Evaluating an optimal integrated renewable energy supply chain with the incorporation of hydrogen storage for a small community

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Abstract

The global effort to address climate change is causing an ever-growing enchantment with implementing clean energies as a viable substitute for fossil fuels. Uncertainties about renewable energies pose challenges, especially in small communities without reliable energy sources. Hydrogen is a promising solution due to its reliability and ability to store energy for long duration. However, there are still questions about if including hydrogen in renewable energy supply chains leads to an optimal configuration and balance between annual cost, environmental and societal impacts in order to meet the energy demands of a small community. Liverpool in Nova Scotia, Canada, was selected as a case study because it is susceptible to power outages and is appropriate for renewable energy development. After a tri-objective optimization, wind turbines (WT), Combined Heat and Power (CHP), Organic Rankine Cycles (ORC), and grid are identified as the most effective technologies. The best solution leads to a total annual cost of $6.14 million, an environmental impact of 0.2 species per year, and a social impact of 1256 utility. By incorporating the probability of power interruptions, the model shows a 2.2% decrease in social impact relative to having full grid access, which rises to 15.4% in an off-grid scenario. By 2030, it is projected that 22 MW of energy will be generated by hydrogen technologies as they gradually mature. Despite a 143% rise in total annual expenses, there is a significant 63% drop in environmental impact and a 4% increase in social impact in this situation. Hydrogen storage for the community has the ability to greatly enhance societal impacts and provide a more environmentally friendly option compared to traditional grid systems.

Keywords— Renewable energy supply chain, hydrogen production, small community, energy storage

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