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COVER PHOTO:
Miguel Rocha, Chief,
Dam Safety Office, Bureau of Reclamation.
Photo courtesy of the Bureau of Reclamation.

PHOTO COURTESY OF THE BUREAU OF RECLAMATION.

Forging the Future of Water Power

By Kris Polly

The United States and the world continue to benefit from the large hydropower dams built in the early 20th century. Among the challenges of the 21st century, however, are maintaining that legacy fleet and developing the water power technologies of the future.

In our cover story, we speak with Miguel Rocha, the chief of the Bureau of Reclamation's Dam Safety Office, which oversees Reclamation's 361 high-hazard potential dams. Mr. Rocha gives us a detailed look at how the office helps make sure that the nation's major hydro facilities continue to operate safely.

Next, we speak with Elaine Buck and Tim Ramsey, who work in the marine energy program at the U.S. Department of Energy's Water Power Technologies Office. Marine energy is a fast-growing, cutting-edge field, and as Ms. Buck and Mr. Ramsey tell us, it has the potential to support the maritime blue economy as well as to eventually provide grid-scale energy.

We also feature two other entities supporting research and development in the marine energy sphere. First, we speak with Shana Hirsch, the codirector of the Pacific Marine Energy Center, a consortium of universities that is one of four National Marine Energy Centers in the United States. Then, we speak with Samantha Quinn, the program director of the Pacific Ocean Energy Trust.

Alden Research Laboratory, the oldest continuously operating flow modeling consultancy in North America, does hydraulic modeling work for dams, spillways, water conveyance structures, and more. Now part of nationwide consulting firm Verdantas, it also provides environmental engineering work focusing on fish passage and protection. We speak with three senior staff about Alden's many services for hydropower clients.

Perhaps surprisingly, reservoirs can be a major sources of greenhouse gas emissions. Open Hydro is a company that helps hydropower owners and operators measure and mitigate their reservoirs' emissions, manage data, and compile reports. We speak with cofounders Cristina Diez Santos and María Ubierna Aparicio about how the hydropower industry can be a leader for the entire water sector.

Ensuring that existing hydropower dams and reservoirs operate safely and efficiently and developing the new water power technologies of the future are two sides of the same coin. I salute all the hydropower professionals carrying out and supporting this work, which will stand our nation and world in good stead in years to come. H

Kris Polly is the editor-in-chief of Hydro Leader *magazine and the president and CEO of Water Strategies LLC, a government relations firm he began in February 2009 for the purpose of representing and guiding water, power, and agricultural entities in their dealings with Congress, the Bureau of Reclamation, and other federal government agencies. He may be contacted at kris.polly@waterstrategies.com.*

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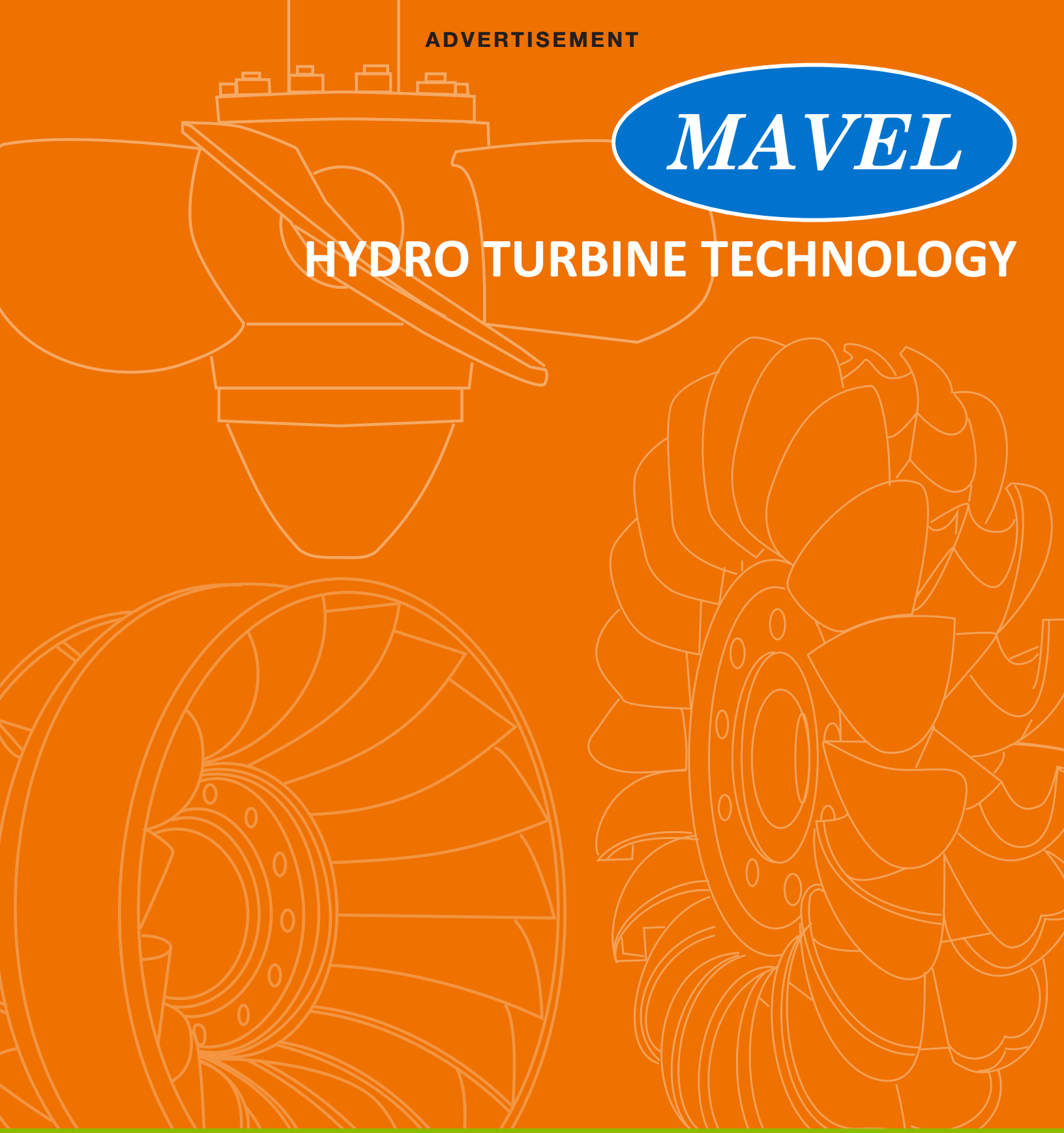

