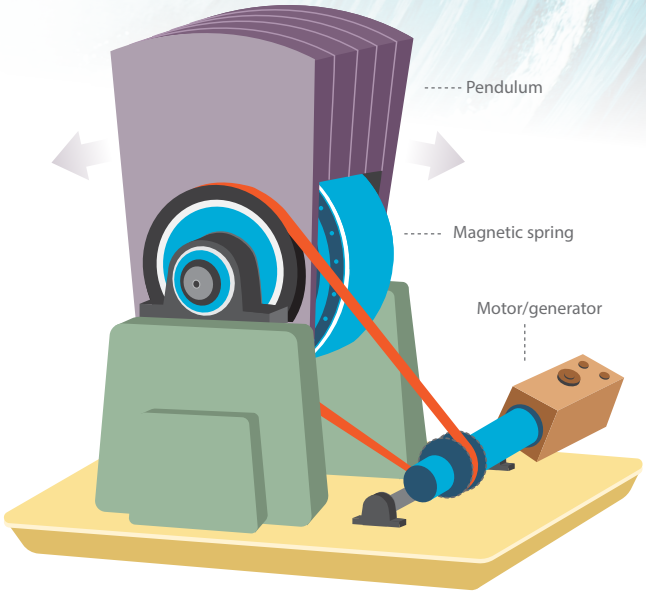
Sandia National Laboratories

DESIGNING THE FUTURE: ADVANCED ENERGY SYSTEMS

Sandia National Laboratories possesses advanced design and modeling capabilities in the marine, wind, and concentrated solar energy sectors. Sandia's multidisciplinary teams solve complicated design challenges using sophisticated simulation tools and unique modeling capabilities to optimize the performance of energy systems.

In addition to design and modeling, Sandia excels in testing and validating these systems under real-world conditions. Their facilities are equipped for extensive bench testing; prototypes can be subjected to various environmental scenarios, simulating the challenges faced in real world settings. Sandia's commitment to advancing energy technologies includes ongoing collaborations with industry partners and research institutions, aiming to enhance integrated energy solutions.

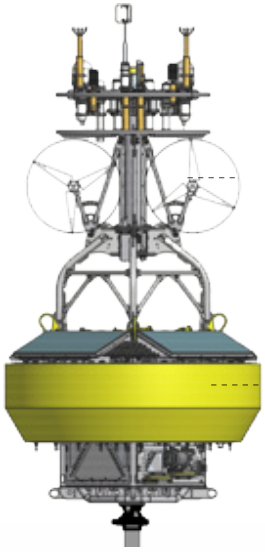


Pitch resonator concept with flywheel.

POWER IN THE OCEAN

Sandia's team of engineers was tasked with designing a wave energy converter (WEC) to provide power to a buoy within the Coastal Pioneer Array. They developed a novel "pitch resonator" WEC, which functions like a metronome by absorbing power from the buoy's pitching and rolling motion. This self-contained "bolt-on" solution integrates seamlessly with the existing Coastal Surface Mooring (CSM) buoy. The engineers explored multiple concepts to identify the most effective design, ensuring the WEC would provide a consistent power supply without impacting the buoy's mooring chain or compromising its scientific mission.

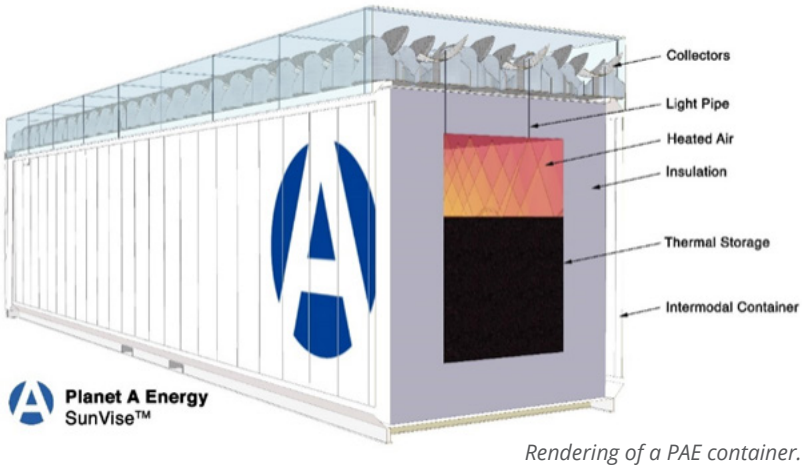
Bench testing of the pitch resonator system is currently underway, with an ocean deployment planned for October 2025. The CSM buoy relies on two Superwind SW350 wind turbines and four Kyocera KD-140 solar panels to power a battery bank and supply electricity to its instruments, with an electrical load ranging from 50-100W. While current wind and solar sources meet power demands about 70% of the time, manual throttling is necessary during shortages. The innovative bolt-on WEC aims to ensure reliable power for the array's sensors and communication systems, addressing the challenges of power supply within a specific timeline.



