

# POWERING the BLUE ECONOMY™

## Economics of Marine Renewable Energy Systems

Scott Jenne, National Renewable Energy Laboratory

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# How do we evaluate economic potential?

## LCOE – Levelized Cost of Energy

Levelized cost of energy represents the **average revenue per unit of electricity generated** that would be required to **recover the costs** of building and operating a generating plant during an assumed financial life and duty cycle.

Source: U.S. Energy Information Association. 2020. *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2020*. [https://www.eia.gov/outlooks/aeo/pdf/electricity\\_generation.pdf](https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf).

$$LCOE = \frac{\overbrace{(FCR * CapEx)}^{\text{Year 0}} + \overbrace{(OpEx)_{Annual}}^{\text{Years 1-n}}}{AEP}$$

### Terms

- **FCR** – Fixed Charge Rate, a simplified financial term that accounts for real discount rate, depreciation, taxes, inflation, and economic life
- **CapEx** – Capital expenditures
- **OpEx** – Operating Expense
- **AEP** – Annual energy production

# Limitations of LCOE

## A lot is baked in...

**FCR** – Not always applicable for Powering the Blue Economy (PBE) applications, and when applicable, may need to be drastically modified.

**CapEx (Capital Expenses)** – Still applicable, but more—or in some cases less—costs may need to be considered for a proper comparison.

**OpEx (Operating Expenses)** – This may be a wild card. Some applications may not allow maintenance (set it and forget it). Some applications may have set maintenance intervals (e.g., rigorous sensor calibration schedule).

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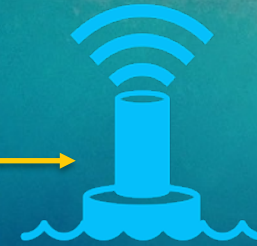
# PBE is rooted in economic opportunities

## Limitations suggest opportunity

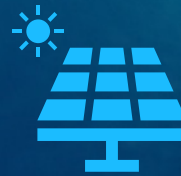
**FCR** – Financing and the timelines associated with it.

**CapEx** – Utility-scale energy projects (for any generating technology, renewable energy or fossil) are capital-intensive.

**OpEx** – For the same reason renewables were attractive early in their development cycles, marine renewable energy (MRE) may be attractive for PBE opportunities.



Example: Many ocean observation systems are not financed and may only operate for months to a couple of years before being decommissioned. This may provide faster learning cycles for MRE technology developers.



Example: Even extremely competitive, low-cost, grid-scale photovoltaic arrays cost millions in up-front capital.\* Low-power PBE markets may provide more opportunities for MRE technologies with lower capital burdens.



Example: Just the cost of vessels for autonomous underwater vehicle deployment and retrieval can be \$15,000 per day (Cavagnaro et al. 2020). MRE systems may be able to significantly reduce operating costs in a similar way that RE technologies could eliminate volatile fuel costs associated with fossil power plants.

\* Smith, B. and R. Margolis. 2019. *Expanding the Photovoltaic Supply Chain in the United States: Opportunities and Challenges*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73363.  
<https://www.nrel.gov/docs/fy19osti/73363.pdf>

# Evaluation of PBE opportunities

## Likely not one metric...

- LCOx – leveled cost of data collection, water, etc.
- Payback period – Can MREs provide a faster payback, and if so, in what scenarios?
- Net present value (NPV) – Can MREs provide additional revenue after the “economic life”?
- Value driven – What can you do with MRE that you can’t do without?
- Resiliency

