Wind power development and its status in Sri Lanka

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1. Abstract

Wind power has become the most significant option among renewable energy based electricity generation due to its wider availability and zero environmental pollution. Advancement in technologies, especially wind turbine configurations, their control features and high power electronics has increased the single turbine rating to over 5 MW and the total installed capacity to 74GW in the world.

Among the renewable energy sources available in Sri Lanka, wind power has been identified as the most promising renewable power option for large power generation. The Pre-Electrification Unit of Ceylon Electricity Board has carried out a wind resource assessment study in Puttalam and Central Regions of the country in 2002. The wind energy resource atlas of Sri Lanka and Maldives was developed by the National Renewable Energy Laboratory in 2003. It also has revealed that there are many areas that are estimated to have "Good" to "Excellent" wind resources in Sri Lanka. These studies have revealed that the overall wind potential in the open land area is 8 MW/km^2.

However, wind power development in Sri Lanka is not at a satisfactory level and it has some technical, logistical as well as policy constraints. At present, only 3 MW grid-connected pilot wind power plant is available in the country at Hambantota. It has been commissioned in 1999 and the monthly plant factor has been in the range of 5% to 15% in year 2006. This is relatively low plant factor. This paper discusses the wind power development in the world and summarizes the status in Sri Lanka. Possible research areas, that need to be motivated in Sri Lanka to check the feasibility of wind power generation, are also discussed.

2. Keywords

Wind power in Sri Lanka, Pilot wind power plant, CEB wind power study, NREL wind power study.

3. Wind power development in the world

Rapid development in wind turbine technologies and advance control features of high voltage and high current power electronics has helped the integration of large amount of wind power into the grid. Further, the introduction of variable speed wind turbines have introduced several advantages, namely, increased annual energy capture, flexible control of active and reactive power, reduced mechanical stresses and reduction of power fluctuations.

The time line of Figure 1 shows the development that has taken place in wind turbines in terms of size, capacity and technology. Initial wind turbine's generation was only few hundreds of kWs and Fixed Speed Induction Generators (FSIG) was employed. Today a single generator can generate up to 5 MW and generator technologies such as Doubly Fed

Induction Generators (DFIG), Variable Slip and Wide Speed Range (WSR) generator are employed. The modern wind turbines not only increase the wind farm capacity but also their range of new attributes enables them to be integrated even into very weak grids. Further, most of the large wind power plants in the range of hundreds of MWs are now placed in offshore.

