OPTIMAL PLANNING AND OPERATION OF ISOLATED MICRO-GRID FOR SUSTAINABLE DEVELOPMENT

Mohammed M. Mishref, Graduate School of Policy Studies, National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan, 08078239530, doc21153@grips.ac.jp
Makoto Tanaka, Graduate School of Policy Studies, National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan, mtanaka@grips.ac.jp

Overview

People living in remote areas account for 13% of the global population [1]. They usually suffer from a lack of electricity connection, which increases their reliance on diesel generators. The dependance on fossil fuels as the primary source of electricity generation is unsustainable due to fluctuating fossil energy prices and high emission values [2]. Renewable energy resources could solve this problem, but their intermittent nature is another issue. Hybrid renewable energy, which combines renewable resources such as PV and wind with backup resources like batteries and standby generators, could be promising for achieving sustainability and flexibility in isolated microgrids [3]. A backup generation of diesel, a micro-turbine, or a fuel cell is mandatory in isolated grid, because battery storage is unreliable [4]. The primary source for charging the battery is the surplus energy of renewable resources from PV and wind. Surplus energy may not always be sufficient to charge the electrical battery, necessitating a backup generator. Although using diesel and micro-turbines as backup resources in isolated micro-grids is less expensive than fuel cells, the emissions are higher[5]. Using a fuel cell requires a source of hydrogen, while importing hydrogen from other prefectures may incur high transportation costs and risks. Using an electrolyzer for generating green hydrogen from surplus energy is not a stable hydrogen supply. The electrolyzer and the reformer combination can provide secure hydrogen production to supply the fuel cells or any other application.

This paper will identify the optimal hybrid renewable for net present cost minimization in an isolated microgrid while considering net-zero emissions. It will specify the optimal dispatch of PV, wind, battery storage, and fuel cells when using an electrolyzer and a steam reformer with carbon capture utilization and storage (CCUS). It will also consider power to hydrogen to power process (P2H2P) for supplying the fuel cell. The steam reformer modeling will be part of a combined heat and power system (Chp) to reduce emissions and costs of CCUS. The management strategy for the electrolyzer and the steam reformer will be highlighted to reduce the cost of hydrogen generation in the isolated microgrid, which reduces the overall cost. It will try to display hydrogen between both devices optimally, considering the mid-term storage and the fluctuation in the natural gas price. The study will be applied in two isolated systems in Egypt, isolated from the main grid, which use a diesel generator to supply the electrical load.

Methods

This research will determine the best hybrid renewable between PV, wind, battery, and the fuel cell's in isolated microgrids considering hydrogen from electrolyzer and steam reformer with CCUS for achieving carbon neutrality. The objective function is net present cost minimization (NPC). The management strategy will be based on determining the optimal operating periods for the electrolyzer and reformer with CCUS to reduce the overall cost of the microgrid. Homer Pro optimizer software will be used for micro-grid modeling, and additional assumptions will be added to the model using Matlab software to display the thermal load of the steam reformer and management strategies. The research will be conducted in two isolated systems, the first in East Owinat in Egypt's western desert and the second in a remote location near Minia prefecture. Both systems are disconnected from the main grid and used for supplying residential loads and submersible pumps for acres reclamation.

