ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

Department of Chemical Engineering

HYDROGEN PRODUCTION SYSTEM FOR A VILLAGE

Esra Gül SENDESEN, Assoc. Prof. Harun KOKU, Prof. Dr. İnci EROĞLU

ABSTRACT

This project aims to compile literature research and conduct calculations about the utilization of hydrogen in different ways. Hydrogen is produced using environmentally friendly methods to provide electricity, fuel, and heating. Produced hydrogen is used in a village comprising 50 houses, 50 transport vehicles, 1000 acres of planted land, and 20 barns, each 53 m². Three different scenarios are analyzed in this project, and how hydrogen is utilized and how much hydrogen is needed in every scenario are shown in the results. Moreover, the power of the electrolyzer is 325.7 kW, and 2154 solar panel which one of the area is 1.727 m² is needed for the whole system that consists of compressor, turbine, pump, and heat exchangers. Also, the cost analysis of this project is done, and the cost of total capital investment is $2,892,000, and the operating cost is $189,000/year.

INTRODUCTION

There are various advantages of producing green hydrogen. Hydrogen can be stored in large quantities for a long time, and it has nearly three times the energy of fossil fuels [1].

Green hydrogen is good for the environment, and it can be used for fuel, electricity, and heating. Solar panels are used to provide electrical power in this project. Solar panels are a good source of clean energy which is the motivation of the project. Produced hydrogen can be used for several purposes.

The first use of hydrogen is producing electricity, which can be used in houses, and the second usage is fuel. Almost all vehicles depend highly on hydrocarbon fuels, and an average passenger car's annual carbon dioxide emissions are around 4.6 metric tons. Using hydrogen as a fuel can eliminate this problem since hydrogen is the only energy source that does not pollute [1].

The third usage of hydrogen is heating. Heat pumps are used for this purpose. Heat pumps offer an energy-efficient alternative to furnaces. Moreover, since hydrogen is used for electricity, heat pump is a good source for heating because it is clean. The working principle of a heat pump is shown in Figure 1.

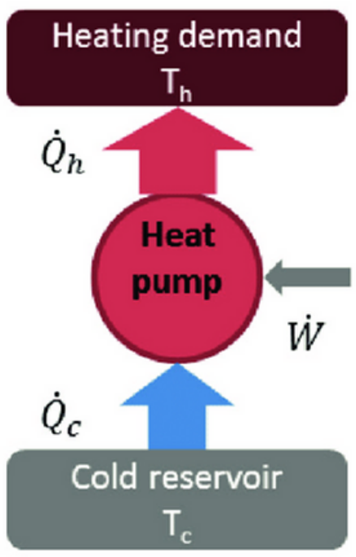

Figure 1: The working principle of a heat pump [2]

RESULTS AND DISCUSSION

Three different scenarios for utilizing hydrogen are examined in this project. The comparisons of three scenarios, and how hydrogen is utilized in every scenario is shown in Table 1. Also, how much hydrogen is needed in every usage is shown in Figure 2.

Table 1: Comparison of three scenarios

Scenarios / Utilization	Scenario 1	Scenario 2	Scenario 3
Electricity	✓	✓	✓
Fuel for tractors&transport vehicles	✓	✓	✓
Heating of houses		✓	✓
Heating of barns			✓
Total hydrogen need (tons/year)	12.6	15.5	15.7

