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CalWave - Unlocking the Power of the Ocean in California

CalWave is a California-based developer of clean energy technology designed to unlock the sustainable power of ocean waves. Currently, CalWave is conducting Californiaâ€™s first in-sea, long-term wave energy pilot off the coast of San Diego. For this trial, CalWave has partnered with the Scripps Institution of Oceanography (SIO), the U.S. Department of Energy, Pacific Northwest, Sandia National Laboratories, National Renewable Energy Laboratory, as well as University of California Berkeley.

Additionally, CalWave is collaborating with PNNL & Integral Consulting, Inc. to observe the wave energy converter (WEC) using three different monitoring tools: a noise spotter buoy, a drifting hydrophone, and three long-term bottom-mounted hydrophones. Because wave energy is still so new, itâ€™s important that scientists collect data on how the machines impact the marine ecosystem through noise, collisions, or ecosystem changes. The 2020 State of the Science report shows the current understanding of marine energy systems' environmental acceptability. The US DOE and PNNL have historically contributed to this report.

It is important to consider the benefits of wave energy as California transitions towards net-zero emissions. Wave power is more abundant and stable compared to solar or wind energy and ocean technology produces less emissions. Ocean waves have a beneficial production profile being more consistent and predictable. Wave energy has one of the lowest lifecycle emissions and forecasts project that it has the ability to displace up to 1.38 - 1.9 GtCO2 emissions equivalent annually.

Looking forward, CalWave is lined up for PacWave, the first commercial-scale, utility grid-connected wave energy farm in the US that started its construction this year and is expected to start operating in 2023.

CalWave remains committed to information sharing and welcomes collaboration. Please visit www.calwave.energy for more information.

Additional submitted attachment is included below.

CALWAVE

2021 Fact Sheet

CalWave Power Technologies Inc. is a California-based developer of clean energy technology.

Our mission is to unlock the vast and steady carbon-free power from ocean waves. We envision a healthier, safer, more equitable, and prosperous world - a world that unlocks the renewable power of ocean waves to sustainably supply 20-30% of global energy demand in upcoming decades.

Our award-winning, proprietary wave energy converter (WEC) technology, called xWave™, has broken through the fundamental challenge of unlocking wave power. The xWave™ architecture achieves high performance while being able to actively reduce overloads caused by rare, but destructive storm events. The system was initially inspired by nature itself, mimicking the ability of a muddy seafloor to completely absorb the energy of passing waves. Unlike many other technologies that extract wave energy at the ocean surface, our device **operates fully submerged** and out of sight. This unique approach enables several improved operating abilities: it **survives stormy seas and extreme conditions**, causes **no visual pollution**, and **allows for precise control of structural loads** by eliminating the need to manage the broad spectrum of wave loads typically found on the ocean's choppy surface.

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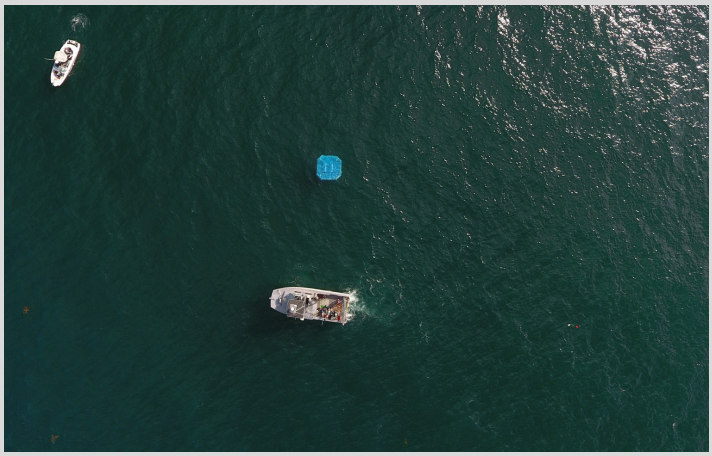
Major Milestones

- **2012-2013:** CalWave's inception and start of its patent family at UC Berkeley, Mechanical Engineering.
- **2013:** Announced as semi-finalists for MIT's Clean Energy Prize.
- **2016:** Graduated from Cyclotron Road, and was awarded the Department of Energy's (DOE) US Wave Energy Prize.
- **2017:** Awarded a multi-million dollar demonstration contract by the US DOE and received support by Breakout Labs, Autodesk, and the Sustainable Ocean Alliance.
- **2019:** CalWave received two additional multi-million dollar awards by DOE to 1) build a commercial scale drive train in parallel to our open water demo and 2) design the next generation of our submerged pressure differential WEC and investments from High Tide Foundation and others.
- **2020:** CalWave's xNode technology was awarded the Grand Prize of the discovery stage of the Ocean Observing Prize. CalWave was selected to join Greentown Labs and present at Climatetech Summit.
- **Present:** CalWave plans to enter the market with a multi-kW system designed to provide access to power and data for offshore end-users, including scientific sensors, enabling completely new applications such as AUV charging.

