Techno-Economic Feasibility of Eavor-Loop Green Hydrogen Production

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Background

Hydrogen has a variety of end-uses. One kilogram of hydrogen has roughly the same energy content as one gallon of diesel – but with zero emissions upon combustion. However, 830 Mt CO2eq/yr is currently associated with hydrogen production [1] with grey hydrogen (see Table 1) representing over 95% of production worldwide. Heavy duty transportation is a necessary but emissions intensive industry, where hydrogen fuel could be a zero-emissions alternative to diesel.

Around the globe, many countries are expanding their hydrogen networks. The United States – specifically California [2] – as well as Japan and Germany are examples of government investing in the hydrogen economy. There is a USD $3/kg Production Tax Credit for clean hydrogen in the USA [4]. However, the price of hydrogen at the pump in California was USD $26/kg [3] at the time of this study. Compressing and cooling the hydrogen is energy intensive, and the infrastructure required to transport the small molecule is costly. Producing hydrogen onsite can eliminate some of these costs.

Table 1: Methods of Hydrogen Production

Colour of Hydrogen	Type of Hydrogen Production Method
Grey	Steam Methane Reformation
Blue	Steam Methane Reformation with Carbon Capture
Green	Renewable Energy with Electrolysis

Geothermal energy offers a green method (see Table 1) of producing hydrogen [5]. An Eavor Loop™ 2.0 design is a dispatchable closed loop geothermal system reaching 7+ km into the earth, with 12 multilaterals at depth to increase the surface area for heat exchange [6]. The hot water from the loop is then run through an organic Rankine cycle (ORC) generator to produce electricity. There are no specific geological conditions (such as a permeable aquifer) required for an Eavor Loop, it can output consistent thermal energy, and there are zero emissions associated with its operation.

