

Decarbonisation of Data Centers via Hydrogen-Based Cooling

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Introduction

Hydrogen-assisted rack cooling combines a PEM/DC power source, compact refrigeration, sensing, and optimization to reduce grid electricity use while maintaining safe server inlet conditions. The project addresses the high energy and carbon cost of data-center cooling by demonstrating a practical rack-scale system that supports temperature and humidity control, real-time monitoring, and lower grid demand.

Constraints

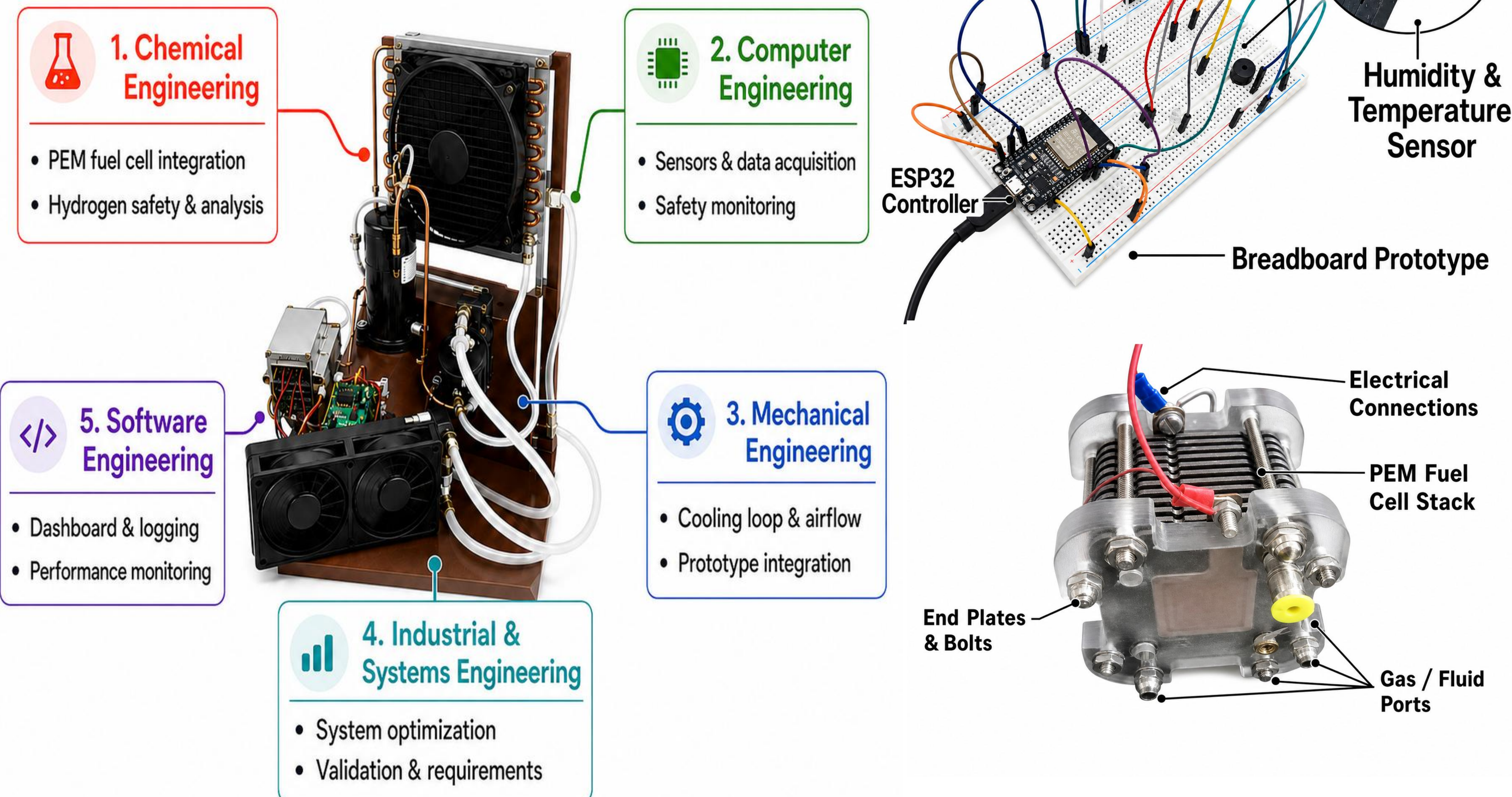
- Budget $\leq 7,500$ SAR.
- Footprint $\leq 0.8 \text{ m} \times 0.8 \text{ m} \times 1.0 \text{ m}$; prototype mass $\leq 40 \text{ kg}$.
- Control electronics must remain within SELV ($\leq 60 \text{ V DC}$).
- Hydrogen handling requires safe monitoring and alarm response.
- Setup and teardown must remain within a practical deployment window.
- Data Format and Documentation Compliance