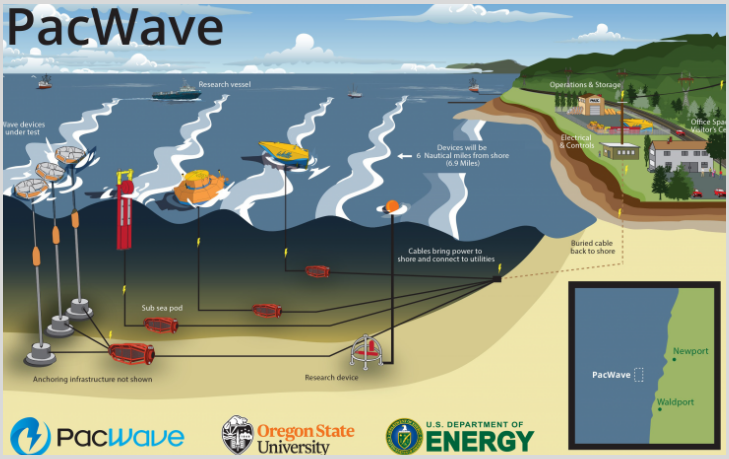
CALWAVE

2021 Fact Sheet

Projects in Our Pipeline



We successfully deployed our wave energy converter technology on September 16th off the coast of San Diego. This milestone event marks the beginning of California's first at-sea, long-duration wave energy pilot.



Following our pilot demonstration, CalWave plans to prepare for deployment of a larger unit at PacWave - the first commercial-scale, utility grid-connected wave energy test site in the US, expected to start operating in 2023.

Our Partners

U.S. Department of Energy
Energy Efficiency & Renewable Energy
cyclotronroad
Breakout Labs
Berkeley
TAF Lab
ISHOW
experiment
The foundry
SOLIDWORKS
Sutardja Center for Entrepreneurship & Technology
SOA
MathWorks
AUTODESK
HIGHTIDE
ANSYS
NHA
NREL
NSF
Sandia National Laboratories
MICHELIN
Greentown Labs
ENVEST
Scripps Institution of Oceanography
LAUNCH ALASKA
1517
startR BLUE
UC San Diego · Rady School of Management
Scripps Institution of Oceanography
Pacific Northwest National Laboratory

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CALWAVE

Frequently Asked Questions

What is CalWave?

Calwave Power Technologies Inc. (CalWave) is a California-based developer of clean energy technology. CalWave's mission is to unlock the vast and steady carbon-free power from ocean waves. Our proprietary and patented wave energy converter technology, called xWave™, operates fully submerged while achieving high performance and surviving storms and extreme conditions.

CalWave spun out of UC Berkeley and the prestigious Cyclotron Road program in 2016, and was awarded by the U.S. Department of Energy's Wave Energy Prize.

What products and services does CalWave offer?

CalWave's proprietary solutions are based on the development and at-sea testing of the xWave™ architecture. For uncabled applications, CalWave offers the xNode and HydroNode. For larger applications cabled to shore, CalWave offers the x100 and x800 rated at 100 and 800 kW respectively.

The xNode is a versatile platform for converting and storing the power of ocean waves, serving as a facilitator in the Ocean Internet of Things. The device utilizes CalWave's scalable, multi-kW PTO platform and is customized toward the needs of end-users in maritime markets and Blue Economy applications.

CalWave's HydroNode is a wave-powered energy node enabling the delivery of fresh water to remote coastal communities. It provides a rapidly deployable, easily operated and maintained system for locally generated desalinated water to support coastal communities and disaster relief efforts.

All solutions utilize a digital twin application, which creates a virtual model of the physical devices to allow for data analysis enabling predictive maintenance and systems monitoring. Comprehensive services also include:

- predictive maintenance solution to ensure lowest inspection and maintenance costs,
- improvement evaluations to ensure optimal efficiency and performance,
- site assessments to conduct region-specific investigations and provide decision-making materials that identify potential risks and uncover needs.