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Miguel Rocha of the Dam Safety Office: Reducing Safety Risks at Bureau of Reclamation Dams

The modification of the B. F. Sisk Dam in central California to reduce seismic risks is the largest project in the Reclamation dam safety program's history.

The Bureau of Reclamation's Dam Safety Office monitors safety risks at the dams in its network to ensure that Reclamation dams do not present unreasonable risks to people, property, and the environment. In this interview, Dam Safety Office Chief Miguel Rocha shares how the department performs site evaluations, identifies dams that pose an increased threat to the public, and takes corrective actions to modify high-hazard dams.

Hydro Leader: Tell us about your background and how you came to be in your current position.

Miguel Rocha: I've worked for Reclamation for 25 years. I started working for the bureau during college. I worked in the Missouri Basin Regional Office, the Oklahoma-Texas Area Office, the Albuquerque Area Office, and multiple offices in Denver. I joined the Dam Safety Office in 2015 as a program manager and was promoted to supervisory engineer about 4 years ago. A year ago, I was appointed chief of the Dam Safety Office.

Hydro Leader: Would you give us a sense of how the Dam Safety Office fits into Reclamation's operations?

Miguel Rocha: The Dam Safety Office is responsible for the organization's dam safety program, which is focused on evaluating the structural safety of all of Reclamation's high-hazard dams. We have a small program staff of 16 and a budget of about $210 million a year. About $26 million of that is dedicated to the ongoing monitoring and evaluation of dams. The rest of our budget is used to make physical modifications to dams when an issue is identified. We provide funding to many other parts of the organization, including area offices, regional offices, and the technical service center, to accomplish our projects. This is a program that requires collaboration and teamwork throughout the agency and with our water and power contractors to be successful.

Hydro Leader: How many high-hazard dams are there in Reclamation's system?

PHOTOS COURTESY OF THE BUREAU OF RECLAMATION.

Miguel Rocha: We have 361 high-hazard-potential dams. The definition of a *high-hazard dam* is one that would result in at least one life lost if it were to fail.

Hydro Leader: What is the breakdown in your work between ongoing monitoring versus programs that may be triggered by specific incidents?

Miguel Rocha: The $26 million that I was talking about goes to our Safety Evaluation of Existing Dams (SEED) program. That funding is dedicated to ongoing risk evaluation, program management, technology development, and supporting instrumentation. The cornerstone of our process is a comprehensive review of each high-hazard-potential dam every 8 years, which is a deep dive into the dam itself—its status and operation and maintenance issues—and an analysis of risks. We also research the original construction and design to see if there are any issues that need to be evaluated.

