[TECHNO-ECONOMIC ANALYSIS: CHARGING AIRPORT'S ELECTRICAL BAGGAGE TRACTORS WITH HYDROGEN FUEL CELL]

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Overview

Fossil fuel is one of the most harmful environmental factors due to carbon dioxide emissions. The CO_2 emission causes global warming urges the world to look for renewable energy sources that are environmentally friendly and sustainable. Green hydrogen is one of the promising sources of clean energy. Many countries and companies have begun to invest in the green hydrogen economy. The Kingdom of Saudi Arabia targes to be the world's largest producer and exporter of green hydrogen to maintain its position as the world's largest energy source, as stated in the Green Saudi Initiative. All this interest in green hydrogen utilization will decrease costs and prompt investors to invest more in its research and development.

Saudi's General Authority of Civil Aviation (GACA) aims to reduce its carbon emissions in Saudi Airports to achieve zero neutrality by 2060 in line with Green Saudi Initiative [1]. Therefore, in this study, the economic feasibility of a project to charge 45 electrical baggage tractors in airports using green hydrogen will be accomplished with a project lifetime estimated to be 20 years. A diesel tractor emits 118 tons of carbon dioxide [2], and charging one electrical tractor from the power grid will indirectly emit 35.2 tons of carbon dioxide annually. Using green hydrogen with fuel cells is one of the most effective ways to produce electricity with zero carbon emissions. Table 1 compares current and proposed scenarios.

Table 1: Comparing the current scenario with the proposed scenario

	Scenarios		
	Current		**Proposed**
Power generator	Fossil fuel	Power grid	Fuel cell
Tractor engine	Diesel	Electrical	Electrical
Overall efficiency	45%	45%	56%
CO_2 emission per tractor	118.0 tons CO_2/year	35.0 tons CO_2/year	0.00 tons CO_2/year
Initial cost	Low	Medium	High
Maintenance	Frequently	Rarely	Rarely

Methods

Polymer Electrolyte Membrane Fuel Cell (PEMFC) uses green hydrogen to react with oxygen to produce electricity and emit only water vapor. The tractors require 360.0 kW of power to be charged. Therefore, the PEMFC needs to be split into stacks of cells to avoid blockage in the cell due to the high current density required, the stack will be 10.0 kW connected in series and charging the batteries four times daily.

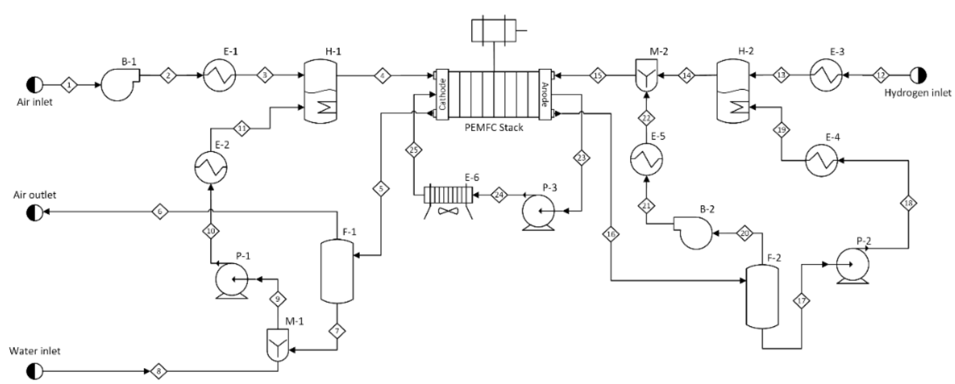

Figure 1: Flowsheet of Polymer Electrolyte Membrane Hydrogen Fuel Cell

Based on our PEMFC system design shown in Figure 1, with a power factor of 0.751, the rest is used to operate the system's equipment to make the station stand-alone. According to a cost analysis from National Renewable

Energy Laboratory, the system price is $4,750.0 for each kW [3]. For the operating cost, the hydrogen price was set at $2.77 per kilogram [4], with the hydrogen price decreasing at a rate of 3.5% annually to reach $1.36 at the end of the project's life. The system will be maintained every five years and will cost 6.0% of the system cost. The project will achieve its profits by saving the cost of electricity and avoiding the carbon price tax by reducing carbon emissions. The global average electricity price is estimated at $0.15 per kWh, increasing at a rate of %2.5 annually to reach $0.24 by the end of the project [5]. The global carbon price average is estimated at $35.14 per ton of CO_2, increasing by 9.1% annually, to reach $200.58 by the end of the project [6].

Results

The study assumed the station would be constructed in 2023 to run in 2024 and continue operating until 2043. A system of 479.44 kW will be needed based on the net power output of the PEMFC. Therefore, the system cost will be $2.277 million. The system's net power generated annually is 3,153.6 MWh using 289.54 tons per year of hydrogen. Establishing this project will cut 5,309 tons of carbon dioxide emissions annually if diesel tractors are used and 1,583 tons of carbon dioxide if the power grid charges electrical tractors. The project will start making profits in its 7th year and will reach the break-even point in 18 years, as shown in Figure 2.

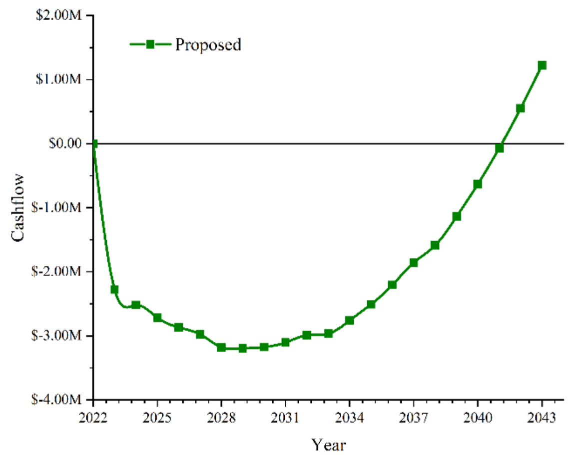

Figure 2: Cashflow of the system

Conclusions

Although the objective of the project is not for economic purposes, the project will make a profit in long term. Establishing this project contributes to achieving Saudi's goals of zero carbon emissions, strengthening the Green Saudi Initiative, and pushing the wheel of investment in the green hydrogen economy and clean energy. The target stated by the department of energy in the US is to make the PEMFC power factor reach 0.833 [7], which pushes the research and development to decrease the system's power loss, and our design is close to this target. Establishing this project will be equivalent to planting 73,000 middle-aged trees, which has a significant impact.

References

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