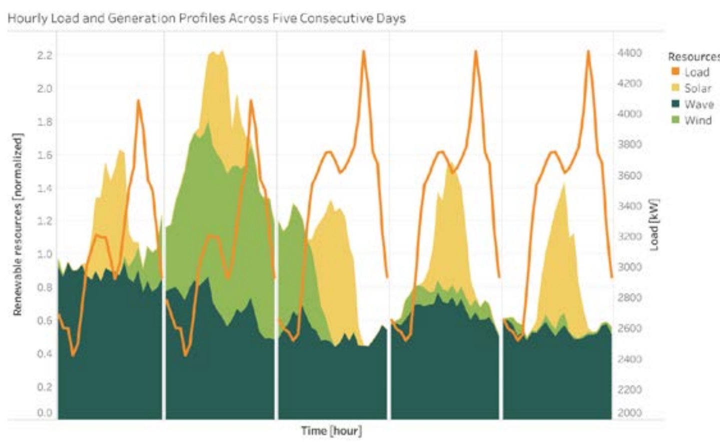
GRID VALUE PROPOSITION OF MARINE ENERGY: **A PRELIMINARY ANALYSIS**

Pacific Northwest NATIONAL LABORATORY

Marine energy has the potential to be a key clean energy resource of the future U.S. grid and its transition to a 100% renewable energy economy. Their promise is significant: a recent study from the National Renewable Energy Laboratory finds that **marine energy resources have the potential to provide 57% of U.S. electric needs**. The currently installed wind and solar capacity across the country served 12% of electricity needs in 2020.

While technologies that convert marine energy resources to renewable power are advancing rapidly, **they remain in an early stage of development and** the industry still faces hurdles to reach full commercialization. Without many real-world deployments, the value they represent to the electric grid is not well known and not captured by traditional energy comparison metrics like the levelized cost of energy.

The goal of this work is to identify, evaluate, and measure characteristics of marine energy that may offer unique benefits to the electric grid by building a crosswalk between resources, technology, and electric grid value.

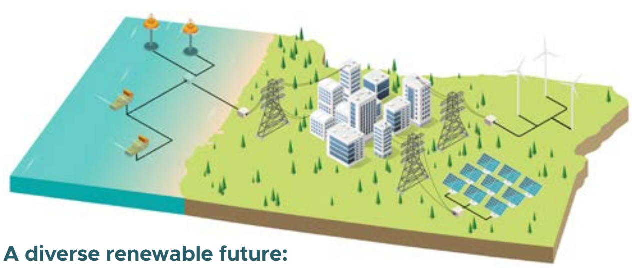


This graph highlights the complementary value associated with deploying wave alongside other renewables on an island system for 5 days in December on the island of Molokai. Load is indicated by the orange line and the generation resources are normalized and stacked: solar in yellow, wind in light green and wave generation in dark teal.

VALUE PROPOSITIONS

Marine energy can provide important complementarity and diversity within a portfolio of renewable resources:

- Marine energy has a **higher load carrying capacity**, a measure of a resource's ability to generate electricity when the grid is likely to experience energy shortfalls, relative to solar and wind generation.
- The added diversity of using marine energy reduces the need for balancing resources to meet electricity needs by up to 20%. This directly manifests in **cost savings to the system at large**.
- Deploying marine energy in a clean grid **reduces the need to build energy storage capacity to ensure system reliability by up to 40%**.



A diverse renewable future: the deployment of wave energy along the Oregon coast.

Marine energy resources can help serve coastal loads where more than 40% of our population resides:

- Deploying marine energy can reduce transmission buildout needed to meet clean energy goals and provide increased reliability and resiliency.
- Increasing amounts of marine energy fulfills local energy needs and provides energy to regional loads, reducing existing transmission utilization and reliance on imports. This additional transmission capacity can then be used to deliver more renewable generation on both western and eastern coasts.

Marine energy resources can help reduce the reliance on imported fuels for small, island and remote grids, while supporting local energy system reliability.

- Marine energy helps stabilize power quality on smaller, distribution grids. For example, tidal deployment on Nantucket can help the system meet voltage quality requirements, resulting in grid equipment staying within limits and extending equipment lifespan, reducing costs.
- Tidal generation minimizes operational risk levels relative to variable resources like solar or wave in both normal operating and grid disruption conditions on Nantucket.
- Incorporating new wave resources to meet a 100% emissions free target on the Hawaiian island of Molokai requires up to 15-50% lower wave capacity than solar to deliver the same energy. Similarly, wave energy's predictability reduces the need for energy storage by up to 20%, reducing both equipment and land costs.

KEY DEFINITIONS

- For purposes of this investigation, the term **grid value** is meant to include, but not be limited to, provision of a defined grid service, measurable benefit to grid performance, avoided costs to system investments or operations, revenue capture, and contribution to desired grid qualities (e.g., low carbon intensity).
- **Capacity and specifically, capacity value,** is a measure of a resource's ability to generate electricity relative to its installed capacity during periods of grid strain, for example, highest energy demand hours, or peak hours.
- **Load-carrying capacity** or effective load-carrying capacity (ELCC) is a statistical measure of capacity value. It represents the amount of additional load a resource can serve (relative to its installed capacity) when added to a system while maintaining system reliability.
- A **distribution grid** is the set of lower voltage infrastructure including wires, substations, feeders and other equipment that delivers electricity from the transmission system to customers. Smaller generators may be directly connected to the distribution system. The transmission system is higher voltage infrastructure that delivers electricity to the distribution system from large generators.
- Delivering reliable electricity to customers requires ensuring generation matches electricity demand at every instant. **Balancing resources, or reserves**, are those resources that ensure this match and can consist of fast moving natural gas generation, energy storage, or to an extent, inverter connected renewable resources.
- **Power quality** is a metric that defines how well the voltage and frequency of electricity complies with specifications. Poor power quality can mean connected devices do not operate properly. A system operator must ensure the system remains within acceptable power quality limits.

For more information, contact:

DHRUV BHATNAGAR
Project Investigator
Dhruv.Bhatnagar@pnnl.gov | (971) 940-7114

https://www.pnnl.gov/projects/marine-energy-grid-value

NOVEMBER 2021 | PNNL-31123 FLY