NREL researchers and crew visited Cook Inlet, Alaska, to collect data for a potential tidal energy site. *Photo by Levi Kilcher, NREL*

Powering the Blue Economy™

Foundational Research and Development

To spur economic growth and revitalize the ocean, the U.S. Department of Energy's (DOE's) Water Power Technologies Office (WPTO) launched the Powering the Blue Economy™ (PBE) initiative, which aims to foster long-term, sustainable growth of the blue economy by protecting the ocean and understanding and leveraging its immense power, learning the power needs of emerging coastal and maritime markets, and advancing marine renewable energy technologies.

NREL is helping achieve PBE goals through early-stage research and development by investigating power needs for blue economy sectors, such as offshore marine aquaculture, underwater vehicle charging, ocean observation, desalination, and seawater mining.

For example, NREL researchers are exploring the feasibility of using marine energy to provide power at sea and build resiliency in coastal communities, with a focus on disaster recovery. To this end, the team is researching designs for small-scale marine energy technologies.

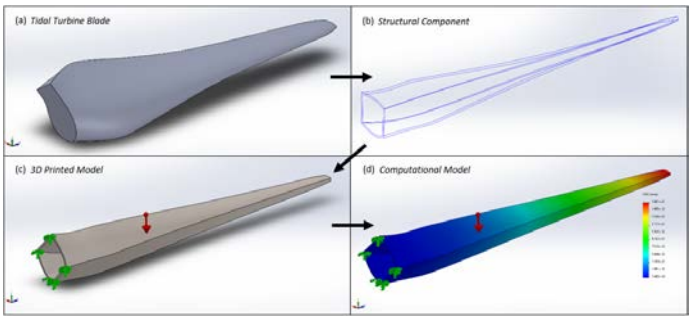
NREL also administers PBE prizes and competitions, like the Waves to Water and Ocean Observing Prizes and the Marine Energy Collegiate Competition, that help advance the foundational research that is necessary to develop and evolve blue economy solutions. By supporting foundational research and development, NREL seeks to advance marine energy by finding the best solutions for real-world applications.

Design and Prototyping: 3D Printing Tidal Turbine Rotors

NREL and Pacific Northwest National Laboratory (PNNL) researchers have been collaborating on new techniques to build and maintain tidal turbines using 3D printing (or additive manufacturing). Specifically, the team is exploring 3D printing to build rotors for small marine turbines. Over the course of the project, the team aims to:

- Specify turbine size and design
- Determine the appropriate 3D printing processes and materials
- Print, test, and evaluate prototypes with critical features to improve the overall design.

In FY 2022, the research team assessed available additive manufacturing processes and materials for marine applications, mechanically characterized the most appropriate materials under both dry and seawater conditions and designed critical tidal turbine features and components for structural validation. Specifically, the team compared the strengths of several materials both before and after being exposed to seawater environments, allowing them to select the best 3D printed materials for tidal turbine structures. The team currently has specimens soaking in Pacific Ocean water at PNNL's Marine and Coastal Research Laboratory. Researchers also began the design and optimization process for axial-flow and cross-flow turbine blade designs to evaluate the feasibility and benefits of 3D printing for tidal energy structures.



Computation models of a tidal turbine blade and the main structural component to be 3D printed for the blade. *Graphic by NREL*

New Tools for Marine Energy Research

The Small WEC Analysis tool on OpenEI allows users to explore and compare small WEC performance. *Image from NREL*

NREL researchers have spent the last year developing tools to help build an innovation ecosystem in marine energy research and development. The various tools are publicly available and offer everything from data visualization for wave energy converters (WECs) to dynamic modeling for mooring systems to open-source software that holistically assesses marine energy technology design, optimization, and control.

Small Wave Energy Converter Analysis

In FY 2022, NREL launched the Small WEC Analysis tool on OpenEI. The tool allows users to explore and compare small WEC performance by visualizing WEC data. The interface features various wave energy devices, like attenuators, oscillating surge devices, and point absorbers. Users can select different devices and choose a specific scale to visualize data; they also have the option to compare different devices. Additionally, users can access graphs, table data, and blueprints for each WEC. The tool also allows users to enter specific energy goals and explore WECs that meet their criteria.

MoorDyn & MoorPy

MoorDyn is an open-source dynamic mooring line modeling tool. It uses a lumped-mass formulation for modeling axial elasticity, hydrodynamics, and seabed contact. In FY 2022, NREL added new WEC-specific capabilities to MoorDyn to simulate buoys or near-shore devices. MoorPy coupled to MoorDyn is a quasi-static mooring system library. MoorPy was updated to allow users to estimate the reliability of their mooring system relevant to PBE projects.

OpenFAST

In FY 2022, NREL engineers worked to develop the first open-source software that can holistically assess novel marine energy technologies, like underwater turbines. The tool—brand new to the marine energy industry—allows the simultaneous design of all a device's different components. The tool uses something called control co-design, a term for blending technology design, optimization, and control (the ability to manipulate the device's energy production from afar). Users can plug in variables to learn how various changes might impact their technology's cost, energy output, and robustness.

The research team is adapting NREL's veteran wind energy code, OpenFAST, to account for the physical differences of water, such as density, and provide marine energy developers with accurate simulations of how different designs would perform in the real world. OpenFAST can be used to design turbines across a range of scales, from microgeneration to utility-scale devices. Ultimately, the tool will help accelerate the design of more innovative, cost-competitive marine energy technologies to get them closer to where wind energy and solar power are today.

