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Techno-Economic and Policy Analysis of Ocean Current Energy for Hydrogen Storage and Grid Resiliency in Florida

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Outline

- Motivation & Vision
- Methodology
- Ocean current variable calculation
- Simulation result
- Conclusion & Future work

Motivation

Energy Dominance (Import Dependence)

• Heavy reliance on imported fuels, including hydrogen
• Limited local generation weakens energy independence
• Vulnerability during national/international supply disruptions

Hurricane Vulnerability

• Florida is frequently hit by severe hurricanes (e.g., Irma, Ian)
• Power outages and fuel shortages during disasters
• Critical need for **resilient, decentralized** energy systems

Vision & Objective

Use	Use Florida’s predictable ocean currents to generate clean energy locally (no primary subsea power export), providing stable and reliable power suitable for continuous hydrogen production and grid support.
Produce	Produce green hydrogen to reduce energy import dependence and support statewide energy dominance
Enhance	Enhance grid resilience during disaster conditions (e.g., hurricanes) using reliable local generation

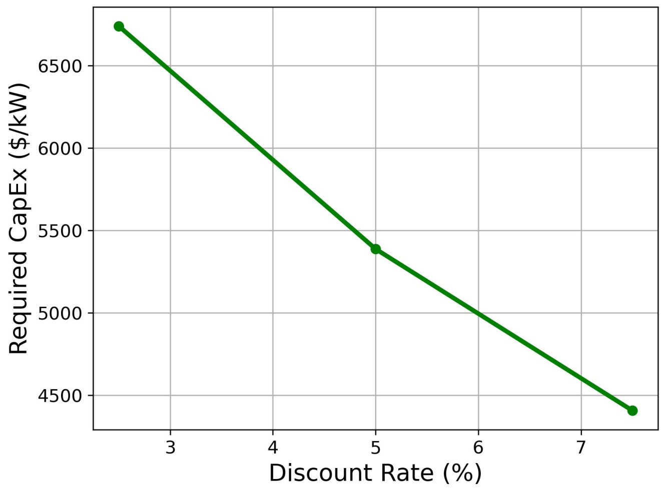
Methodology

- **Simulate realistic system configurations** (OC, PV, Grid) for hydrogen production and delivery by HOMER

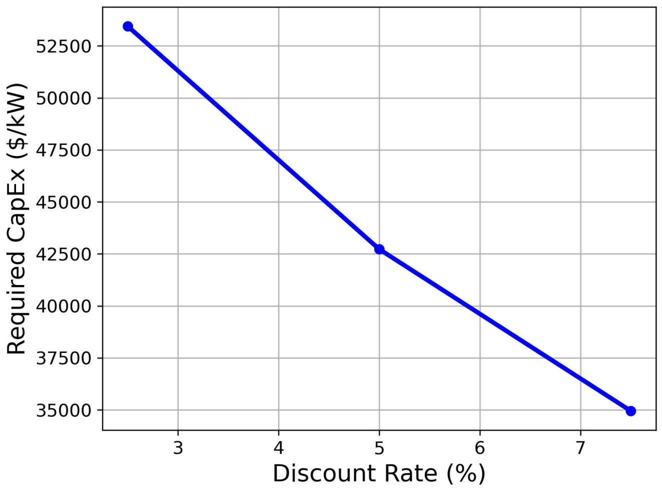
- **Use DOE 2035 cost targets** for LCOE and LCOH as *benchmarks* to estimate required capital & operation costs (FOM)

Capital Cost Estimation Based on DOE Target

The results for different discount rates are plotted. For example, at a discount rate of 7.5%, achieving an LCOE of $0.11/kWh requires a capital cost of approximately $3750/kW.



LCOE= 0.11



LCOE= 0.56

$$\text{LCOE} = \frac{(CRF \cdot OC + FOM) \cdot 1000}{8760 \cdot CF}$$

$$\text{CRF} = \frac{r(1+r)^t}{(1+r)^t - 1}$$

- OC is the overnight capital cost ($/kW)
- CF is the capacity factor
- FOM is the fixed operation and maintenance cost ($/kW/year)
- CRF is the capital recovery factor, calculated as:

[4] N. Sockeel, A. Galeana, and R. Cox. "Techno-economic study of marine hydrokinetic turbines for electricity production over the US Gulf Stream". In: Proceedings of the 2022 IEEE Green Technologies Conference (GreenTech). IEEE. 2022, pp. 68–73.

The sensitivity of the levelized cost of energy (LCOE) to variations in fixed operation and maintenance (FOM) cost

- ✔ Capital cost (CapEx) of $3000/kW[4]
- ✔ Capacity factor (CF) of 0.76 [4]
- ✔ System lifetime of 20 years
- ✔ Discount rate of 7.5%.