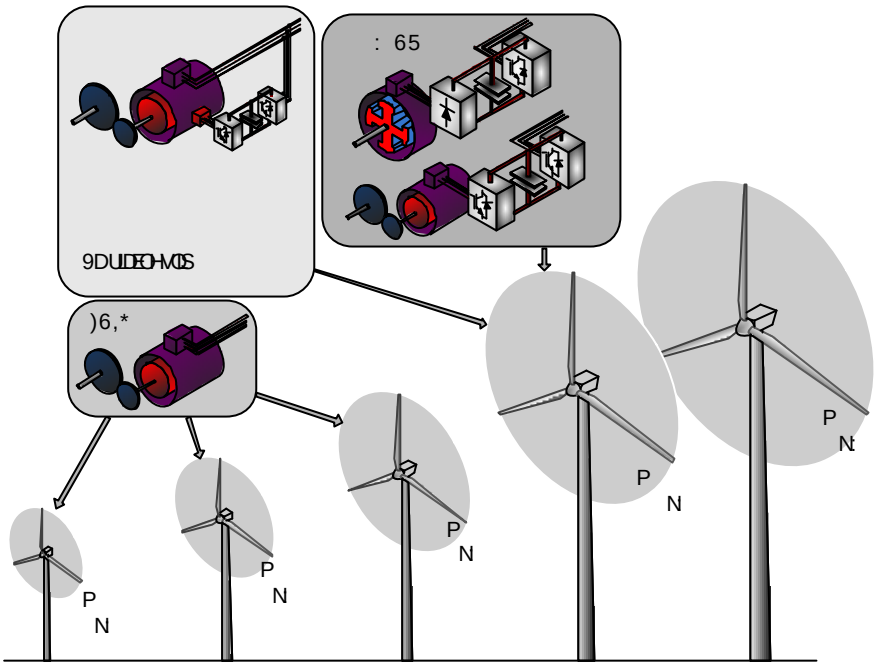

Figure 1: Development in wind generator technology in the world

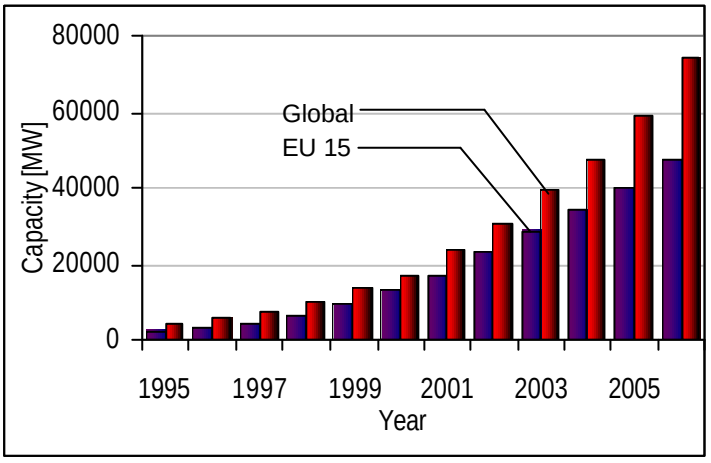

Figure 2: Increasing wind power penetration to the power system network

Figure 2 shows that the total global installed capacity of wind power and it can be seen that it has gone up to 74 GW at the end of 2006 marking an increase of 15 GW in 2006 alone. As the wind power penetration becomes larger, the power system network experiences problems of voltage control and threat to its stability during system faults.

Figure 3a shows the possible grid faults in the power system network or within the wind farm network. To avoid such risk, the grid code has been developed in such a way that it imposes some regulations on the wind farm operators to make sure the grid operation will not be disturbed due to faults. They are the voltage or reactive power control and achieving the Fault Ride Through (FRT) operation of the wind farm. As an example, the Great Briton (GB) grid code operation is shown in Figure 3b. It shows the voltage magnitude with the time period. Above the marked line, the wind farm supposed to be in operation. It could be seen that for a fault to remaining 30% of grid voltage for a period of 385 ms, the wind farm supposed to be in operation and remained in connection with the grid. These grid code requirements have been developed based on the network studies.

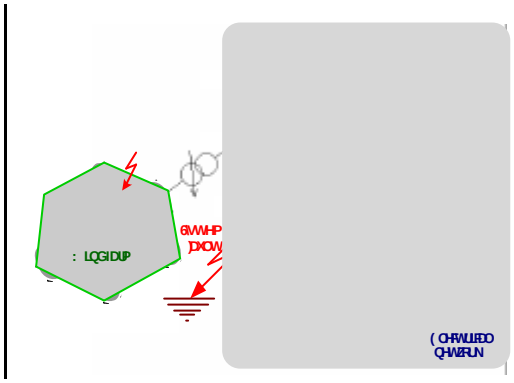

Figure 3a: Wind farm connected with the grid

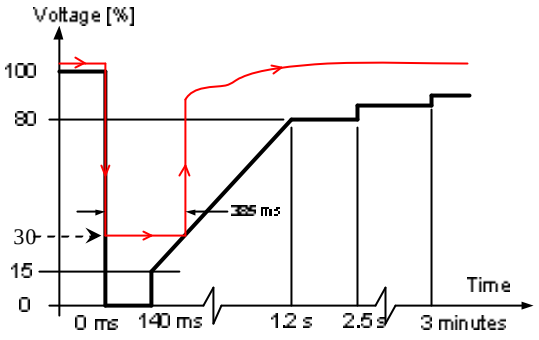

Figure 3b: GB grid code requirement for FRT operation

4. Status of the wind power in Sri Lanka

Among the renewable energy sources, next to the hydro, wind power has been identified as the most promising option for grid connected electricity generation. The Pre-Electrification Unit of Ceylon Electricity Board (CEB) in 2002 and the National Renewable Energy Laboratory (NREL) in 2003 have studied the wind power distribution in Sri Lanka.