Puerto Rico's Transition to 100% Renewable Energy Study (PR100)

Puerto Rico has committed to meeting its electricity needs with 100% renewable energy by 2050. In a 2-year study, NREL and a team of five other national labs will provide Puerto Rico's decision makers and planners with the advanced grid analysis and cross-sector modeling support to generate feasible pathways for their clean energy transition. As part of the Puerto Rico Grid Resilience and Transition to 100% Renewable Energy Study (PR100), NREL water researchers spent FY 2022 investigating marine energy resource characterization and techno-economic analyses, which can help provide reliable, affordable, and resilient electricity to Puerto Rico's coastal cities and communities.

DOE Secretary Jennifer Granholm and Puerto Rico Governor Pedro Pierluisi sign a memorandum of understanding which outlines accelerated work to strengthen Puerto Rico's energy resilience and enhance initiatives for clean energy. *Photo by Benjamin Applebaum, U.S. Department of Homeland Security*

NREL researchers and crew prepare to deploy three moorings in Cook Inlet, Alaska. *Photo from Christopher Pike*

Powering the Blue Economy™

Systems of Innovation

The PBE initiative aims to foster long-term, sustainable growth of the blue economy by protecting the ocean and understanding and leveraging its immense power, learning the power needs of emerging coastal and maritime markets, and advancing marine renewable energy technologies. *Graphic by NREL*

Since the PBE initiative started in 2019, WPTO has partnered with a range of industry organizations, incubators and accelerators, universities, and other federal agencies to help advance marine energy technology and attract a diverse community of innovators. To facilitate this strategic network, NREL contributes to commercialization, entrepreneurship, and energy justice efforts.

Commercialization

In FY 2022, NREL continued to support the development of WPTO's strategic innovation ecosystem to make commercialization support more accessible to anyone in the marine energy industry. This ecosystem is made up of prizes, partnerships and sponsorships, and the Testing Expertise and Access for Marine Energy Research (TEAMER) program.

TEAMER
Testing & Expertise for Marine Energy

To improve the diversity of innovators working on marine energy challenges, NREL administered multiple prizes and competitions in FY 2022 that have the potential to fast-track blue economy technologies. These challenges are meant to be more accessible than traditional funding opportunities, attracting a wider pool of applicants and a diverse group of entrepreneurs, students, academics, and hardware developers.

During FY 2022, NREL also fostered partnerships with the Naval Surface Warfare Center in Carderock, Maryland, and the Coastal Studies Institute in Nags Head, North Carolina, for PBE prizes and research projects. As a result of these partnerships, NREL tested water-powered devices in real-world scenarios. These FY 2022 activities helped identify research areas in marine energy technologies that NREL can help advance to bring these technologies closer to market.

To address some of the barriers that hinder advancements in the blue economy for marine energy developers and researchers, the TEAMER program grants innovators access to the nation's best marine energy testing facilities and awards funding for marine renewable energy testing and development projects. TEAMER assists the PBE initiative's goal to move marine energy technologies closer to market by helping researchers and developers refine their blue economy technologies, advance

toward commercial viability, and navigate development and testing barriers. In FY 2022, NREL worked with TEAMER to support innovators by providing access to numerical modeling and analysis; laboratory and bench testing; tank, flume, tunnel, and basin testing; and open water testing.

Economic Development Administration

To better support economic development, entrepreneurial ventures, and job growth as the blue economy continues to develop, WPTO, in partnership with the U.S. Department of Commerce Economic Development Administration, awarded $4 million for the 2020 Industry Challenge: Innovation in the Blue Economy.

NREL continues to support the Blue Economy Industry Challenge, which provides funding for start-up incubators, accelerators, and other innovation hubs that support a range of regional entrepreneurial activities related to generating power from oceans, rivers, and other freshwater and marine environments.

Under the Powering the Blue Economy initiative, seven organizations received awards to support entrepreneurship and accelerate company growth in their communities or regions with an overarching goal to drive growth in the blue economy. Over 3 years, these organizations will contribute to that growth by:

- Supporting the commercialization of blue economy technologies
- Improving the competitiveness of blue economy start-ups
- Increasing connectivity and collaboration between blue economy stakeholders
- Leveraging the blue economy broadly to support innovation and job creation.

In FY 2022, NREL supported these organizations by hosting quarterly workshops for awardees to share best practices, connect with other technology developers, and engage with industry investors.

Evolution of Energy Justice

In FY 2022, NREL worked closely with WPTO to ensure that PBE goals help advance the Justice40 Initiative. NREL supports various PBE funding mechanisms and research opportunities that encourage economic equity, diverse solutions, energy and climate justice, and community resilience. For example, NREL administered the Inclusive Energy Innovation Prize to identify and support activities related to climate and clean energy that build trust and strengthen relationships and partnerships with

Scott Jenne prepares NREL's hydraulic and electric reverse osmosis wave energy converter device for its ocean outing in North Carolina. *Photo by Andrew Simms, NREL*

disadvantaged communities. The prize seeks to enable and enhance business and technology incubation, acceleration, and other community- and university-based entrepreneurship and innovation efforts to develop climate and clean energy technologies as part of the transition to a net-zero-carbon economy by 2050.

Underpinning this work is a collaborative effort between NREL and Arizona State University to better understand the energy and environmental justice (EEJ) implications of past and current WPTO and NREL activities. In understanding these implications, the team aims to develop a tool to better evaluate and inform the likely EEJ impacts of future activities. So far, the project has submitted two manuscripts and is hard at work developing a hands-on tool for researchers and portfolio managers to better track critical aspects of EEJ in their planning, execution, and performance evaluation.

More information

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