NUCLEAR HYDROGEN

An investigation into the design, cost, feasibility, and impact of the Copper Chlorine thermochemical cycle in producing clean H_2.

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BACKGROUND

The increasing environmental impact of traditional energy sources has spurred the development of cleaner alternatives, including hydrogen. Hydrogen offers **high energy density**, **low environmental impact**[2,3], and **abundant availability**. Our team is investigating the implementation of hydrogen production alongside nuclear energy to store excess energy. Nuclear plants are most efficient when running continuously at high temperatures, but energy demands fluctuate, as seen in figure 1. To optimize efficiency and resource utilization, we propose **using excess thermal and electric energy** during low demand for on-site hydrogen production. We are investigating a four-step thermochemical cycle for this purpose that involves copper and chlorine compounds to split water into hydrogen and oxygen. This cycle, known as the **four-step Copper Chlorine cycle**, offers high utilization of intermediaries, potential 100% recyclability [4], and lower thermal energy demands compared to other methods [5].

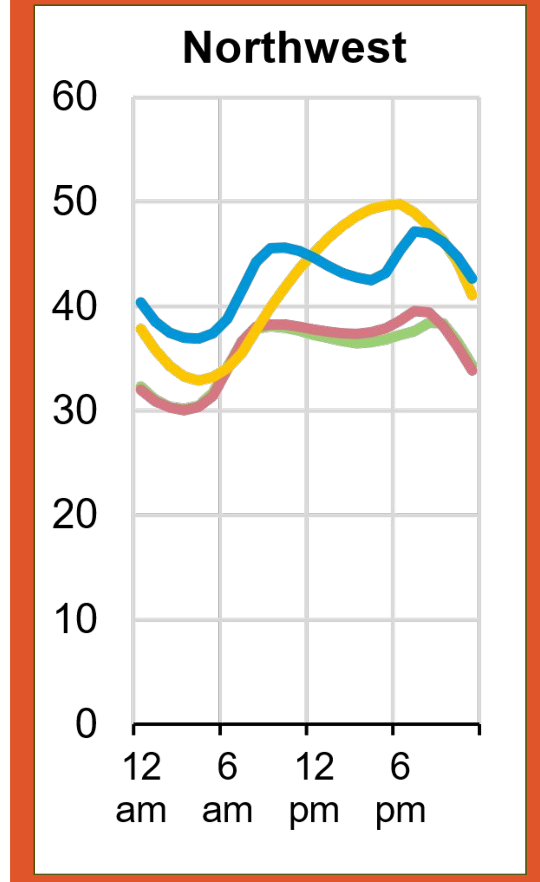

Figure 1: Average hourly electricity load (million kWh)[1]

ENVIRONMENTAL IMPACT

- Nuclear energy: no CO_2 emissions (clean energy) [2,3]
- Thermochemical cycles and electrolysis: no greenhouse gas emissions [4]
- Cu-Cl cycle: least contribution to global warming and acidification among hydrogen production processes, fewer toxins into the atmosphere [6]
- Reactors: require less space compared to traditional clean energy (e.g., 3 million solar panels to one nuclear plant) [7]