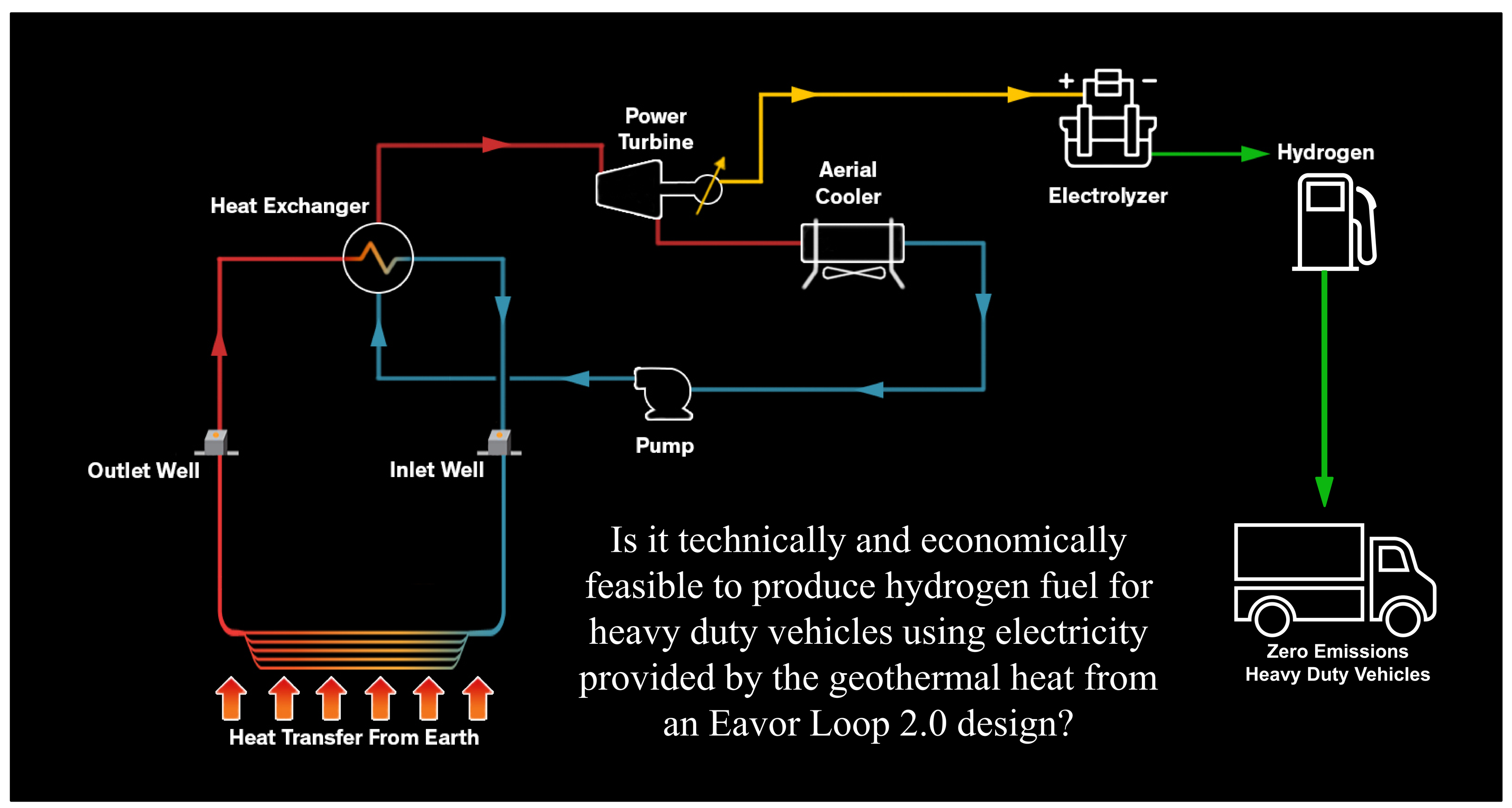

Figure 1: Eavor Loop Hydrogen Production System & Research Question

Combining the zero emissions energy from an Eavor Loop with an ORC generator and electrolyzer (as shown in Figure 1) would produce green hydrogen, which could be used to fuel heavy duty vehicles. This study compares the financial and environmental costs of this proposed system to solar, wind, and blue hydrogen production methods.

Financial Calculations

A financial analysis for each method was performed from the point of construction of the energy production facilities to the dispensing of the hydrogen at the pump. The functional unit for comparison in the financial scenarios is the "Levelized Cost of Hydrogen" (LCOH), or the levelized cost of electricity converted to cost per kilogram of hydrogen, and it was obtained by calculating a per kilogram price for each of the following variables in California, Japan, and Germany. A cost for both 2023 and 2030 were calculated for solar, wind, and blue hydrogen. For the Eavor Loop, sourcing the cost parameters such as lateral drilling cost [7] allowed for multiple cost estimates (see Table 2).

Table 2: Financial Parameters Considered in Comparison

Variable		Solar	Wind	Blue	Eavor Loop
Hydrogen Production	Electricity Production	✓	✓	x	✓
	Electrolyser	✓	✓	x	✓
	Steam Methane Reformation	x	x	✓	x
	Geothermal Gradient	x	x	x	30º, 50º, 70ºC/km
	Drilling Depth	x	x	x	7 km, 9 km
	Lateral Drilling Cost	x	x	x	$200, 400, 600/m
Transportation		✓	✓	✓	x
Fueling Station		✓	✓	✓	✓

Emissions Calculations

For emissions intensity of the hydrogen production from well-to-pump, a preliminary life cycle analysis (LCA) was performed to estimate the emissions for each energy source from materials sourcing to dispensing of the fuel. Emissions (in grams or kilograms of CO2 equivalent) per unit of energy (such as kWh) were converted to emissions per kg of hydrogen. The Eavor Loop emissions included components such as materials sourcing, construction, and the life cycle emissions of the electrolyser. The emissions for the wind, solar, and blue hydrogen production methods were taken from a literature review [8, 9].