Specifications

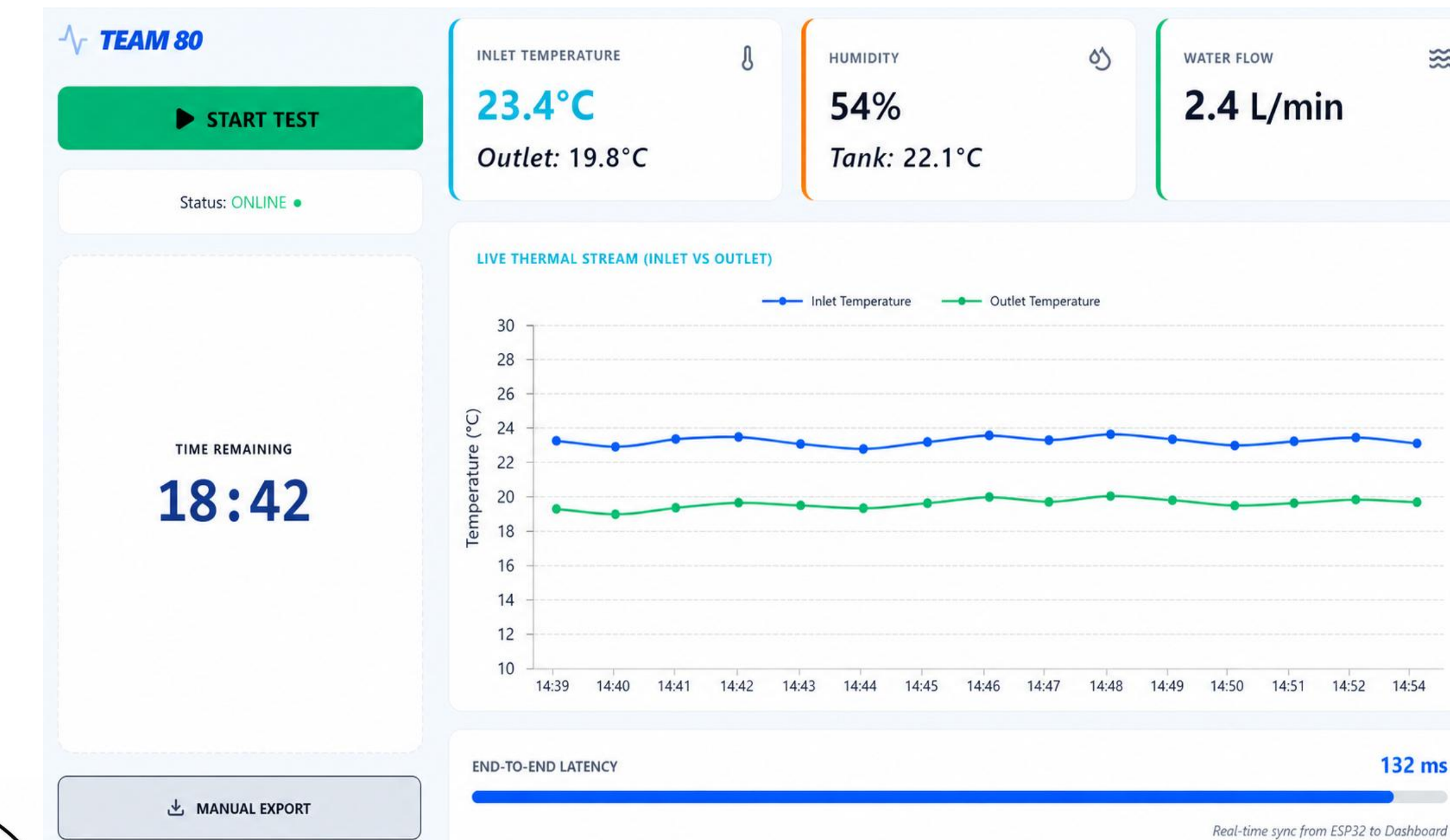
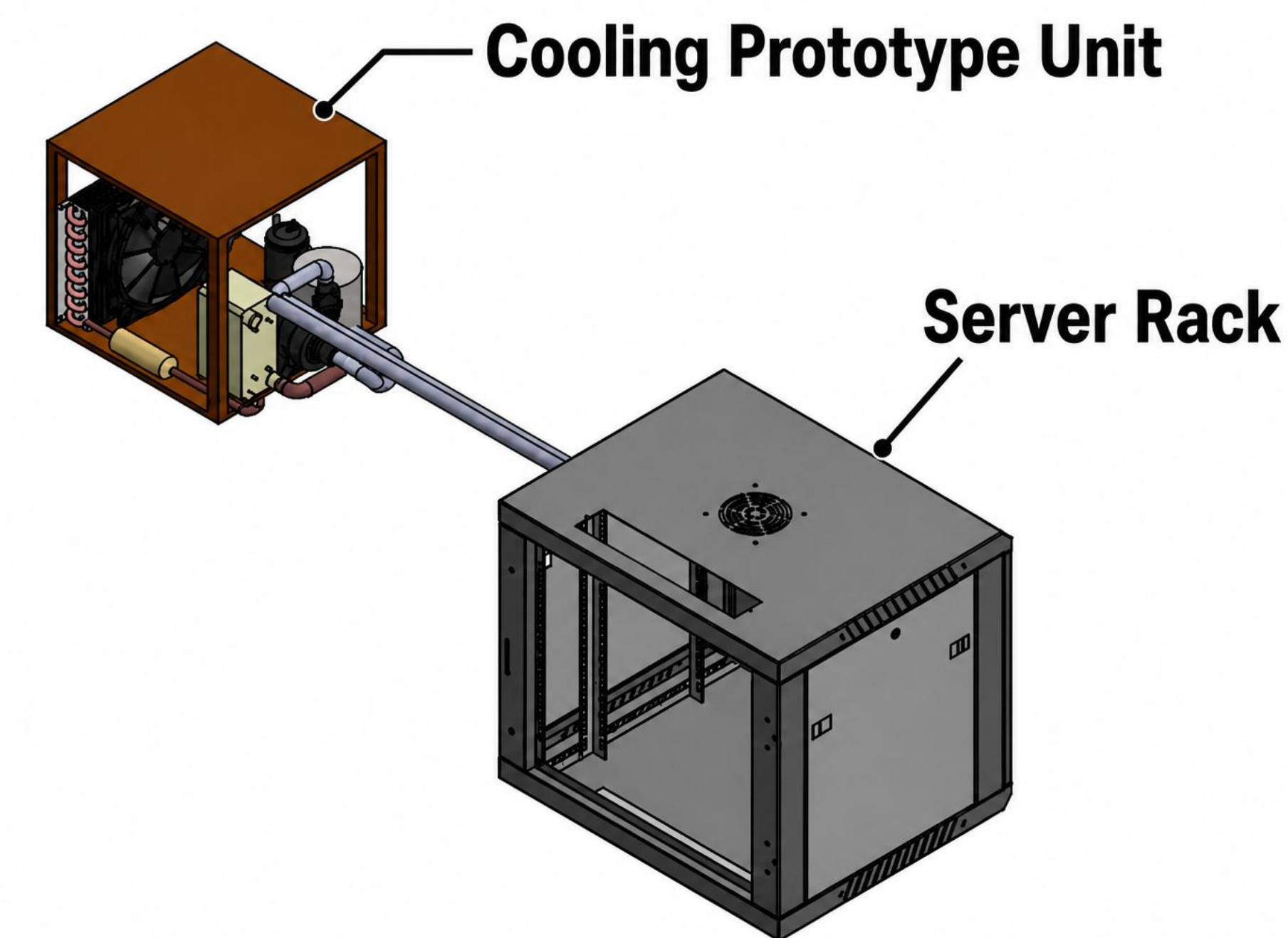
- Cooling load $\geq 500 \text{ W}$
- Rack inlet: $20\text{--}27^\circ\text{C}$
- Relative humidity: $30\text{--}60\%$
- Inlet airflow $\geq 70 \text{ CFM}$
- COP ≥ 2.5
- Sampling $\geq 1 \text{ Hz}$
- Packet loss $\leq 1\%$
- Dashboard latency $\leq 500 \text{ ms}$
- Local alert response $\leq 1 \text{ s}$
- OR mode selection every 5 min

Discipline Contribution

Hydrogen-Assisted Cooling System Prototype



Prototype Development



560 W Cooling load	21% Energy reduction	2.63 Measured COP
23.1°C Final inlet	110 CFM Condenser airflow	<500 ms Dashboard latency

Conclusion

- Feasible hydrogen-assisted architecture for partial grid displacement at rack scale.
- Met key thermal, airflow, monitoring, and optimization targets.
- Next step: dedicated hydrogen hardware validation and larger-scale testing.