New project on hybrid renewable energy generation technology to Sri Lanka

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Abstract:

Recent development in Sri Lanka will boost the electricity demand in near future. Extending national grid, especially for some islands, will cost more than installing renewable energy generation technologies. Justification studies confirmed that, for some islands closer to the northern part of Sri Lanka it is more cost effective to electrify with renewable sources.

This paper discusses a new hybrid generation option for Eluvaithivu, an island located close to Jaffna, Sri Lanka. Eluvaithivu is a small island covering an area of 1.7 km^2 with 130 houses. Seventy houses are supplied electricity by a 28 kVA diesel generator owned by the Ceylon Electricity Board and operated (CEB) from 4.30 am to 6.30 am and 6.00 pm to 10.30 pm. The average monthly consumption is 3,100 kWh. Cost of electricity generation is about 60 Rs/kWh while the average tariff is about 5Rs/kWh. This financial loss prevents the complete electrification of the island and round the clock supply to the island.

Eluvaithivu is well exposed to both monsoons. According to a study done by National Renewable Energy Laboratory (NREL) study, the annual average wind speed is approximately 6.5 m/s. The first phase feasibility study proposes wind-diesel hybrid system as the most cost effective generation technology for this island. This will minimize the financial loss to the CEB by about 60% in supplying the electricity to this island while providing electricity round the clock.

Currently, research studies are carried out to check the time domain plant operations with the recent hybrid control techniques. This will bring a solid hybrid system with optimized operational strategy between generators to effectively and efficiently electrify the island.

1. Introduction:

It is well known that changing socio-economic conditions in rural areas in Sri Lanka have created an increasing demand for electricity, mainly for lighting and common household electric appliances. To meet this demand, households in un-electrified villages are resorting to renewable energy based off-grid technologies such as solar PV and micro hydro. Adoption of these technologies is now gathering momentum in Sri Lanka. Given the limitations of grid-based electrification, off-grid technologies might find a growing market in meeting electricity needs of about 15% of rural households.

With the expansion of off-grid electrification there is potential to adopt other technologies such as wind and biomass. Use of wind energy for off-grid electrification is, however, limited by the seasonality and intermittent nature of the resource. This barrier could be overcome by coupling wind power with other type of stable generation technology thereby forming a hybrid power system. Given the comparatively higher investment cost, a hybrid power plant needs to be carefully designed and optimised to generate electricity at competitive prices.

In November 2004, NREL (National Renewable Energy Laboratory, USA) conducted a training course in Sri Lanka to build the capacity of engineers in the Asian region on design and implementation of hybrid power systems using renewable energy technologies. One of the case studies analysed during this course concerns the use of a wind-diesel hybrid power system to provide electricity to Eluvaithivu Island situated close to Jaffna in the Northern Province. The project idea was supported by a Jaffna-based non-governmental organisation called “Ootru Organisation” which is interested in introducing new technologies among societies to uplift their living standard.

2. Overview of Eluvaithivu:

Eluvaithivu is a small island located on the western side of the Jaffna peninsula. The island is oriented in a north-south direction and covers an area of 1.7 km^2. Population in the island covers 130 houses. The general climate prevailing in the island is very much similar to the overall climatic condition of the northern part of Sri Lanka. Being a small island, Eluvaithivu is well

exposed to both monsoons. Annual average wind speed in the area is estimated as 6-7 m/s based on data collected in the Mannar Island situated to the south of Eluvaithivu.

Currently, CEB supplies electricity to 70 houses in the island using a diesel generator set of capacity 28 kVA. Electricity is made available from 4.30 am to 6.30 am and 6.00 pm to 10.30 pm. Monthly consumption in 73% of the households varies between 20 kWh and 40 kWh.

Table 1 shows the average fuel cost for generation cost in every month based on the CEB data collection. The average fuel cost of the power generation per unit is calculated as Rs. 44.60 while the average selling price is remaining Rs. 10.50. This generation cost is only contains with the fuel cost and does not include the capital or operational cost. It may rise around Rs. 60 if all related cost has been taken into account.

	Month (Year 2008)	Fuel/ (ltrs.)	Oil /(ltrs.)	Unit/(kWh)	Fuel Cost /(Rs.)	Oil Cost /(Rs.)	Total/(Rs.)	Price/Unit
1	January	1,454	20	3,527	159,940.00	8,600.00	168,540.00	47.79
2	February	1,168	5	3,062	128,480.00	2,150.00	130,630.00	42.66
3	March	1,352	5	3,499	148,720.00	2,150.00	150,870.00	43.12
4	April	1,260	5	3,109	138,600.00	2,150.00	140,750.00	45.27
5	May	1,235		2,806	135,850.00	-	135,850.00	48.41
6	June	1,080	5	3,417	118,800.00	2,150.00	120,950.00	35.40
7	July	710		1,577	78,100.00	-	78,100.00	49.52
	Average generation cost for one unit							44.60

Table 1: The average generation cost for one unit (Without overheads)

With all the above as is situation, if we consider the wind resource of the island it gives an very good opportunity for green power generation. As per the National Renewable Energy Laboratory for U.S.Department of Energy; the selected area (ie; Eluvaithivu) has the wind speed of 6.0 -8.0 m/s and the power density in the elevation of 50 m above from the sea level has 400-600

W/m^2.The above information gives strong conceptual foundation for implementing wind power turbines in the area

3. Proposed technology for Eluvaithivu:

In the process of designing a wind-diesel system for the island, several system configurations were analyzed using the Homer software. In the pre-feasibility study, the optimum design emerged with 1 Wind Turbines Generator, 2 Diesel Generators, a battery bank, a converter and a hybrid controller. Total project cost, based on preliminary quotations obtained from reputed equipment manufacturers, was about 60 Million Rupees.

