3 MW Pilot Wind Power Project of Sri Lanka

by Ariyadasa Lekamlage
Chief Engineer, Operational Plants, former Project Manager – Pilot Wind Power Project,
Ceylon Electricity Board

1. BACKGROUND OF THE PROJECT

Activities concerning the development of alternate energy sources were first initiated by Ceylon Electricity Board (CEB) in 1976 focusing on small-scale technologies primarily for electrification of remote areas. Systematic studies on large-scale wind power generation too were conducted throughout this period. These activities led to the launching of the first ever detailed wind monitoring programme in the south-eastern part of the country in 1988 by the CEB with the technical and financial assistance from the Government of Netherlands. The wind energy resources assessment over the Southern Lowlands, the first activity undertaken by CEB in this regard, had been carried out over four years – 1988 to 1992. The area covered under this project was approximately 1500 km^2.

Following the resource assessment phase, CEB started to plan its first grid-connected wind power plant of capacity 3 MW to be located in Hambantota on the southeastern coast. It was planned as a pilot plant for CEB to get hands-on experience and also to study the implications of integrating wind power into the grid system. Feasibility study and design of the plant were carried out using the database developed by the earlier wind energy resources assesment. The project was financed by the World Bank and GEF, under the Energy Services Delivery Project and the wind power plants were commissioned in March 1999. This pilot project was expected to allow CEB to gain first hand experience with grid connected, and related grid-interconnection requirements. It was also expected to demonstrate the Commercial viability and long-run economic potential of wind power in Sri Lanka and to catalyse future private sector wind power development.

2. PROJECT PREPERATION

2.1 Wind Resource Assessment in the Region

Ten measuring stations, equipped with wind anemometers at 10m, 15m and 20m heights, were installed in the Southern region including one in the Central highlands. The results of the analysis of monitored data in Southern Lowlands showed a typical day-night wind pattern, with weak night-time winds and moderate to strong day-time winds, peaking around 3 p.m. The results concluded that the wind regime, with the annual average wind speeds between 5.6 to 6 m/s at 10 m height, was characterised as a "moderate to good" wind regime and "suitable for electricity generation". The final report on the wind resource assessment published in 1992, further indicated a wind potential of 8 MW/ sq km of open land area.

2.2 Site Selection and Environmental Requirements

The Wind Resource Assessment had recommended to install a wind plant of 5 to 10 MW capacity on experimental basis in Bundala area, which encompasses a bird sanctuary. Based on the Wind Resource Assessment's recommendation, following technical guidelines for site selection, were used in the feasibility study, which was conducted in 1996:

- Good wind resource
- Terrain suitability
- Geotecnical suitability
- Physical access
- Electrical access

The decision on the site selection was influenced by following environmental restrictions also :

- Pilot wind farm should be located outside the Bundala Bird sanctuary and any other natural reserves
- The area should be selected so as to minimise residential resettlement or land acquisition requirements

Further, concerns of Central Environmental Authority (CEA) namely :

- The rotation of turbine blade will disturb the migratory path of birds and will kill birds
- The noise of wind turbine will disturb the movements of wild elephant

had influenced the site, to be located near Karagam Lewaya.

The CEB's request for the environmental clearance for selected site near Karagam Lewaya submitted to the CEA was channelled to Department of Wild Life Conservation (DWLC) for concurrence. DWLC referred the proposal to their Flora & Fauna Advisory Committee to make recommendations to the Secretary to Ministry of Environment and Parliamentary Affairs for the final decision. The Flora & Fauna Advisory Committee comprises of DWLC officials and members of certain non governmental organisations involved in environmental matters. The Environmental Clearance was issued for the project with following conditions;

- The project capacity should be limited to 3 MW.
- The wind farm should only be limited to 5 turbines.
- There should be no expansion of the project at the site.
- The project should run as an experimental project to study all aspects of wind power generation
- The turbines should be spaced at least 240 m apart
- Any fencing should only be constructed around each turbine footing and no fence should be constructed around the total project area
- The areas other than turbine footing should not be disturbed
- Officers of the Dept. of Wild Life Conservation should have access to the project site at any time for any inspection purpose

2.2 Site Details

The identified land near Karagam Lewaya is a strip of land parallel to the proposed southern railway line and covering an area of approximately 17 ha. measuring 1200 m length and 120 m width. Karagam Lewaya is situated outside Bundala National park buffer zone. This site is well exposed to North-East and South –West monsoonal directions. The land was leased to CEB for 30 years for this pilot project by the Mahaweli Authority of Sri Lanka who owns the land.

3. PROJECT IMPLEMENTATION

3.1 Contract

The wind energy projects in the southern Lowlands in Sri Lanka are technically and economically feasible, according to the feasibility study carried out in July 1996. It was decided, during the feasibility study, that a third party developer would deliver a turnkey project for the pilot wind farm in response to a competitive solicitation.