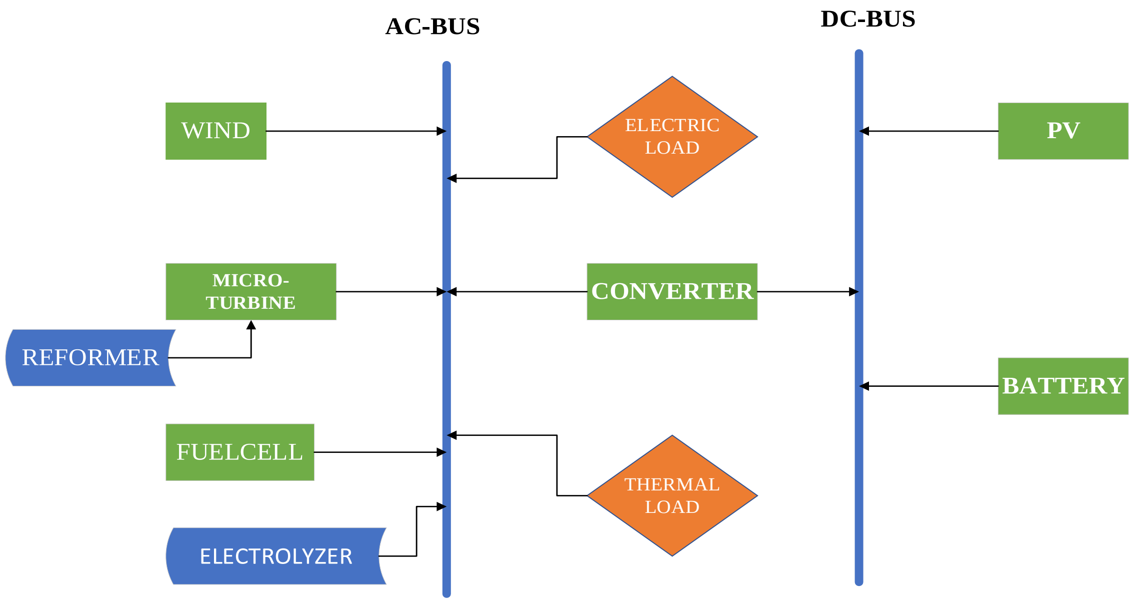

Fig. Main Microgrid Components

Results

The results will show the optimal dispatch of PV, wind, battery storage, and fuel cell for net present cost minimization. It will demonstrate the benefits of using P2H2P to supply fuel cells in reaching net zero emissions. The model will use the electrolyzer to generate hydrogen from surplus energy and directly from the micro-rid. It will also show the modeling of the steam reformer as a part of the combined heat and power (Chp) of the microgrid and its impact on reducing the cost of CCUS. The optimal operation of the electrolyzer and the reformer is another concern. The study will demonstrate management strategies' role in displaying the electrolyzer and reformer with CCUS in reducing the overall system cost.

Conclusions

Isolated grids, particularly in Africa and Asia, pose a significant threat to the environment, with many still relying on diesel generators and burning wood for stoves and heating during the winter. Hybrid renewable will be a promising solution for carbon neutrality and increasing system flexibility. In remote areas, hydrogen is critical for supplying fuel cells as an essential backup resource. The study will elaborate the optimal dispatch of PV, wind, battery, and fuel cells for the net present cost minimization as an objective function, considering electrolyzer and steam reformer with CCUS. It will show the importance of management strategies between the electrolyzer and the steam reformer with CCUS for reducing the overall cost of the microgrid. It will also suggest three management strategies for providing hydrogen for P2H2Pprocess. The study will achieve sustainability by replacing diesel generators with fuel cells driven by hydrogen generation, using Chp to provide heat for the reforming process to reduce the reliance on natural gas, and using management strategies for reducing the hydrogen Levelized cost and the entire microgrid cost.

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- A. Guerello, S. Page, G. Holburn, and M. Balzarova, ``Energy for off-gridhomes: Reducing costs through joint hybrid system and energy ef_ciencyoptimization,'' *Energy Buildings*, vol. 207, Jan. 2020, Art. no. 109478, doi:10.1016/j.enbuild.2019.109478

3- A. A. Eajal, A. El-Awady, E. F. El-Saadany, K. Ponnambalam, A. Al-Durra, A. Al-Sumaiti, and M. Salama, ``A Bayesian approach to the reliability analysis of renewables-dominated DC microgrids,'' *IEEE Trans. Power Syst.*, early access, Feb. 3, 2021, doi: 10.1109/TPWRS.2021.3056314

4- B. Hodge, *Alternative Energy Systems and Applications*, 2nd ed. Hoboken,NJ, USA: Wiley, 2017, pp. 143_167.

5- 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.