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Simulation of a hydrogen energy system for a zero emission building in Alberta

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ABSTRACT

Alberta's greenhouse gas (GHG) emissions are the second highest in Canada. Among the distribution of GHG emissions, nearly 39% of GHG are emitted by the residential and large buildings in Alberta. It is essential to reduce the GHG emission of buildings to ease the current climate change crisis. The hydrogen energy systems (HES) with renewable energy (RE) comprise a RE source, battery, hydrogen-generating devices, hydrogen storage tank and fuel cell, which are considered promising renewable systems to replace current indoor energy systems and reduce GHG emission, even achieve zero-emission. However, the seasonal energy output and seasonal energy storage pattern of HES through the year are still few reported. Then, it is obscure that the actual capability of hydrogen replacing the current energy to meet energy demand and achieve the minimum GHG emission in Alberta's building. This paper aims to study these issues, including different season operation patterns, the annual maximum efficiency of HES and the least GHG emission. These issues will be investigated in a bench-scale HES based pilot building (floor area about 200 m^2, energy demand about 15KW/day) in Edmonton. This model will be simulated by MATLAB/Simulink for one year period. In this simulation model, the photovoltaic (PV) system is the RE source, providing the direct-use energy for building consumption. The excess energy of PV can be transformed and stored as hydrogen in the tank and generate energy by fuel cell when the generating energy is insufficient, such as at night. For the uncertain RE production and energy demand, the one-year weather data and actual pilot buildings consumption are taken from Environment Canada and theoretical calculation that predicts the RE generation and the actual energy demand. Meanwhile, the mathematical models of PV, water electrolyzer, battery, tank and fuel cell are built to reveal the net efficiency of energy conversion under various operation patterns. To accomplish the goal of minimum GHG emissions, the optimum energy storage scheme based on data of weather and demand is carried out to adjust the difference of RE production in different seasons. This work will provide technical analysis to show that the HES can achieve annual self-sufficient to meet the building demand without traditional energy addition (i.e., grid power or CH_4) and achieve zero GHG emissions.

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