Who can CalWave's products serve?

Our commercial turnkey solutions are capable of powering a range of offshore applications, communities, and different industries around the globe. Not only can CalWave's products provide clean electricity for up to 30% of U.S. homes and small island development states, which represent 11% of the global population, but we also offer our products to blue economy sectors like aquaculture, security and defense, inspection, navigation, disaster relief, and ocean science.

How does CalWave differ from peers in the ocean energy industry?

Unlike conventional technologies that extract wave energy at the ocean surface, CalWave's devices operate fully submerged and out of sight. This unique approach enables several improved operating abilities: it can survive stormy seas and extreme conditions, causes no visual pollution, and allows for precise control of structural loads by eliminating the need to manage the broad spectrum of wave loads typically found on the ocean's choppy surface. CalWave's devices are also designed for simple transportation and deployment.

When will CalWave's technology become commercially available?

We are currently piloting our demonstration device, which represents a scaled version of our utility-scale architecture. The scaled system has been operating in the open ocean since September 2021, connected via umbilical cable from Scripps Institution of Oceanography research pier in San Diego, California. This test will run for six months and we anticipate the potential to go-to-market thereafter in 2022.

Why is now the right time for CalWave to bring its technology to market?

Global energy consumption is projected to grow by nearly 50% between 2018 and 2050. Unfortunately almost 80% of energy demand currently falls on fossil fuels in the form of coal, natural gas, and oil - unsustainable sources which we won't be able to rely on for much longer. While governments begin to transition to renewable energy to tackle anticipations of shortage and the looming threat of climate change primarily driven by fossil fuel dependence, ocean-based solutions have enormous potential to address these challenges - yet they are completely underutilized at the moment.

CalWave's wave energy converter technology has been tested as a feasible solution for unlocking the vast and steady carbon-free power from ocean waves worldwide. We now have the opportunity to complement existing energy solutions to equip communities with clean, reliable, and local energy while keeping our planet and the health of future generations in mind.

What is the potential impact of CalWave's solutions?

Wave energy is the third-largest renewable resource after wind and solar in the US, and studies have shown that it has the potential to satisfy 20-30% of the global energy demand. Additionally, it has one of the lowest lifecycle emissions at 17 gCO2e/kWh, and forecasts project that ocean energy has the ability to displace up to 1.38 - 1.9 GtCO2 emissions equivalent annually.

Further, we primarily anticipate our short-term impact being in small island development states. They still heavily rely on diesel imports, yet diesel has emissions as high as coal in terms of CO2/kWh. They have limited space - and even with wind and solar as alternative resources, hurricanes are a constraint. Tourism is one of their biggest industries, so having a renewable resource that works completely underwater and doesn't take up space while providing power close to baseload is a great opportunity for these communities.

What additional projects are in CalWave's pipeline?

CalWave plans to test the x100 rated at 100 kW at PacWave, the first commercial-scale, grid-connected wave energy test site in the US, expected to start operating in 2023. This project is supported by a 2019 US DOE award,

How can I connect with CalWave for additional information?

Please contact marcus@calwave.energy for business inquiries and press@calwave.energy for press/media inquiries.

CALWAVE

PRESS RELEASE

CalWave pilots California's first at-sea, long-duration wave energy demonstration.

San Diego, CA — CalWave Power Technologies Inc. successfully commissioned its *CalWave x1™* on September 16th off the coast of San Diego. This milestone event marks the beginning of California's first at-sea, long-duration wave energy pilot operating fully submerged. The *CalWave x1™* will be tested for six months with the goal of validating the performance and reliability of the system in open ocean.

This project is supported by a US Department of Energy award with the goal to demonstrate CalWave's scalable and patented *xWave™* technology. *"CalWave's long-duration deployment is a novel open water demonstration of a wave energy technology with active and passive load management features,"* said Jennifer Garson, Acting Director of the Department of Energy's Water Power Technologies Office (WPTO). *"WPTO is pleased to recognize this accomplishment as a major milestone for unlocking the potential of wave energy from our oceans and providing access to clean energy for the growing blue economy in the US."* Several key partners collaborated with CalWave on this project including the Scripps Institution of Oceanography, the National Renewable Energy Laboratory, Sandia National Laboratories, DNV GL, and UC Berkeley.