The surface mooring contains instruments attached to a surface buoy floating on the sea surface. The pitch resonator will be mounted to the underside of the surface buoy.

THERMAL ENERGY STORAGE (TES)

Funding from the U.S. Department of Energy's Solar Energy Technologies Office supported the Planet A Energy project to verify the technological and commercial usefulness of a grid-scale solar long-duration energy storage system that can operate either as a stand-alone industrial heat system or with an electrical generator at a concentrating solar power plant. The project will assess techno-economic analysis trade-offs between cost and performance to arrive at an optimum container design that maximizes internal rate of return or other key metrics. Following optimization of the system design and establishment of the operating conditions for components, the team will perform an integrated system test at process conditions of flow, temperature and pressure, but at a lower power level. PAE will complete its demonstration during the first stage of the project and proceed to develop and validate a higher system during the next stage.



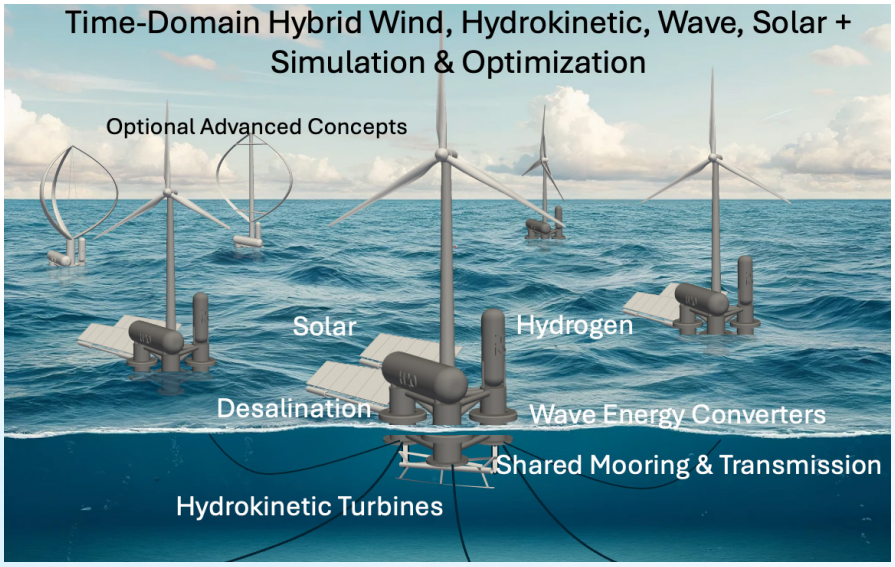
Rendering of a PAE container.

The PAE containers are conceived as being able to support 24-hour, seven days a week, year-round energy delivery, as well as intermittent higher-power energy delivery when used as a firming resource. At that duration, each container with 28 m2 can collect and deliver an average of 4.5 kWth continuously, with the state of charge varying seasonally due to an integral of seasonal direct normal irradiance.

SIMULATING WIND AND WATER POWER

The Onshore/offshore Wind/Water Energy Simulator (OWENS) toolkit was developed for the analysis of land based or offshore novel wind and water turbine systems. The tool has the required physics models to enable coupled analysis of aero-hydroservo-elastic simulations necessary for design and certification of wind and water energy systems.