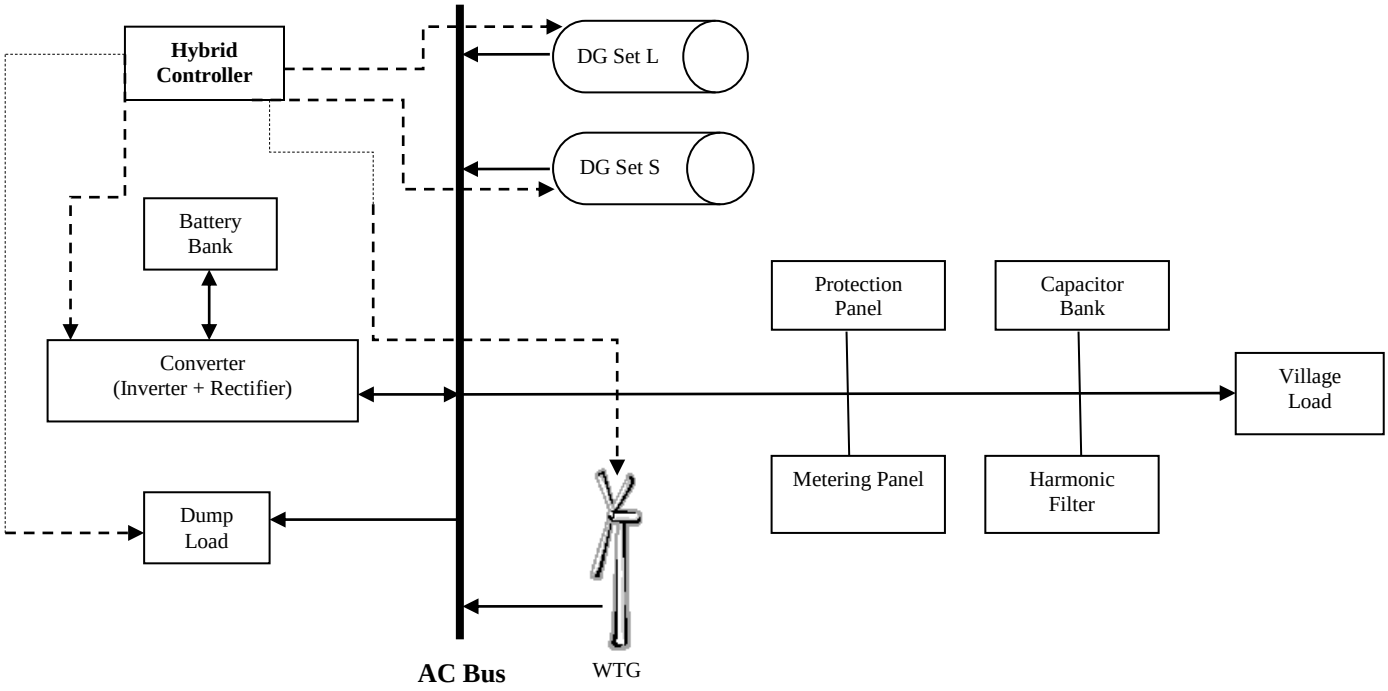

Figure 1: Power Plant Configuration

As shown in Figure 1, the two DG Sets and a WTG will connected to the AC bus bar and will be directly pumping power to the consumers. Batteries are connected to a DC bus which is coupled to the AC bus through a converter (inverter and rectifier) which also includes a hybrid controller, battery charger and a dump load. Therefore the 'Converter' between the two bus bars performs the controlling of the whole system and keeps the whole power system stable under varying generating and load conditions.

4. Cost benefit study results:

Calculated cost of electricity generated by the selected wind-diesel plant configuration was 49 Rupees/kWh, while the operational cost amounts to 20 Rupees/kWh. Based on the CEB tariff charged from presently electrified customers in the island, households pay on average 5 Rupees/kWh. This would imply that the consumers will have to pay almost 4 times the present expenditure on electricity just to meet the operational cost. Thus, the economic viability of the project, in the form of a community owned wind-diesel system operated on cost-recovery basis, would be not feasible.

The average operational cost of supplying electricity by CEB's existing diesel generator amounts to 60 Rupees/kWh. Charging a tariff of only 5 Rupees/kWh, CEB incurs a financial loss of about 2 Million Rupees per year in operating the existing diesel generator system in the island. And the loss will further increase with diesel price escalations and increased electrification of the island. In this context, the wind-diesel option with an estimated operational cost of 20 Rupees/kWh has the potential to reduce the financial loss to CEB by about 60%.

5. Additional advantages:

Besides the provision of electricity supply to the island population, the project has the potential to serve the wider objective of demonstrating the feasibility of wind-diesel systems to meet the electricity needs of people in remote regions in Sri Lanka. Also it supports the green energy concept directly, which is recently considered as high potential concept in the country. The project could, thus, be a lesson learning experience.

Further integrating the research and development in this project will create professionals with more depth knowledge in this technology to the country. Proper management and development of this research program will lead to produce low cost components, which can be manufactured within the country. The local manufacturing process will help to optimize the system to the site requirement, rather purchasing the complete in-built models. Therefore integration of a good research program will increase the trend on electrifying other islands with low cost and optimized technologies. Thus the GDP of the country will be lifted up.

6. Conclusion:

The study results confirmed that the electrification of the Eluvaithivu Island using a wind-diesel system would be an economically attractive option for the CEB. In other words, if CEB implement this project, it would be an ideal win-win situation where both the CEB and the island community are benefited.

Further this is directly supporting the green energy concept, which proposed to increase the power generation from renewable energy. This is one of the major requests by the Minister of Power Energy in Sri Lanka.

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