On the basis of International Competitive Bidding, CEB awarded the contract for Engineering, Procurement and Construction to NEG MICON A/S who is a wind turbine manufacturing company in Denmark. The contract was signed on 9th January 1998 between CEB and NEG-Micon. The contract price had three components as indicated below;

1. Foreign Danish Component Kroner - DKK 14,822,796
2. Foreign Indian Component Rupees. - INRs.17,369,500
3. Local Sri Lankan Component Rupees - SLRs. 51,358,400

The main contractor NEG MICON A/S subcontracted the local Civil and Electrical works of the site to a Danish company Intertec Contracting A/S.The construction work was started in May 1998 after receiving the environmental clearance in April 1998. The installations of turbine with the interconnection facilities were completed on 26 February 1999.

3.2 Plant layout

The total capacity of the wind farm is 3 MW consisting of 5 wind turbines of 600 kW each. The turbine specification is given in Table 1. The expected total farm annual energy generation was around 4.5 GWh.

Table 1. Turbine specifications

Turbine type	**3-bladed, stall regulated, grid connected, up-wind turbine**
Turbine model no.	M1500-600/150
Generator type	Asynchronous, 3-phase, 2-speed (1000/1500 rpm)
Nominal rating	600 kW
Nominal voltage	690 V
Frequency	50 Hz
Cut-in wind speed	3.5 m/s
Cut-out wind speed	25 m/s
Survival wind speed	69 m/s
Rotor revolutions	27/18 rpm
Rotor diameter	43 m
Swept rotor area	1452 m^2
Hub height	46 m
Tower	Painted, 24-edged, conical, tubular steel tower
Brake system	Fail safe disc brake and blade tip brakes
Control system	Self-diagnostic computer control
Weights	Tower - 40 t
	Nacelle - 19 t
	Rotor - 13 t

Usually the wind turbine row is oriented perpendicular to the prevailing wind direction (SW & NE) in order to absorb maximum energy. However owing to the constrains in the process of land allocation, the land allocated for the pilot project does not fully satisfy the above requirement. Initially, the plan was to locate all turbines (5) in a row spaced equally along the strip of land allocated for the project. The distance between two turbines was kept around 5 times the diameter of the turbine blade. But due to geographical reasons i.e. inundation of the two turbine foundations during the rainy reasons, the initial arrangement had to be changed.

The project is provided with a control room with an office room and a small demonstration room. Living quarters with water facilities for operational staff is also provided at the site.

3.1 Power Collection System

The power output from each generator at 690 V is connected to the step-up transformer by an underground cable (150mm^2 XLPE). The sealed type transformer (690/33,000 V) of 800 kVA capacity is mounted on a plinth and located about 25 m away from the turbine. All transformers are connected to the interconnection point by a overhead line (Racoon) running along the site road. Each transformer substation consists of an Isolator, a DDLO Fuse set and a Lightning Arrestor.

At the interconnection point, which is located near the control room has a SF6 Circuit Breaker (CB) and also measuring equipment for the current, voltage, power factor and the energy delivered to the grid. Isolators are provided on each side of the CB.

3.2 Supervisory System

The wind turbines are equipped with a built-in computer (WP3000), which monitors and automatically controls the running of the turbines. If a fault occurs with a turbine or the electricity grid, the turbine will stop and the nature of the fault can be seen on the control panel. The turbine will re-start automatically once the central computer has checked the turbine and the grid.

In addition to the individual computers at each turbine, there are two computers; one is a park computer and the other is a remote computer. These two computes are normal PCs with Wind Power Monitoring System (WPMS) software. The park computer is located in the site control room whereas the remote could be located any location with a telephone linkage. Both these computers can monitor the status of all turbines and also can receive alarms.

3.3 Commissioning

All the turbines were commissioned at the end of February 1999. The generated electricity by the wind plants is supplied to CEB national grid through 33 kV feeder (no. 6) of Embilipitiya Grid Substation. It was observed, after few days of operation, that the main contactors were burnt and unusable at two turbine panels. The operation of the Auto Recloser installed for the 33 kV feeder (no. 6) in Embilipitiya Grid Substation attributed for this failure. The auto recloser settings were as follows:

Cycle 1 – instantaneous trip and reclose time setting t1 =0.45 sec.

Cycle 2 – delayed trip and reclose time t2 = 15 sec.