Table 1: Fixed O&M Impact on LCOE

Fixed O&M ($ /kW/yr)	LCOE ($ /kWh)
100	0.044
200	0.059
300	0.074

Simulation Setup

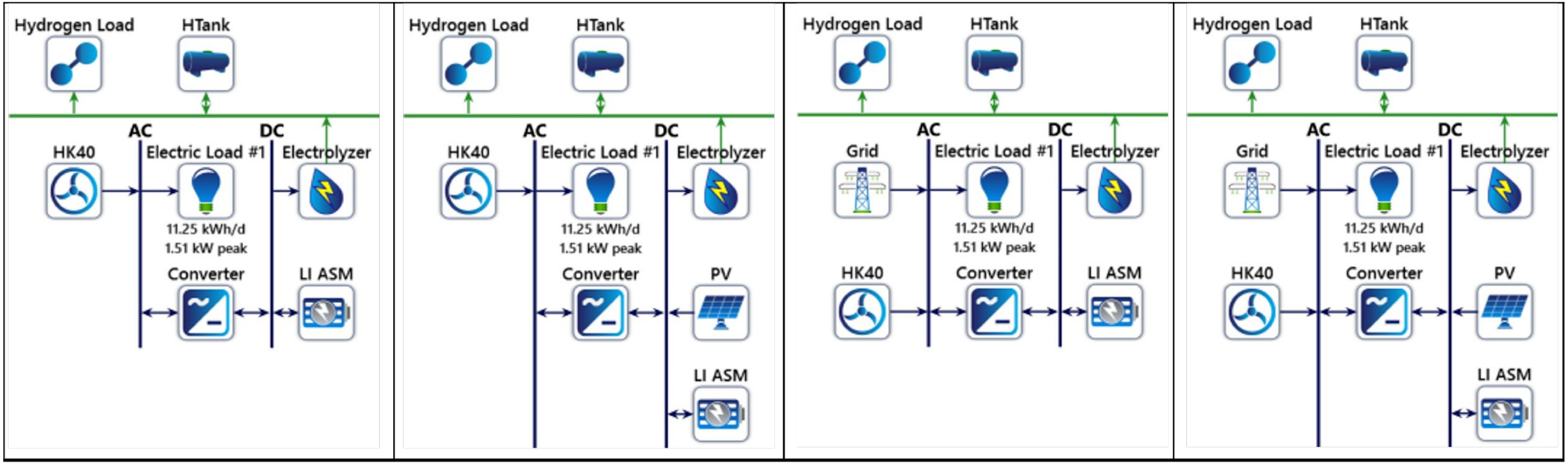


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Table 1: Fixed O&M Impact on LCOE

Fixed O&M ($ /kW/yr)	LCOE ($ /kWh)
100	0.044
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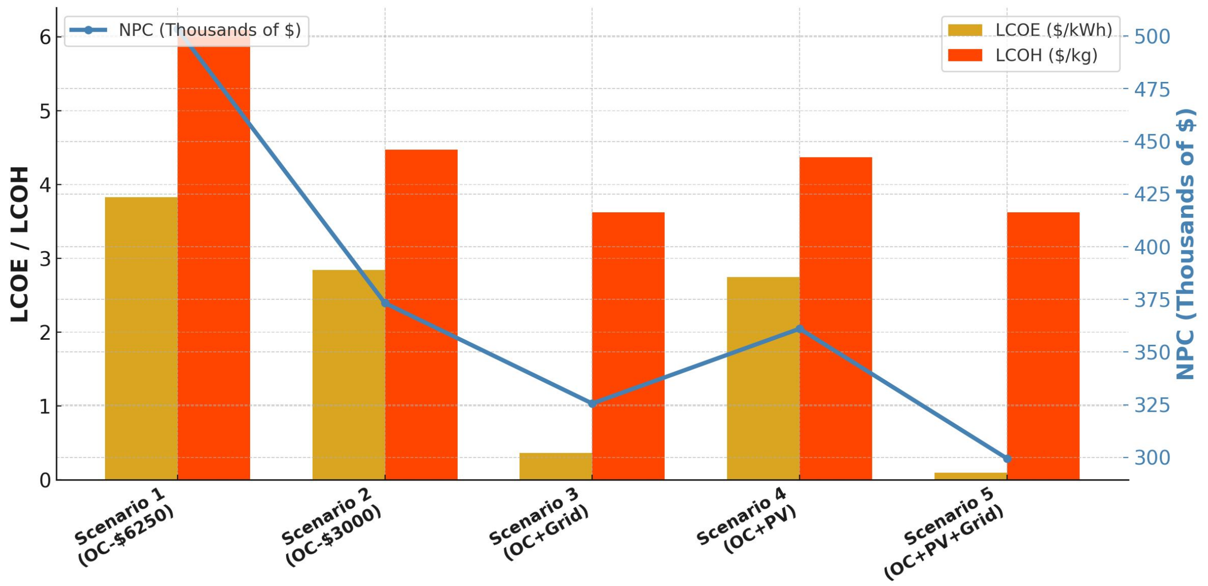
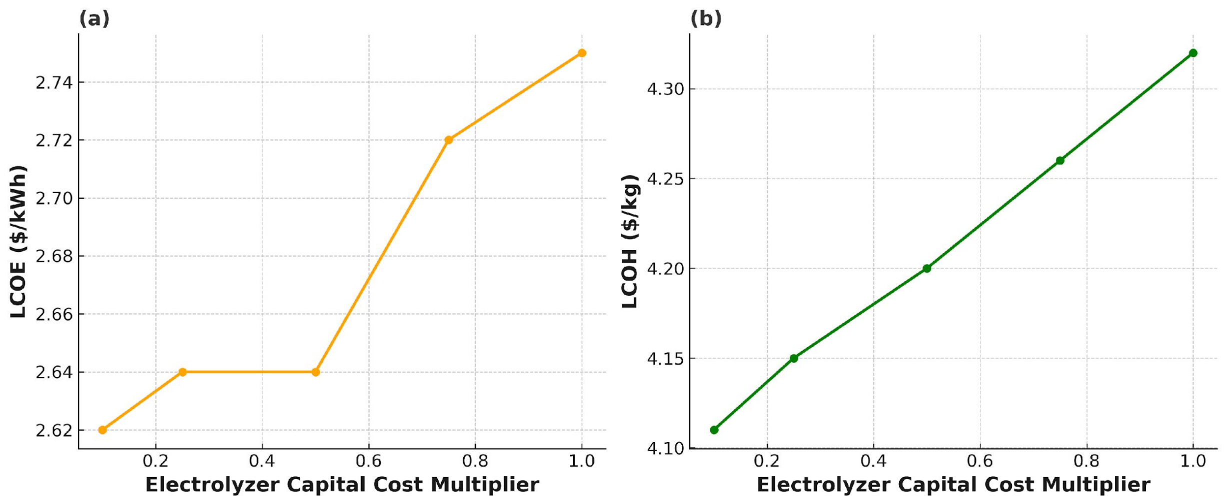
300	0.074