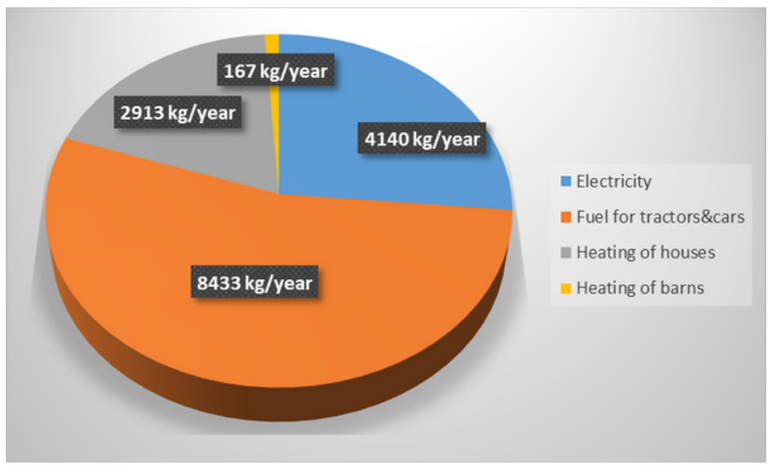

Figure 2: Utilization of hydrogen and the amount of hydrogen

The proposed hydrogen production system configuration is shown in Figure 3. PEM water electrolyser is used to produce hydrogen and, produced hydrogen is stored in the metal hydride storage tank. Then, required electricity for heat pump and electricity is produced in PEM fuel cell.

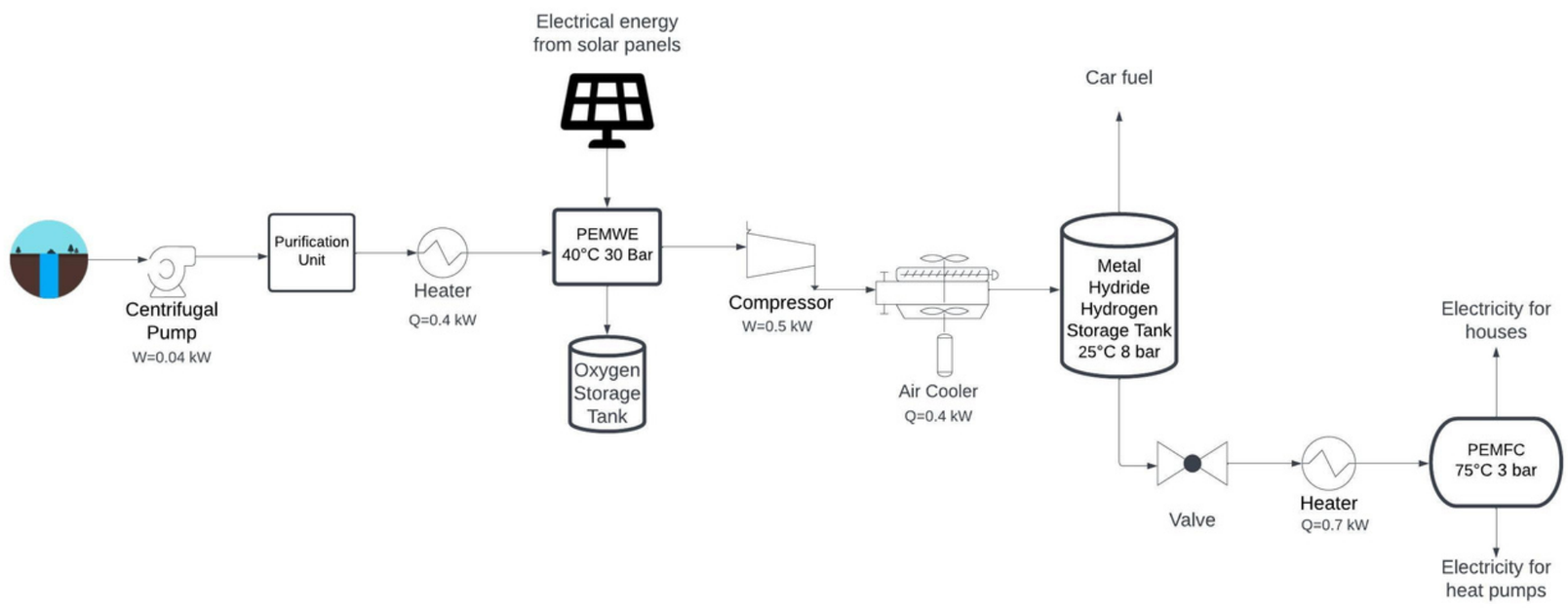

Figure 3: The Proposed Hydrogen Production System Flowsheet

Capital investment cost calculations are done by using purchased equipment costs. Equipment costs are found using literature and Aspen Plus software. The tabulated results of the equipments are shown in Table 2. Then, for other costs short cut methods are used. Calculated costs are shown in Figure 4.

