OPTIMAL HYBRID RENEWABLE COMBINATION FOR COST AND EMISSION MINIMIZATION OF MINI-GRIDS

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Overview

The people living in remote areas represent 13% of the global population [1]. They are mainly in Aisha's southern region and Sub-Saharan Africa. These areas are not connected to the main grid, so residents and businesses are rely on diesel generators to provide their needs of electricity. Such diesel generator is highly polluting to the environment and contributes to increased greenhouse gas emissions. A further issue is the volatility of the fuel price and its transportation [2]. Using renewable generation from Photovoltaic and wind is candidate to solve this problem; but the intermittent nature of renewable generation is another problem [3]. In mini- and micro-grids, the hybrid combination outperforms single renewable generation. Although generating electricity from wind and PV systems can minimize greenhouse gas emissions and the cost of establishing new fossil fuel generation plants; entirely depending on renewable sources is inadequate. Renewable generation is intermittent; it is critical to find a way to make a stable operation[4]. The hybrid combination of PV, wind, and backup sources such as storage, fuel cell, diesel, and microturbine can accomplish system stability and increase their generation capacity.

The global aim these days is to significantly raise the use of hydrogen in various applications to reduce greenhouse gas emissions. Various local resources can be used to produce hydrogen. It has the potential to expand in the stationary and transportation energy sectors[5]. Grey and green hydrogen are the most well-known types of hydrogen. The production of green hydrogen is based on surplus energy from renewable resources such as PV and wind, which is separated from water using an electrolyzer. Grey hydrogen is typically produced from natural gas via the steam reforming process. Transporting hydrogen over long distances could be costly. The solution is to build a way of producing hydrogen in a micro-grid. Because surplus energy varies from season to season, generating hydrogen from surplus energy may be insufficient to supply all loads in the mico-grid. Grey hydrogen production is also necessary for remote areas with abundant natural gas to bridge the gap in green hydrogen supply. This research will also look into the costs of implementing green and grey hydrogen in micro-grids.

Methods

The main issue is determining the best hybrid combination of these resources to reduce the overall cost of the mixture, improving the system reliability and reducing emissions. Another concern is the best management strategy for lowering overall costs and ensuring the highest electrical power supply to loads. This study will present a variety of renewable and nonrenewable generation resources and decide the best hybrid combination to reduce overall costs while providing maximum power to consumers by complying with management criteria. The candidate resources are PV, wind, battery, fuel cell, diesel and micro-turbine.This problem will be solved using a combination of an optimization technique and a management strategy. The management strategy is responsible for displaying power between various components, whereas the optimization technique will determine the best output of each element for the system's optimal cost minimization and emission minimization. The study will also show how surplus energy in each hybrid renewable case can reduces overall system costs. A cost-effective comparison between off-grid and grid-connected systems will be accomplished. Homer software will be used to find the optimal solution; it is used to both technically and financially design and evaluate off-grid and on-grid power system options for remote, stand-alone, and distributed generation applications.

This study will also look at modeling electrolyzers and steam reformers and conducting techno-economic analyses to determine which will be more cost-effective and beneficial to the micro-grid and the environment. The main goal is to find a combination that reduces both the net present cost value and the energy cost. In each case, the emission analysis will be performed to determine the lowest emission combination.

The studies will be on Egypt's two systems. The first is in the east Owinat in Egypt's western desert; this system usually depends on electricity from a diesel generator to reclaim thousands of acres using underground water. The second system is also in Minya, Egypt, and it uses diesel to supply electrical power to many reclaimed acres.

Results

First, the results will show the best hybrid combination that can reduce the overall cost of the mini-grid while also reducing greenhouse gas emissions and maximizing the output of each device. Second, the effect of the hybrid combination's surplus energy utilization in lowering the overall cost of the system. Third, determining the most cost-effective method of Mimi-grid isolation or connection to the main grid. Finally, a techno-economic analysis of green and grey hydrogen implementation in micro-grids will be discussed. The comparison will determine which of the two systems is the most cost-effective. The study will also demonstrate the environmental and cost-cutting effects of modeling grey hydrogen as a combined heat and power system.

Conclusions

Hybrid renewable generation, which combines renewable and nonrenewable resources, can provide numerous benefits to consumers and governments. It has the potential to improve the reliability of supplying power to consumers without interruption. Governments can benefit from reducing investment in new fossil-fuel generation plants, reducing line losses and environmental pollution. The first section of the study will focus on the best hybrid renewable combination. This combination will rely on a single strategy for multiple components. The best hybrid will be identified by combining the optimization method and the management strategy. Based on the management strategy, optimization the best output of each component will be determine. The second section focuses on excess energy from hybrid renewables, which can be used to supply a dumbed load and reduce overall system costs. The third section compares off-grid and on-grid designs from cost minimization prospective. The fourth will focus on the techno-economic analysis of grey and green hydrogen in micro-grid and compare them. The best combination will be chosen based on minimizing overall costs and lowering greenhouse gas emissions. The hybrid renewable generation is the best solution for far places to overcome diesel generation issues and for on-grid to improve the rigidity and stability of supplying electrical power.

References

1- N. Ninad, D. Turcotte, and Y. Poissant, ``Analysis of PV-diesel hybrid microgrids for small Canadian arctic communities,'' *Can.J. Electr. Comput. Eng.*, vol. 43, no. 4, pp. 315_325, 2020, doi:10.1109/cjece.2020.2995750.

2- E. A. Al-Ammar, H. U. R. Habib, K. M. Kotb, S. Wang, W. Ko, M. F. Elmorshedy, and A. Waqar, ``Residential community load management based on optimal design of standalone HRES with model predictive control,'' *IEEE Access*, vol. 8, pp. 12542_12572, 2020, doi:10.1109/access.2020.2965250.

3- M. Islam, B. Das, P. Das, and M. Rahaman, `Techno-economic optimization of a zero emission energy system for a coastal community in Newfoundland, Canada,'' *Energy*, vol. 220, Apr. 2021, Art. no. 119709, doi: 10.1016/j.energy.2020.119709.

4- E. G. Vera, C. Canizares, and M. Pirnia, ``Renewable energy integration in Canadian remote community microgrids: The feasibility of hydrogen and gas generation,'' *IEEE Electri_c. Mag.*, vol. 8, no. 4, pp. 36_45, Dec. 2020, doi: 10.1109/MELE.2020.3026438

5- R. Neves, H. Cho, and J. Zhang, ``Pairing geothermal technology and solar photovoltaics for net-zero energy homes,'' *Renew. Sustain. Energy Rev.*, vol. 140, Apr. 2021, Art. no. 110749, doi: 10.1016/j.rser.2021.110749.