Table 2: Unit Cost Assumptions

Component	Cost
HK Turbine (HK40)	$3,000–$6,250/kW
Electrolyzer	$1,080/kW
H_2 Tank	$1,200/kg
Converter	$300/kW
Solar PV	$2,500/kW

Simulation Results





Scenario	LCOE ($/kWh)	LCOH ($/kg)	Electrolyzer Utilization	Grid Export	Notes
1: OC Only (CapEx=$6250/kwh)	3.87	6.05	Low	❌	Too expensive
2: OC Only (CapEx=$3000/kwh)	2.80	4.62	Low	❌	Single source limitation
3: OC + Grid	0.30	3.75	Medium	⚠️ Partial	Low renewable share
4: OC + PV	2.70	4.47	Medium	❌	High variability
5: OC + PV + Grid	**0.12**	**3.60**	**High**	✅	Best trade-off, most effective

Conclusion

- Techno-economic feasibility of ocean current energy for hydrogen and grid resilience in Florida was assessed.
- DOE 2035 benchmarks (LCOE $0.11/kWh) used to derive capital cost targets.
- Discount rates (e.g., 7.5%) via public-private partnerships improve project viability.
- Hybrid system (Ocean Current + PV + Grid):
  - CapEx = $3,000/kW
  - O&M = $100/kW/year
  → LCOE = $0.12/kWh, LCOH = $3.62/kg
  - Jang: Wind-to-hydrogen systems show falling LCOH=$6.72
  - Temiz & Dincer: PV-powered hydrogen ferries proposed LCOH=$6.83/kg
- Electrolyzer utilization reached 82%, enabling net-negative CO_2 and surplus electricity export.
- Hybrid ocean systems + policy support (Discount rate,..) → energy independence, zero-carbon hydrogen, marine hydrogen leadership for Florida.

Future Work

- **1. Unmet Load and Energy Shortfall Analysis**
  - Quantify reliability and resilience under various outage or demand surge scenarios
- **2. Sensitivity Analysis: O&M Costs**
  - Assess how varying maintenance expenses affect overall LCOE/LCOH and project viability
- **3. Economic Sensitivities**

  Explore effects of:
  - Electricity price volatility
  - Hydrogen market price
  - Inflation and discount rate assumptions
- **4. Environmental Impact Assessment**
  - Evaluate life cycle emissions, marine biodiversity impact, and grid decarbonization contribution
- **5. System Expansion Planning**
  - Investigate scalability and potential integration with ports, EV charging

Thank you

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This work was supported in part by the National Science Foundation under Grant No. CMMI-2145571 and the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Water Power Technologies Office (WPTO) Award Number DE-EE0011382.

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