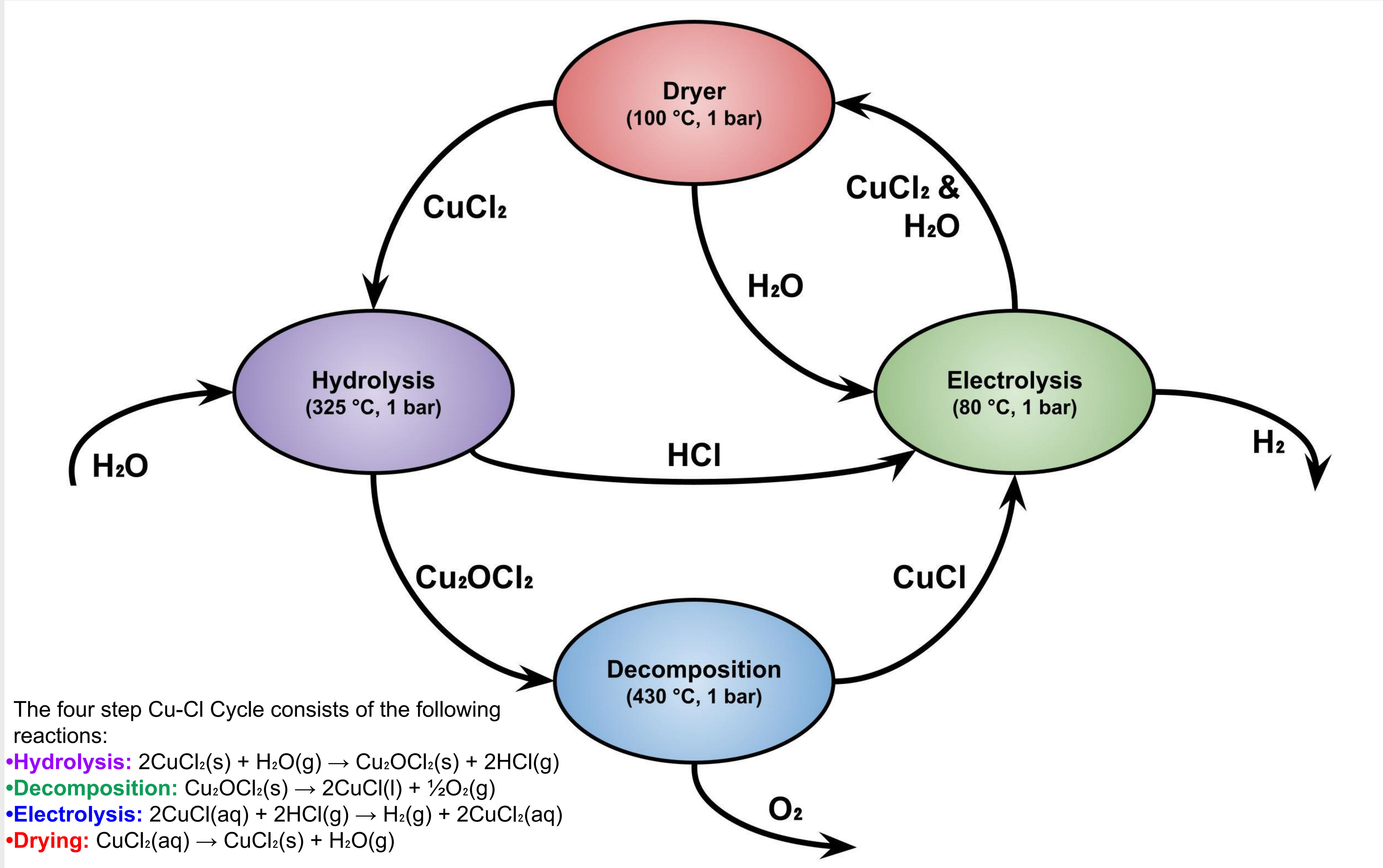

Figure 2: Visualization of the Four-Step Copper Chlorine cycle

SENSITIVITY ANALYSIS

- Calculations based on production rate of 187,000 kg H_2/day
- Different temperatures affect the efficiency/conversion of each step
- Figures 3-5 present the cost dependence on operating temperatures

