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Techno Economic Analysis of Modular Microgrids in Cold Regions

Karen Supan[1], Seth Soman[2], Michael Cross[3]
[1]Norwich University
158 Harmon Drive, Northfield, VT, USA
ksupan@norwich.edu
[2]ssoman@norwich.edu
[3] mcross2@norwich.edu

Extended Abstract

As the Army looks to expand into remote Arctic locations, it is imperative to investigate how a forward operating base in such a location will receive its power and heat. The objective of this study was to analyze renewable energy technologies for use in a modular, mobile microgrid that could operate in remote Arctic locations. The scope of the work was to select renewable energy generation components based on design criteria and a Pugh decision matrix and then optimize the winning component in HOMER (Hybrid Optimization Model for Multiple Energy Resources) [1] Pro Software. The HOMER Pro simulations compared a base case of a diesel generator to a proposed system that included renewable energy generation resources. Each simulation provided a proposed system, present worth of savings, cost of energy, annual electric production, and environmental impacts. These simulations were run for hydrokinetic turbines, solar photovoltaics (PV), wind turbines, and gas microturbines.

For the hydrokinetic turbine analysis, the proposed system included a 12 kW model and 28 kWh of battery storage. The present worth of savings was $169,372 and cost of energy was $0.55/kWh. This model could replace the diesel generator for approximately 6 months of the year and reduce emissions of pollutants by 56%.

For the solar PV simulation, the system was optimized to include a 25 kW diesel generator, 46 kWh of battery capacity, 38 kW of PV, and a system converter. The present worth of savings was $220,850 and cost of energy was $0.49/kWh. The PV system could reduce the load of the diesel generator for all 12 months of the year. Emissions of pollutants can be reduced by 50% if switching to the proposed system that includes PV.

For the wind turbine simulation, the system was optimized to include a 25 kW diesel generator, 46 kWh of battery capacity, and 6 kW of wind generation capacity. The present worth of savings was $124,872 and cost of energy was $0.61/kWh. The wind turbine proposed system could reduce the load of the diesel generator for all 12 months of the year. Emissions of pollutants can be reduced by 45% by switching to the proposed system.

For the gas microturbine simulation, a proposed system with combined heat and power was compared to the diesel generator. The present worth of savings was $406,663 and cost of energy was $0.25/kWh. By using the gas microturbine in place of a diesel generator for heat and power there will be a reduction in emissions of pollutants by 46%.

Given the requirement that the microgrid be mobile the components included would become a toolbox that would be drawn upon based on location (i.e. near a river or high winds). The simulations were run in isolation to provide evidence for each component's use compared to the diesel generator. Each of these components alone provided economic and energy savings along with a reduction in pollutants, so that when combined there may be even more additional savings and an opportunity to use renewable energy resources regardless of the location.

References

[1] *HOMER Pro* (2022), HOMER Energy by UL. Accessed: Aug. 1, 2022. [Online]. Available: https://www.homerenergy.com/products/pro/index.html.