According to the turbine manufacturer the normal protection time setting for the generator control system in case of a grid failure is 1 second. In order to have the wind turbines operating with the Auto recloser in function, the contractor has investigated the problem and installed separate fast acting mains decoupling relay (SEG MRN2) in all generator control panels. The MRN2 relay which covers the protection requirements in generators runs in parallel operation has following features;

- Over/ and Undervoltage protection
- Over/ and Underfrequency protection
- Extremely fast decoupling of generators in case of mains failure

The MRN2 detects mains failures with in 60ms and with the operating time of the circuit breaker, the total disconnection time could be set below 150 ms.

4. OPERATIONAL EXPERIENCE

4.1 Generation

The project was commissioned in March 1999. Total gross generation recorded from the month April to December 1999 was 3,457,747 kWh and the gross generation recorded for the year 2000 was 3,362,602 kWh. Figure below shows the monthly breakdown of gross generation for 1999 and 2004

4.2 Regular Servicing, Inspection & Maintenance

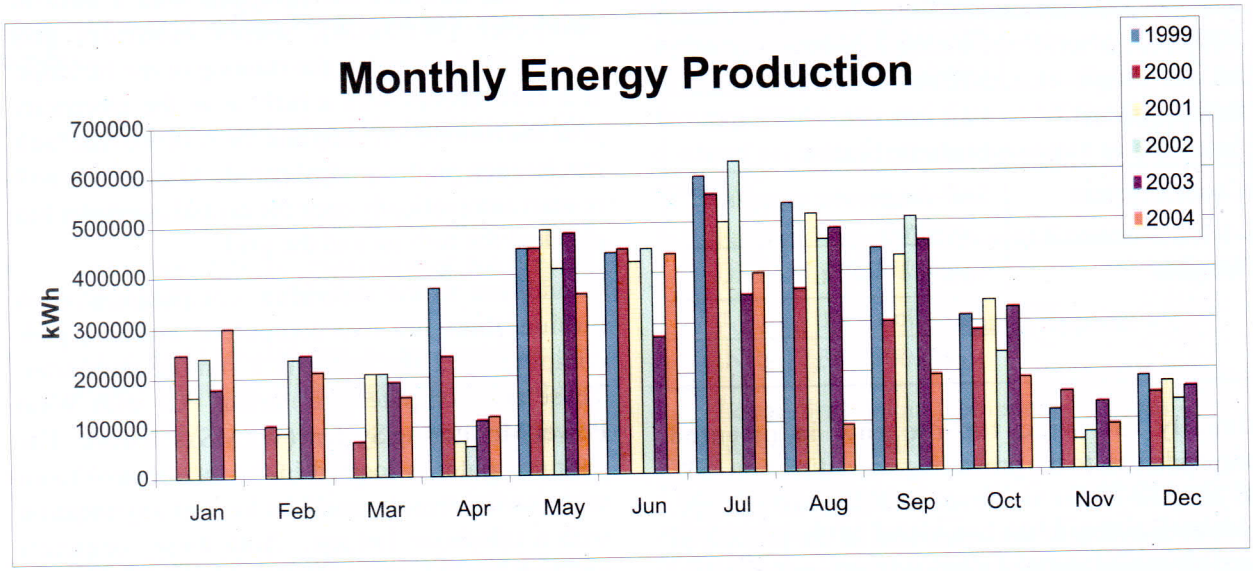
During the period from the commissioning till December 1999, the contractor has carried out two service programs.

a). Service A- after 3 months of operation

This service was carried out in May 1999 by two Danish Technicians. Generally the objective of this service is to check the lubrication of all moving parts including purification of oil in the gear box and also to check the bolt tightness of all assemblies.

b). Service B- after 6 months from the Service A

Two Danish Technicians carried out the Service-B in November 1999. Generally the objective of this service is to check the lubrication of all moving parts and running safety checks.



All the turbine gearboxes were inspected for pitting in the contact surfaces of gear wheels during the Service B and no pitting marks were found on gear wheels.

Brake pad usage of all the turbines was considerably high. The high brake pad wear is mainly due to the frequent stoppages of turbines owing to;

1. Frequent grid outages and voltage drops
2. Problems associated with turbine computer software

5. MAIN STUDY AREA

Keeping with the objectives of the pilot project, CEB has identified the following additional areas of study for the future.

- Grid integration problems
- Radio/TV interference problems

5.1 Grid Integration Problems

Wind turbines can create certain operational problems when integrated into a utility system in large numbers. This is mainly due to unpredictability of wind availability. This will have effects on the quality of electricity supply of local 33 kV network. The scope of this work is to study the nearby load centre on the quality of supply when the wind plant is in full operation. The subsequent study shows that impact to power quality by the wind project is negligible.

5.2 Radio/TV Interference Problems

Wind turbines with metal rotor blades are known to create interference with radio and TV transmissions. However the blades of these turbines are made of Glass Fibre and no interference will result from the operation. This was further proved during the household survey in the vicinity of the project site.

REFERENCE

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