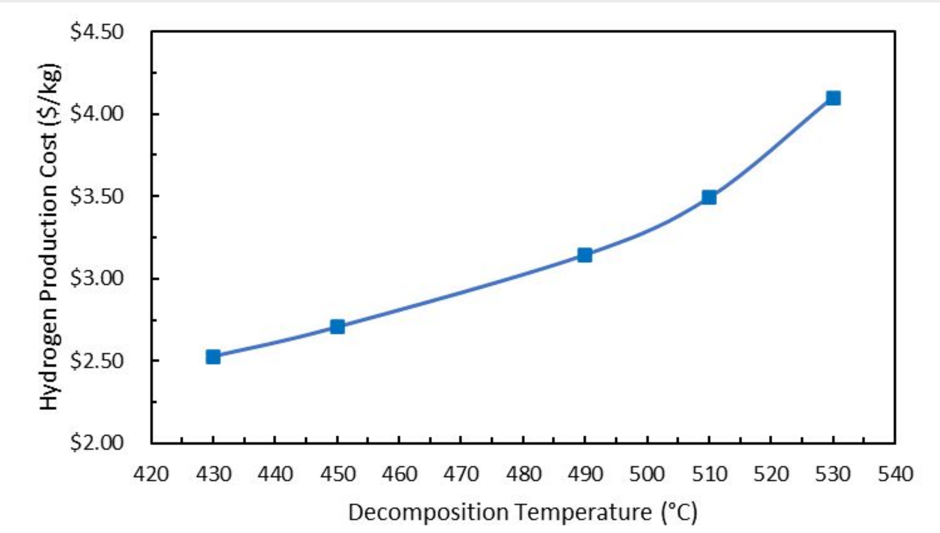

Figure 4: Decomposition Temp. Sensitivity Analysis

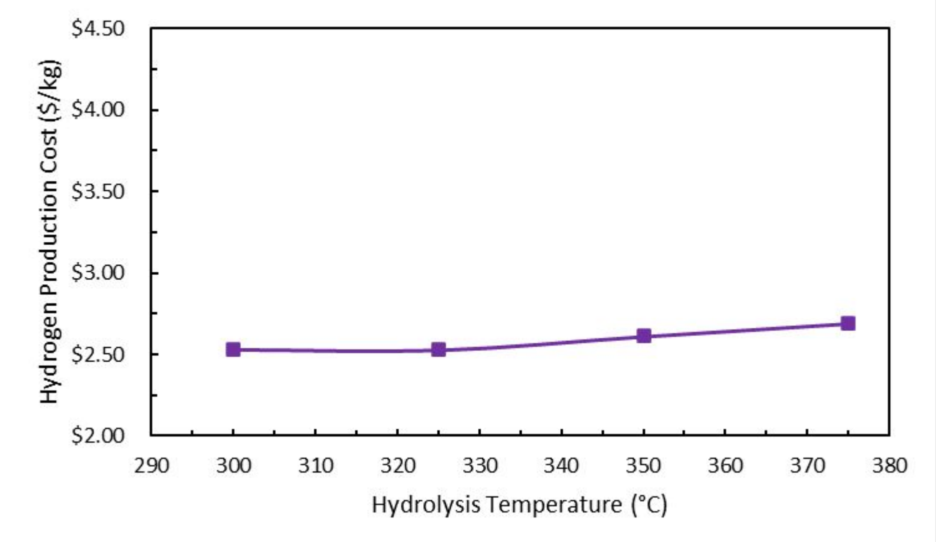

Figure 3: Hydrolysis Temp. Sensitivity Analysis

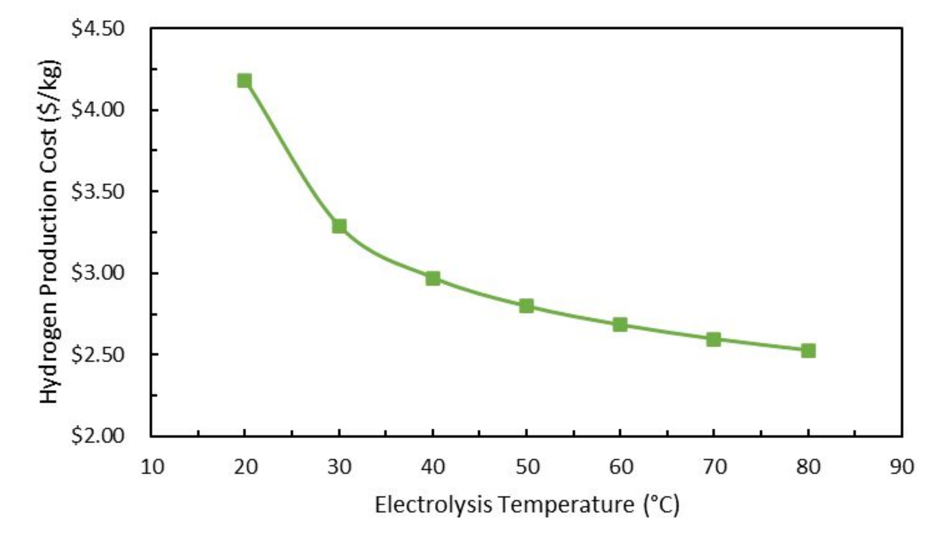

Figure 5: Electrolysis Temp. Sensitivity Analysis

CONCLUSIONS

Government agencies such as Atomic Energy of Canada Limited (AECL); United States Department of Energy (DOE); Japan Atomic Energy Agency (JAEA); and French Alternative Energies and Atomic Energy Commission (CEA) have recognized the Cu-Cl cycle to be one of the most promising cycles for thermochemical hydrogen production that utilizes Generation IV nuclear reactors, SCWR [8]. This support's our model's preliminary calculations for cost as shown below in Figure 6.

Method	Cost ($/kg H_2)
Cu-Cl (model)	2.50 – 4.25
Cu-Cl (literature)	2 - 3
HTSE	2 - 5.71
S-I	2.07
HyS	2-3

Figure 6: Cost comparison to our model

Considering environmental concerns, energy usage, and our model's calculations, the **Cu-Cl cycle is a viable** method for hydrogen production.

FUTURE WORK

- Reactor design
- Scale-up and integration
- Oxygen usage

ACKNOWLEDGMENTS

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