Operating fully submerged without visual impact, CalWave's *xWave*TM architecture is capable of breaking through the fundamental challenges that have held the industry back so far: a technology that achieves high performance while being able to control structural loads in rare but destructive storms on all parts of the system.

The *CalWave x1™* is well suited for the needs of end-users of the blue economy with applications in offshore inspection, aquaculture, ocean science, and others that require access to power and data offshore.

Following this demonstration, CalWave plans to prepare for deployment of a larger unit at PacWave, the first commercial-scale, utility grid-connected wave energy test site in the US rated at 20 MW.

Marcus Lehmann, CEO and Co-Founder of CalWave:

"Wave power is the largest unused renewable resource and the third-largest after wind and solar globally. Wave power can provide power at night and during wintertime where other renewables can't, and so far it is completely unused.

Wave energy devices are no different than wind turbines or other hydro turbines. It's a kinetic device that captures a renewable resource to produce electricity. At the highest systems engineering level, the functions to make a technology viable are the same. To generate cost-competitive power, technology must be able to use the most of a resource to produce the greatest amount of electricity at minimum capital and operating cost. For us, capital efficiency means that any system must be able to reduce primary loads from storm waves just like pitch and yaw control, a critical feature of our modern wind turbines. Next to high performance, this is the second fundamental and critical feature of a wave energy device to be able to survive storms without being overdesigned for these rare events that don't contribute to the annual energy production but drive up the cost.

Our team is excited about this major milestone and wants to express our gratitude to all partners and supporters that helped us along the way."

Details on the *xWave*TM Technology

Unlike conventional technologies that extract wave energy at the ocean surface, CalWave's patented *xWave*TM architecture operates fully submerged at a range of different water depths and distances to shore, achieving high performance and unlocking the ability to be fully shut down in storm conditions. This unique approach enables several advantageous operating abilities: It survives stormy seas and extreme conditions, causes no visual impact, and allows for unique control of structural loads by eliminating excessive loads during storms that drive up the cost of systems without substantially contributing to annual energy production. Wave farms export power using the same electrical export infrastructure as offshore wind farms.

Status of the Industry

The Department of Energy recently published a study including an updated resource assessment and found that wave power can provide up to 30% of the 2019 energy consumption in the US, representing the technically feasible resource potential and not just the theoretical.

The wave energy industry is at an inflection point and CalWave is taking a leading role in unlocking the vast and steady carbon-free power from ocean waves worldwide. As several governments aim to transition to 100% clean energy, such as California through the passage of Senate Bill 100 in 2018, CalWave's scalable technology has the potential to complement existing renewable energy forms to provide reliable power when no other renewables are available. Similar to wind turbines, wave energy converters (WECs) are scalable in power rating and CalWave plans to offer product lines with different power ratings in the coming years. Utility scale units can be co-located with offshore wind farms using the same electrical export infrastructure and achieve a significantly higher joint capacity factor due to the complementary production profile of wind and wave power.

About CalWave Power Technologies Inc.

Founded in 2014, CalWave is a California-based developer of clean energy technology designed to generate electricity and freshwater from ocean waves. Through rigorous research, innovation, and testing, we offer next-generation solutions that protect our planet and unlock the potential of its global citizens.

CalWave's mission is to unlock the vast and steady carbon-free power from ocean waves, thereby contributing to a healthier, safer, more equitable, and prosperous world. The company is a member of the National Hydropower Association's Marine Energy Council, which is calling for domestic marine energy deployment targets of at least 50 MW by 2025, 500 MW by 2030, and 1 GW by 2035.

Contact

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CALWAVE

Executive Bios

Marcus Lehmann, CEO and Co-Founder

Marcus Lehmann founded CalWave in 2014 and serves as the CEO. Marcus was accepted into the first cohort of Cyclotron Road, a 2-year fellowship and incubator for entrepreneurial scientists working in clean energy at the Lawrence Berkeley National Laboratory (LBNL) that allowed to form the founding team. Marcus is a co-inventor of several key US and international patents and has managed CalWave's industry collaborations and relationships.In 2016, he was named in the Forbes 30 under 30 list for Energy. Marcus has previous industry experience with the major European utility E.ON and has worked for Siemens and BMW in the past. Marcus holds a M.Sc. in Mechanical Engineering from the Technical University Munich, an honors degree in Technology Management and a PhD. in Systems Engineering from Technical University Hamburg-Harburg.