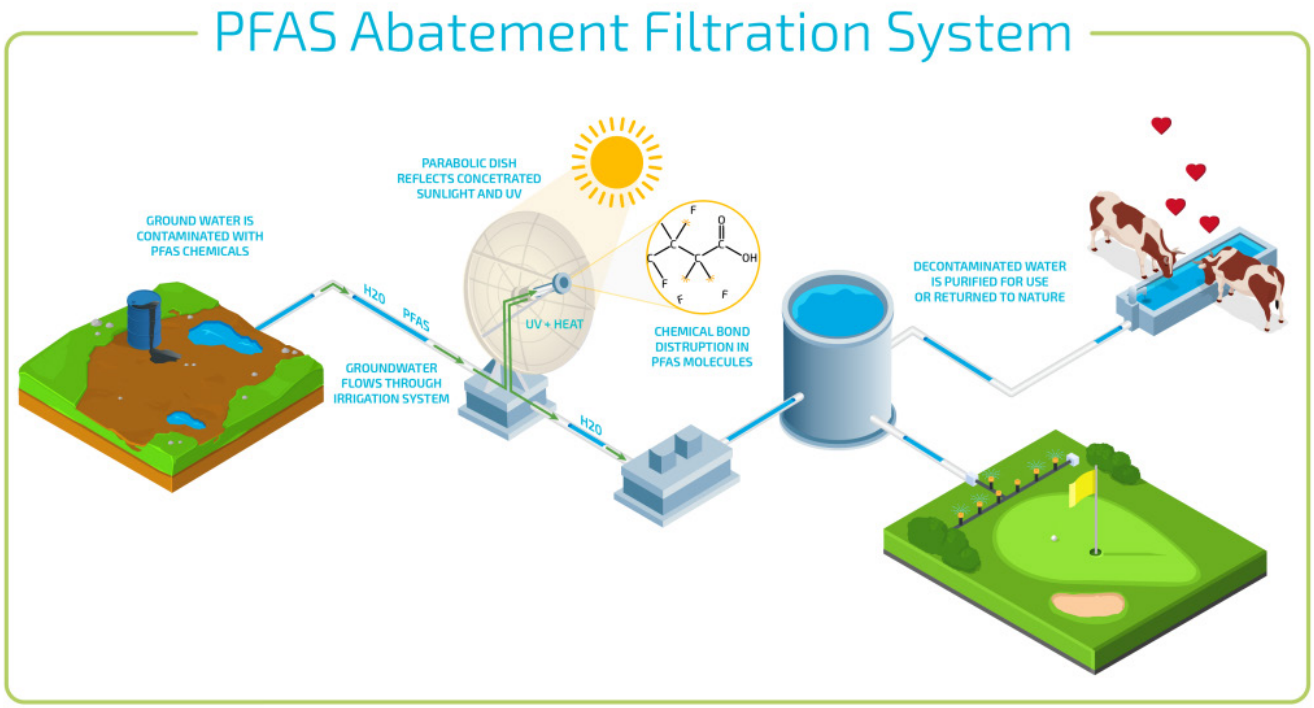
It is comprised of five modules, that combined provide a continuous analysis workflow from basic parametric inputs to response outputs for steady, transient, and modal analyses. While it has been tuned for stability and accuracy, it also makes a wide range of fidelity and solution parameters accessible to the user for case specific tuning. This driver also includes drivetrain control, pre-, and post-processing, enabling fully automated runs spanning internally calculated composite sectional properties to fatigue and limit state results.



Integrated wind and water turbine system with desalination plant.

FROM WASTE TO WATER

The Fluorinated Alkyl Remediation for Military DEployments and Farmland Environments with Non-grid Solar Energy (FARM-DEFENSE) project is focused on utilizing concentrated sunlight for remote, dispatchable wastewater treatment applications. The project will measure the effectiveness of concentrated UV light in the decomposing of Polyfluoroalkyl Substances in ground water into safe, stable byproducts such as fluoride while recovering the water. This project will also provide a proof-of-concept for utilizing heat from concentrated sunlight to destroy PFAS in solids, such as recycling of granulated activated carbon filters and treatment of contaminated soil where PFAS were to be spilled or applied to the ground. The results will measure the amount of PFAS destroyed using concentrating solar thermal heat, the byproducts produced and a technoeconomic assessment to determine the cost and most promising applications for this approach.



The system is designed to use concentrated UV to decompose PFAS, recover stable byproducts, and recover the water for agricultural and other uses.

LEADING THE CHARGE

Sandia National Laboratories is dedicated to advancing innovative, reliable, cost-effective energy production. Additionally, Sandia is actively working to enhance the efficiency and reliability of energy infrastructure, making it more adaptable to changing demands and potential disruptions. By investing in research and development, Sandia aims to create robust energy systems that can deliver consistent performance while minimizing costs.

FOR MORE INFORMATION CONTACT:

Peter Kobos; pkobos@sandia.gov

U.S. DEPARTMENT of ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND2025-03638M

Sandia National Laboratories