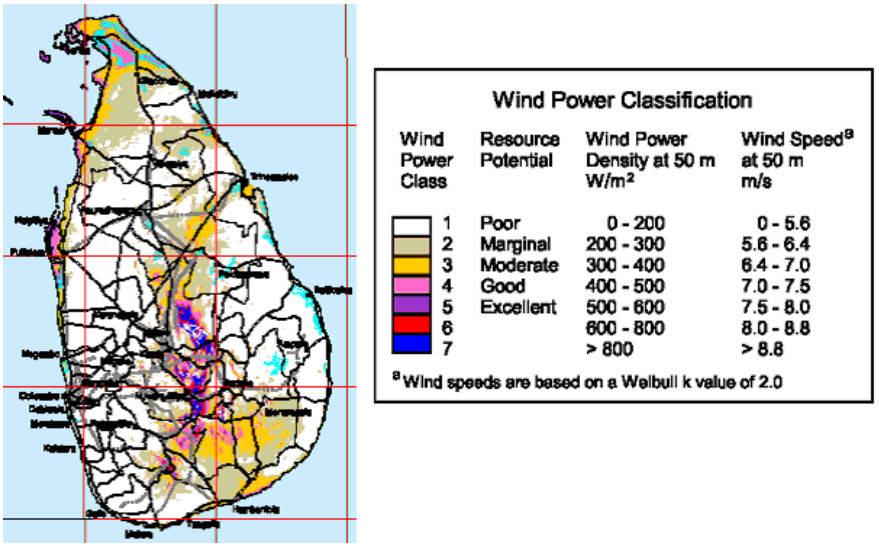

Figure 4: Wind power distribution in Sri Lanka

Figure 4 shows the NREL study result. The studies in Sri Lanka have revealed that the annual average wind speed in Puttalam is 7.15 m/s. From June to August, i.e. during the period of Southwest monsoon, it has been 10.0 m/s. Similarly, the annual wind speed in Ambewela has been found to be 7.31 m/s. However, the available wind power in Ambewela is less due to the lower air density of the region. Therefore Puttalam has been identified as the best site for wind power development. Both studies have revealed that there are many areas that are estimated to have "Good" to "Excellent" wind resources in Sri Lanka. A similar study has been carried out in the South Eastern quarter of the island by CEB in 1992, and it has been revealed that the overall wind potential in the open land area is 8 MW/km^2.

However, wind power development in Sri Lanka is not at a satisfactory level. At present, only 3 MW grid connected pilot wind power plant is available in the country at Hambantota. It has been commissioned in 1999 and the plant factor has been in the range of 5% to 15%. This is relatively low plant factor as the wind resource at the project site is low. Figures 5 and 6 show the plant factor and power generation of the wind farm during a year 2006. These were calculated as an average of every month.