Daniel Petcovic, COO

Dan Petcovic joined as CalWave's COO in early 2018 to support CalWave's evolution from research to product development and commercialization. With over twenty years of experience in product development, Dan was the Program Manager for a successful 1:2 scale WEC in water deployment in Scotland, making him familiar with the unique challenges in offshore wave energy demonstration deployments. Prior, Dan worked primarily in the defense industry, including seven years with Lockheed Martin with positions largely related to field testing and customer acceptance of advanced prototype technologies, and six years in the US Navy Nuclear Engineering Program. Additionally, Dan has held roles in environmental remediation consulting and as a helicopter mechanic/crew chief with the US Army National Guard. Dan holds a Masters in Renewable Energy from Loughborough University, England, a Graduate Certificate in Marine Hydrokinetics from Instituto Superior Tecnico (IST), Portugal, a M.Sc in Information Technology from Florida Institute of Technology, and a Bachelors in Electrical Engineering from UCLA. He is a licensed Professional Engineer (P.E.), Journeyman Electrician, and holds formal certifications in Construction Management and Lean Six Sigma.

CALWAVE

Executive Bios

Thomas Boerner, CTO and Co-Founder

Thomas Boerner serves as the CTO and has been leading the hydrodynamics and controls engineering at CalWave since the start of CalWave. Thomas is co-inventor of CalWave's key patents and trade secrets. Next to completing his PhD in holistic control strategies for wave energy conversion at the Hamburg University of Technology (TUHH), he holds a M.Sc. in Energy Technologies as well as an M.Sc. in Economics from RWTH Aachen University. After working in the wind turbine industry with Bosch Rexroth in China and Germany, focusing on pitch and yaw control mechanisms, Thomas started his work on novel wave energy conversion methods at UC Berkeley. From early on during CalWave's technology development path, Thomas evolved state-of-the-art Hardware-In-The-Loop (HIL) and numerical modeling environments for application towards wave energy conversion. These crucial tools allowed the derivation of CalWave's unique Holistic Control platform applicable to all of CalWave's WEC technologies and scales.

Nigel Kojimoto, Lead Mechanical Design and Co-Founder

Nigel Kojimoto is the lead mechanical design engineer at CalWave and co-inventor of CalWave's xNode provisional patent with a M.Sc. from MIT. He contributes expertise in hydraulics, Solidworks computer aided design (CAD), rapid prototyping, and LabVIEW. Nigel led the mechanical and structural design effort for CalWave's open ocean pilot system.

Josiah Clark, Mechanical Design

Josiah Clark is a mechanical design engineer. He joined CalWave in 2019 after receiving a B.Sc. in mechanical engineering from Stanford University. He contributes experience in modeling belt fatigue and stress elements, Solidworks/Fusion360 CAD and FEA, rapid prototyping, and drafting.

CALWAVE

Past Press Coverage

Alternative Markets for Ocean Energy.

Ocean Energy Systems, September 2021.

CalWave to Kick Off Wave Device Pilot Mid-September.

Offshore Energy, August 2021.

Sea Change: Activate Fellows and the Blue Economy.

Activate Global, June 2021.

Wave Energy Making Progress in the Blue Economy.

The Mendocino Voice, June 2021.

How CalWave Is Reducing The Cost Of Wave Power Harvesting.

The Impact, April 2021.

Marine Energy Industry Sets New Goal of 1GW of Deployments by 2035.

National Hydropower Association, April 2021.

California Marine Energy Developer on a Quest to Provide a Powerful Solution to Fresh Water Challenges.

National Hydropower Association, February 2021.

Oregon's PacWave Aims to Jump-Start US Marine Energy Market.

Green Tech Media, June 2020.

How Engineers of New Energy Technology Are Taking Cues From Nature.

Smithsonian Magazine, August 2019.

DOE Announces $24.9 Million Funding Selections to Advance Hydropower and Water Technologies.

US Department of Energy, October 2019.

Inaugural Ocean Solutions Accelerator Cultivating Diverse Crop of Innovations.

Sustainable Brands, 2019.

Ocean Solutions Accelerator Names Its First Wave of Conservation Startups.

TechCrunch, 2018.

Five New Startups To Give Oceans A Hand With Plastics, Bycatch, Energy.

Forbes, June 2018.

The Renewable Power of Ocean Waves.

PBS, July 2017.