Results

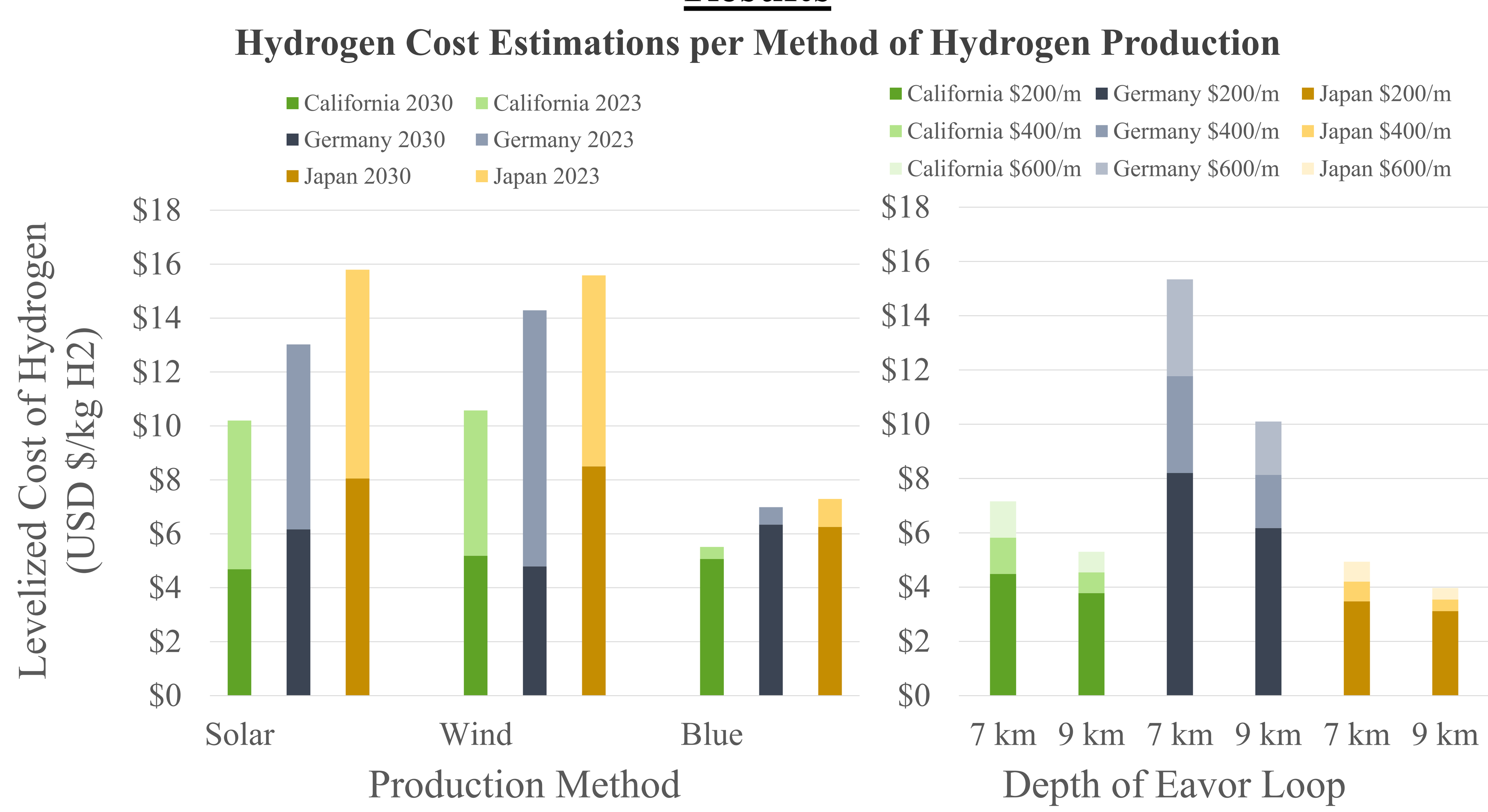

Figure 2 & 3: Solar, Wind, and Blue Hydrogen Costs Compared to Eavor Loop Cost

Results - Continued

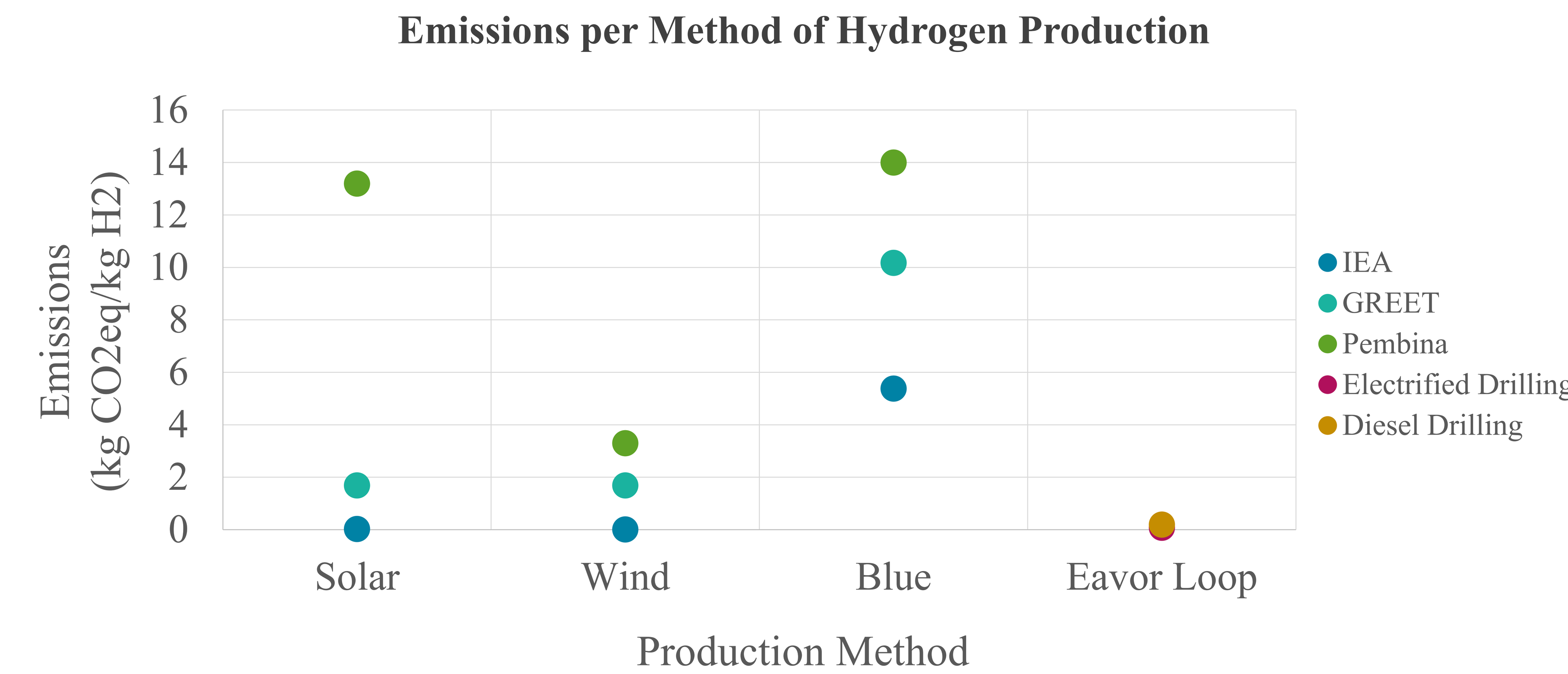

Figure 4: Emissions per Production Method, from Well-to-Pump

The cost of Eavor Loop hydrogen production is shown to be competitive. The 9 km loop with a $200/m lateral drilling cost brings the price below $4, which is lower than the calculated cost of production using solar energy in California in 2030 – the lowest of the 2030 cost estimates. As for emissions, the Eavor Loop is lower than all other methods. Solar can be quite high in emissions, but blue hydrogen is the highest overall.

Discussion

An Eavor Loop for use in hydrogen production has low cost estimations and emissions intensity due to zero emissions electricity and production onsite. Costs for other methods come down in future predictions, but Eavor Loop numbers are feasible. Compared to blue hydrogen, which is based on fossil fuels, the Eavor Loop hydrogen production system is financially competitive and far less emissions intensive. Blue hydrogen is experiencing issues with capturing the promised percentages of carbon [10], thus making the carbon intensity similar to grey hydrogen (no carbon capture). Wind and solar as hydrogen production electricity sources are less competitive due to their land usage and the need to transport the hydrogen but are lower in emissions intensity compared to blue hydrogen. Most solar panels are also produced using energy from fossil fuels in China, thus raising the associated emissions intensity.

Therefore, an Eavor Loop could be used for onsite hydrogen production and dispensing at a fueling station. The need to decarbonize the heavy-duty trucking industry is an issue worldwide, and converting to zero emissions, cost competitive fuel could lessen our dependence on fossil fuels.

Conclusions

An Eavor Loop, used in conjunction with an ORC generator and an electrolyzer, can produce emissions free and low cost hydrogen when compared to both traditional and newly popular methods of hydrogen production. The emissions of an Eavor Loop are a fraction of those associated with wind, solar, and blue sourced hydrogen. Financially, the Eavor Loop hydrogen production system is competitive in price compared to other methods. The proposed system in this study has a lot of potential to decarbonize methods of hydrogen production and the trucking industry.

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