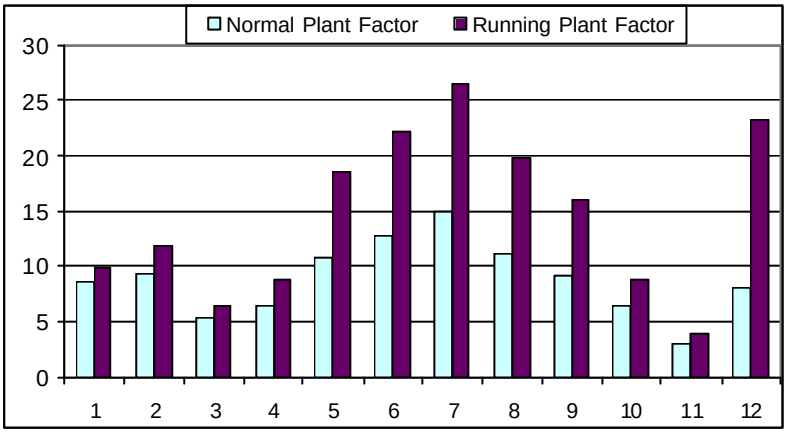

Figure 5: Plant factor of the 3MW Sri Lankan wind farm during year 2006

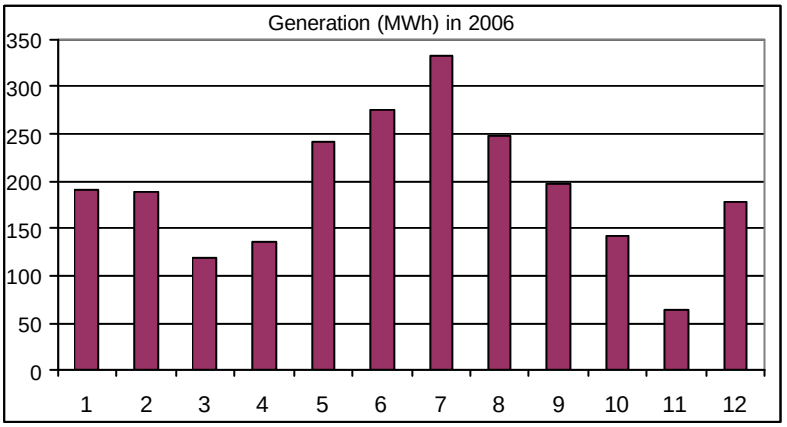

Figure 6: Generation of the 3MW Sri Lankan wind farm during year 2006

5. Targeted researches in Sri Lanka for wind power development

Offshore wind power

All most all large wind farms which are under development in the world will be in offshore. In Sri Lanka no studies are carried out to assess the offshore wind resource. As onshore wind assessment studies reveals that most of the high wind resources are located closer to see, one can expect more wind resources offshore. Therefore, it is very important to investigate about the offshore wind resource and it can easily be done in parallel to offshore oil excavations.

Off-grid wind power

The renewable energy technologies have also opened up possibility of operating power generation plant either in grid-connected or in off-grid modes. In many parts of Sri Lanka electrification rate is very low and possibility of grid expansion is less likely. For such applications off-grid solutions can play a vital role. Out of different off-grid renewable energy solutions wind is only second to hydros. However, networks in the regions where hydro potential is high are now congested and also further development of hydro resource is unlikely in the foreseeable future. In the dry zone of the country where hydro is not feasible option, wind power can play a major role.

The "Practical Action" has already studied several off-grid power projects. Recently a 2.5kW off-grid wind power project was implemented at Gurugoda village. This was done by Practical action together with NERD center and University of Peradeniya. This was a pilot project which contained an automated battery charging controller and it has been running since September 2006 without any problem.

The performance of the off-grid wind power generation can be boosted with hybrid operation with solar power. Especially in the dry zone, several isolated solar projects could be seen. A potential research study has to be highlighted to promote the hybrid operation of wind and solar power.

Large scale wind power

Generally high wind power potential sites are available in lightly dense, remote areas and possibly in offshore. In these areas the electrical network is weak. Especially in Sri Lanka as the total power generation is about 2GW, the power system network cannot absorb large wind power. Because the wind power penetration will alter the network voltages and the intermittent nature of the wind is a threat to network stability.

Hence, a critical load flow, contingency and stability analysis on the system is required to identify the amount of power that can be taken from wind. This will help to develop a standard for interconnecting larger wind power plants. A research study must be launched to identify the grid code requirement and amount of wind power that can be penetrated. This will reduce the risk of unprofitable operation of the power system network in future.

6. Discussion and conclusion

The world has already moved into a rapid development in wind power technology which has been marked with 74GW wind power production and over 5MW wind generator sizes. Two major studies were carried out on wind power distribution in Sri Lanka. Results of

these studies have been discussed. Only 3MW grid connected wind power plant is available in Sri Lanka. The operation of this plant is discussed with the plant factor. It has been reported that the plant factor is very low within 25%. This is mainly due to the low wind in the site.

Some potential research areas on offshore wind power, off-grid wind power hybrid with solar power and large scale wind power plant are discussed. As these studies have proven that Sri Lanka is having enough onshore wind power distribution - the wind power is one of the key technologies, which should be studied at a higher level research to get the benefit to the country.

7. Acknowledgment

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9. Biographies

Atputharajah Arulampalam was born in Sri Lanka in 1971. He received the B. Sc. Eng. (Hons) and PhD degrees from the University of Peradeniya 1997 and UMIST 2003. Dr. Atputharajah was occupied with the European Micro Grid Project at UMIST in 2002.He visited to pursue further research on microgrid at the University of Manchester in 2004. He is working on UK project of Grid code compliance of offshore wind turbine generators at University of Manchester. He is a member of the IEEE and attached to the Department of

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