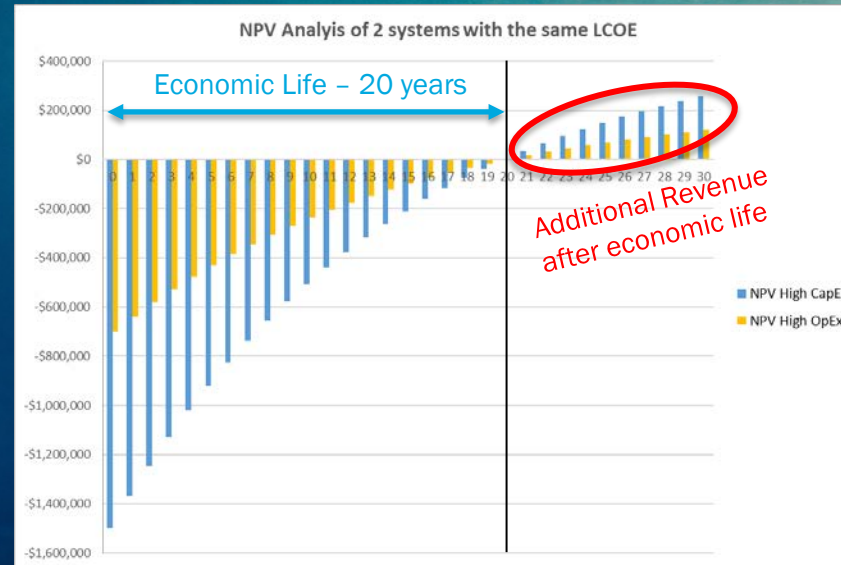


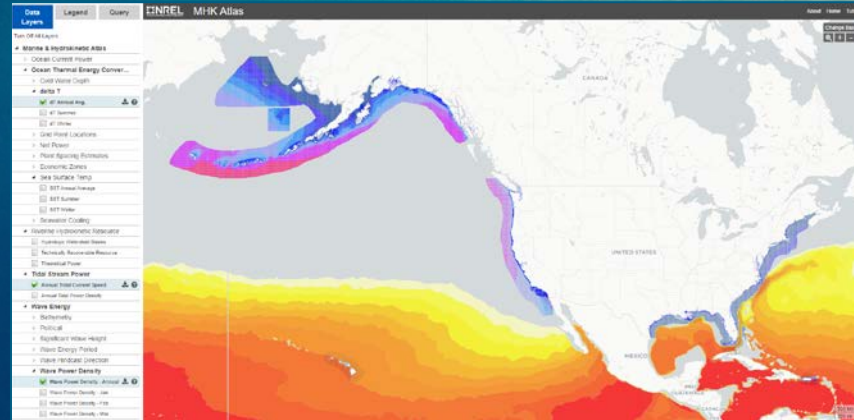
Image courtesy of: Woods Hole Oceanographic Institute, Ocean Observatories Initiative.

Potential for data collection that would otherwise be impossible without MRE

# Looking Forward

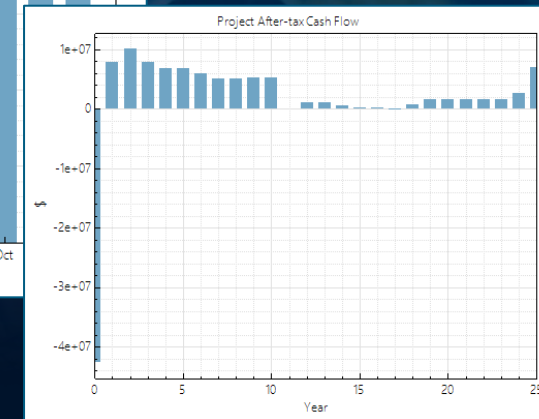
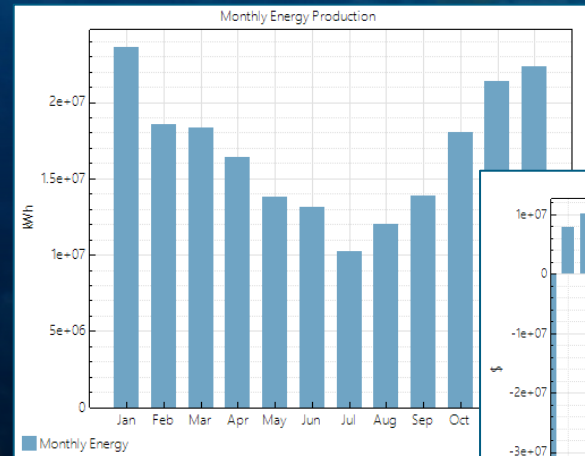
## SAM Upgrades

- Link System Advisor Model (SAM) with Marine and Hydrokinetic (MHK) Atlas (new resource data including time histories).
- Develop more versatile economic models (e.g., traditional cash flow, flexible process models).



## More Use Cases

- **Customer Discovery** – Understand pain points and economic drivers for potential end users.
- **System Requirements** – Continue understanding technical and nontechnical requirements for different applications.



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# Thank you

Scott Jenne, NREL

Dale.Jenne@nrel.gov

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