects is logistics and infrastructure, especially when compared to Europe and the USA. For example, large 400 ton cranes are not readily available and moving such cranes, which are 40–50 metres high, around on limited access roads is a problem. Further, the Caribbean is hit quite often by hurricanes of sufficient intensity to damage beyond repair turbines designed for the milder climates of Europe and the USA.

More restricting is the fact that the grids on many islands are supplied primarily by diesel and heavy fuel oil generation, and wind energy is considered to be best limited to a penetration of 10–12%. Moreover, the grids on some Caribbean islands are complex, laid out in a haphazard manner, and may have frequent power cuts.

2.3. Jamaica

In Jamaica a 225 kW Vestas machine has been operated by a high school — Munro College — since December 1995, providing electricity to the grid.

The Petroleum Corporation of Jamaica, in conjunction with a British Company, Renewable Energy Systems Limited, is preparing the implementation of a wind farm, capable of providing a total of approximately 20 MW, on the Manchester Plateau on the southern side of central Jamaica.

The wind farm site at Wigton on the Manchester Plateau, is at elevations of between 900 and 1000 metres above sea level. The elevation has caused topographic enhancement of the wind speeds that show little diurnality and are relatively constant throughout the 24-hour day. Wind speed monitoring of hourly data has been conducted using anenometers at heights of 10 m and 40 m, since January 1996 at one site, and since August 1999, at two sites.

Wind speeds at Wigton are high, averaging around 8 m/s. Using data from the Manley International Airport, some 75 kilometres away, the long term average annual mean windspeed may be over 9 m/s.

Project parameters are as follows:

Site Location	Wigton, Manchester
Installed Capacity	20 MW
Electricity Production	62.6 GWh/yr
Carbon Dioxide Emission Savings	60,000 tonnes/yr
Project Life	20+ years

The present plan is to commission the wind farm in 2002 using NEG–Micon 900 kW machines at a total project cost of approximately US$23 million. A financing package is being sought and a power purchase agreement negotiated with the utility company. Externality benefits are required in the power purchase agreement in order to make the project viable.

Although systematic wind studies have not yet been conducted on other areas, there are sites in Jamaica that could provide a further 40 MW of wind power without creating stability problems in an expanding national grid of over 650 MW. Electricity demand increases at about three per cent per year in Jamaica.

2.4. Neighboring countries

Immediately outside the Caribbean there are various wind projects that are operating or awaiting implementation.

In Argentina there is 11 MW of installed capacity. In Brazil two new wind farms of 30 MW each are being built in addition to the 1.2 MW facility presently operating. Costa Rica has the region's largest plants, the 20-MW Aerogeneracion plant built by the private sector and the 20 MW Tejona wind farm, financed jointly by GEF and IDB. Peru is operating a 250 KW turbine and is developing a 450 kW station. Ecuador is assessing the wind resources and seeking financing for a project aimed at building a 32 MW wind farm (400 turbines of 80 kW each). Mexico operates a 1.5 MW plant and a 2 MW station. In various parts of that country a total of 30 MW of small windpower generation are being considered for implementation.

3. Environmental aspects

Negative environmental effects due to the use of wind turbines are primarily acoustic noise emission, visual impact, and electromagnetic interference influencing the reception of radar, radio and television signals.

However, aero-acoustic research has provided design tools and blade configurations that make blades considerably more silent. So wind turbines can now be installed within 200 metres of houses. Because of electromagnetic interference, wind farms should not be built near airports.

A primary impact of wind turbines on Caribbean islands is visual. This is exacerbated by the need to site wind farms in the windiest areas, which are usually exposed high areas, which themselves often have a natural beauty. Where possible wind farms on islands, indeed anywhere, should not be sited within or near nature reserves, protected areas or special areas of conservation [6].

The potential to reduce CO_2 emissions depends on the fuel used in the thermal plants with which the wind turbines are compared. During normal operation a wind turbine causes no emissions. Thus Caribbean countries can introduce into their wind projects tradeable green certificates. Perhaps over time the public in Caribbean countries will begin to recognize “green electricity” as a product which is different from regular electricity, and be prepared to pay more for it.

4. Conclusions

Factors influencing wind energy growth in the Caribbean include:

• Oil prices; prices above US$20 barrel will stimulate growth.

• Use of larger and more efficient wind turbines.

• Price, availability, and improved efficiency of larger wind turbines.

• Availability of suitable land in areas with adequate wind resources.

• Penetration capacity of the utility grids in particular countries.

• Low interest rates on loans, and access to green energy subsidies, where required.

• Fiscal credits for the reduction of emissions, including carbon trading.

It is clear that wind, as a renewable energy resource, will become an important part of the energy mix of many Caribbean islands in the next decade. In some Caribbean countries it promises to provide 10 per cent or more of electricity capacity by 2020. Wind will be the fastest growing renewable energy technology in the region over the next two decades. As Caribbean countries, such as Jamaica, move towards a Renewables Obligation, windpower is certain to constitute 25 per cent or more of the electricity provided from renewable energy sources.

References

1. Bourillon C. Wind energy — clean power for generation. In: Proceedings of the 17th Congress of the World Energy Council, Houston, Texas, September 13–18, Division 4, 1998:209–222.

2. Projekt–Consult. Report on Caribbean Renewable Energy Development (CREDP), vol. 1. Report to Caribbean Energy Information Systems. April 2000.

3. Tujeehut K. Wind energy development in Curacao. Paper presented at Workshop on Renewable Energy in the Caribbean, Curacao, October 11, 1996.

4. Guda MH. Aruba wind resource assessment. Unpublished report, FAPE, Curacao 1997.

5. Bal JL, Lenir M, Bernard R, Bernard M. The development of renewable energy sources for electricity generation: the example of the French overseas departments. In: Proceedings of the 17th Congress of the World Energy Council, Houston, Texas, September 13–18, Division 3, 1998:175–183.

6. F. Weightman. *Planning for windpower: guidelines for project developers and local planners*, Friends of the Earth Limited, UK (1995).