Design of an optimal stand alone Hybrid Renewable Energy System with storage for supplying priority loads in a typical off grid community

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1. Background and Introduction

In this modern age, electricity has taken its shape from a luxury to a necessity but there are still more than a billion people without adequate access to electricity which is evident in the rural areas of Tanzania, where less than 5% of its people have access to grid electricity and hence, powering prioritized loads such as hospitals would further be a challenge due to its continuous power requirements.

This project was thus aimed at designing and modelling an optimal Hybrid Renewable Energy System (HRES) with storage for meeting the demands of such priority loads in two Tanzanian regions namely Upanga and Ngamiani. The use of a storage option acted as a backup option to continuously supply and meet the load demands of both these locations. The simulations and optimizations were carried out in the HOMER software.

2. Methodology and Modelling

The methodology steps included site selection, renewable resource assessment, software selection, data collection, HRES modelling, sensitivity analysis and developing case studies. The figures below indicate the daily load profile, monthly solar data and one of seven case studies for Upanga.

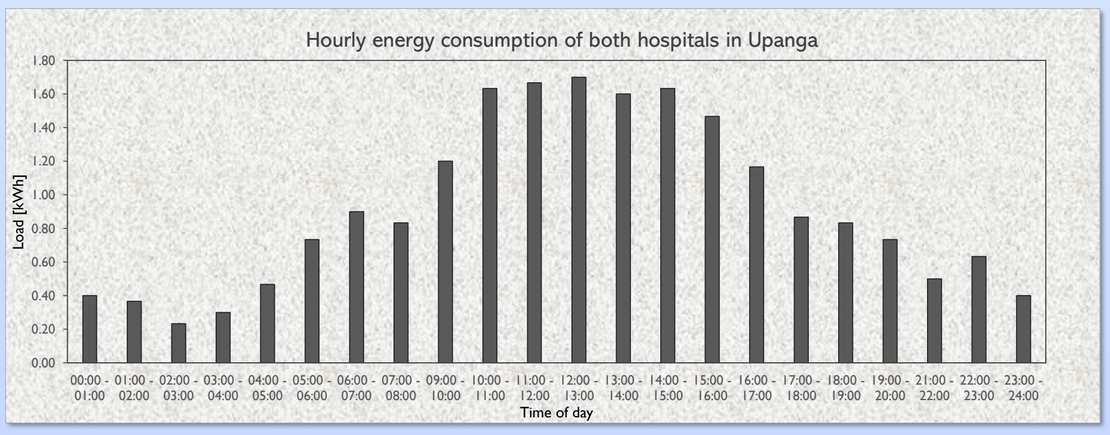

Figure 1: Daily load profile for Upanga

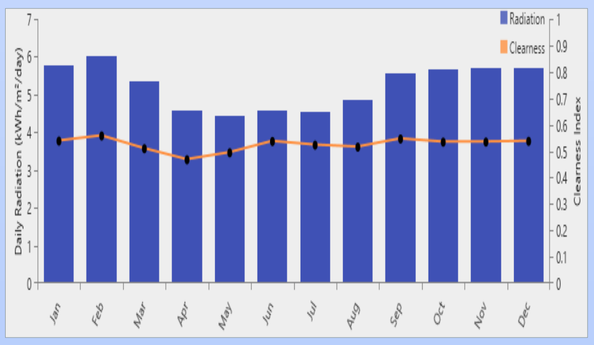

Figure 2: Monthly solar data for Upanga

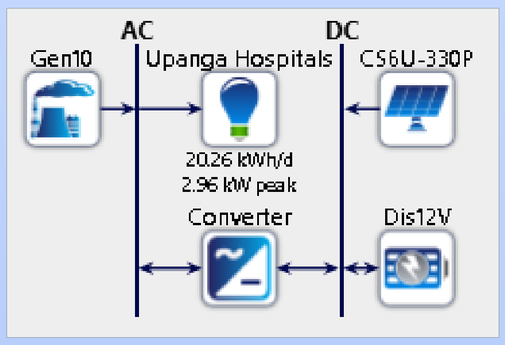

Figure 3: Case study for Upanga

Upanga had an average energy consumption of 20.26kWh per day, an annual solar irradiance of 1900kWh/m2 and average wind speed of 5.74 m/s.

3. Results and Discussion

The following optimization results were obtained from the seven case studies conducted for Upanga.

Architecture									
					CS6U-330P (kW)	AWS3.3kW	Gen10 (kW)	Dis12V	Converter (kW)
✓		✓	✓	✓	4.48		10.0	10	2.71
		✓	✓	✓			10.0	19	8.14
✓	✓	✓	✓	✓	1.58	1	10.0	6	3.55
	✓	✓	✓	✓		1	10.0	20	5.83
✓			✓	✓	6.34			27	2.77
✓	✓		✓	✓	5.25	1		24	3.33
	✓		✓	✓		3		68	5.00

Figure 4: Optimization results for seven studies for Upanga

This was then followed by a cost, excess electricity and CO2 emissions comparison for all the studies for both the locations to obtain the optimal configuration. The figure below indicates these comparisons for the case studies done in Upanga.

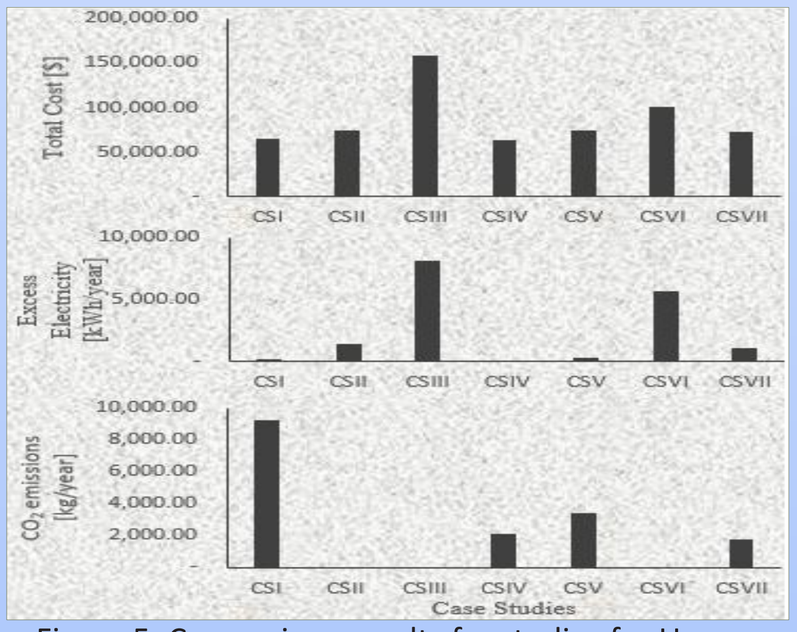

Figure 5: Comparison results for studies for Upanga

4. Conclusion

The project was a success since an optimal standalone HRES configuration with storage was obtained to meet the priority load demands for both the locations in Tanzania. The optimal system chosen was CSIV which involved a combination of solar PV, diesel generator and a storage option. Upanga's system had a total cost of only $63,137 with an excess electricity of 1.01% and a renewable fraction of 77.70% whereas Ngamiani's system had a total cost of $51,545 with an excess electricity of just 0.84% and a renewable fraction of 75.50%.