Table 2: Equipment costs

Equipment	Cost ($)
Pump	200
Water purification unit	1000
Solar panel	236,937
Electrolyzer	362,873
Air cooler	3000
Fuel cell	4000
Compressor	25000
Heaters	6000
Valve	100
Oxygen tank	20000
Hydrogen tank	20000
Total	679,111

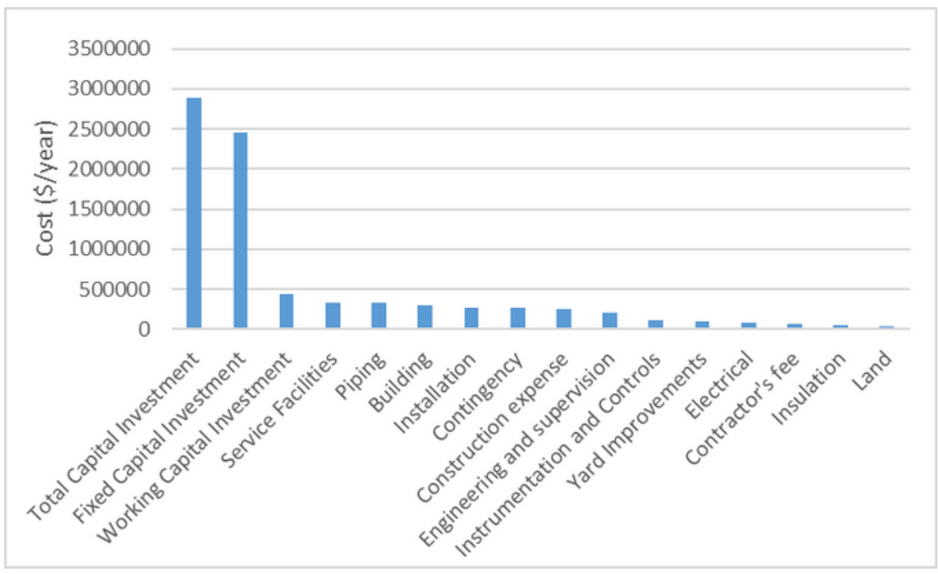

Figure 4: Capital investment costs

Figure 5: Comparison of regular cost and operating cost of the green hydrogen village

Regular cost of the village that is the cost when hydrogen is not exist, and traditional methods are used, and operating cost of the hydrogen village is shown in Figure 5. Regular cost is less than operating cost, but green hydrogen is needed for the sustainable world. Moreover, more hydrogen, and oxygen can be produced in the village, and it can be sold to manufacturing plants which is good choice for profit.

CONCLUSION

- Hydrogen is utilized in the village in three different scenarios: electricity, fuel, and heating.
- 12.6 tons/year of hydrogen is needed in the first scenario, 15.5 tons/year in the second scenario, and 15.7 in the third scenario.
- Total equipment cost is $679,111 while fixed capital investment and operating costs are $2,892,000 and $189,000/year, respectively.
- The regular cost is $86,284/year, and even if it is less than the operating cost of the village, green hydrogen village is a better choice because it is sustainable. Green hydrogen reduces carbon footprint when it is replaced with fossil fuels; that is the motivation of this project.

REFERENCES

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2.Timmerman, J., Vandevelde, L., & Van Eetvelde, G. (2014). Towards low carbon business park energy systems: Classification of techno-economic energy models. Energy, 75, 68–80. https://doi.org/10.1016/j.energy.2014.05.092