When we determine that there's something we need to understand further, we go into an issue evaluation. We'll spend additional money to do field investigations, collect data, and undertake detailed engineering evaluations to determine whether there's an issue to which we need to allocate funding. If we identify a risk through the issue evaluation, we go into the other aspect of the program, which is physical modification. That includes planning, design, and construction.

There are sometimes incidents at the dams—for example, sand boils or seepage. We'll use our SEED program to support the immediate response to the incident. For instance, if we see sediment within the seepage, we will send out a team to do a field investigation and determine whether it's a concern that needs to be addressed immediately or whether it is something we should monitor for worsening conditions.

Hydro Leader: What are some of the issues that most frequently end up requiring your attention and, potentially, physical modification?

Miguel Rocha: We tend to focus our modifications on the three areas authorized under the Reclamation Safety of Dams Act: seismic, hydrologic, and state of the art. For seismic, we look at the chance of the dam failing during an earthquake. For hydrologic, we look at the chance that a flood would threaten the dam. The state of the art category is fairly broad. It can include original design concerns, construction concerns, or internal erosion. The potential for internal erosion is one of the biggest potential failure concerns that we address under state of the art. For example, current dam design includes two-stage filters to prevent the movement of materials within the dam that could lead to a breach of the dam, but some of the dams in our system were constructed before filters became standard. When it is deemed necessary, we modify a dam to reduce those risks.

Hydro Leader: I imagine that modifying a dam can be a big and expensive project. Would you provide a few examples of what those projects look like?

Reclamation modified the 109-foot-long Lake Tahoe Dam in 1987 under the Safety of Dams program.

Spillway gates at Bull Lake Dam in Wyoming.

An aerial view of work on the spillway at Bull Lake Dam in Wyoming.

Miguel Rocha: It is a challenge to modify dams, especially because we try to keep them operating during construction to the extent possible. We keep the water flowing, keep the reservoir full, and try to maintain operations.

Right now, we're undertaking the largest project in the dam safety program's history: We are modifying the B. F. Sisk Dam near Los Banos in central California to reduce risk from seismic events. B. F. Sisk Dam, also known as San Luis Dam, was constructed from 1963 to 1967. It is a 382-foot-high embankment dam that is over 3½ miles long. The reservoir has a storage capacity of over 2 million acre-feet and provides water for irrigation, municipal, and industrial purposes as well as recreation and fish and wildlife benefits. The dam is located in an area with a high potential for earthquakes, and an active fault crosses the reservoir. Sections of the dam are founded on liquefiable and soft soils. During an earthquake, sections of the dam could deform or crack, leading to dam failure. The modification includes the removal of the liquefiable soils, the installation of a two-stage filter, the construction of a berm, and the raising of the dam by 10 feet. These modifications will reduce deformation and help filter any cracks that develop. The total cost of this modification is $1.1 billion.

Another example is the modification of the spillway at Bull Lake Dam, which is about 40 miles northwest of Riverton, Wyoming. The dam was constructed from 1936 to 1938 and has a height of 68 feet and a length of around 3,500 feet. The normal reservoir storage capacity is slightly more than 150,000 acre-feet and provides water for irrigation as well as recreation, flood control, and fish and wildlife benefits. The dam safety issues at Bull Lake Dam include the internal erosion of the spillway foundation and the potential for the failure of the spillway piers, gate structures, and chute caused by an alkali-silica reaction in the structural concrete. Analyses indicate that the risks are increasing over time. The modifications include the partial removal and abandonment of the existing spillway and the construction of a new spillway with the appropriate defensive measures to resist internal erosion.

Hydro Leader: How is the cost of those projects shared between Reclamation and the local sponsor or operator?

Miguel Rocha: The Reclamation Safety of Dams Act provides for an 85 percent federal cost share. The remaining 15 percent cost share is typically paid by the water and power contractors. A repayment contract can extend up to 50 years, depending on a partner or beneficiary's ability to pay.

Hydro Leader: Have you seen any emerging issues in terms of dam safety?

Miguel Rocha: Changes in hydrology affect risk. The changing climate is something that we're looking at and working to quantitatively incorporate into our evaluation of risk. We're working with the University of Wisconsin and the National Center for Atmospheric Research to develop new tools to help us understand the change in the risk of extreme events such as floods.

Hydro Leader: Are there any specific concerns about the construction of older dams that have recently come to light?

Miguel Rocha: We use a risk-informed process to evaluate our dams that involves an analysis of potential failure modes, which includes an evaluation of how the original design and construction could lead to dam failure. It was once common to install seepage collars on the outlet works of a dam. We have found that these collars can lead to internal erosion. If a dam has those collars, we develop a potential failure mode with that information in mind to assess the risk. In some cases, that will drive us to do some type of modification; in other cases, the specific design features and geology mean that action is not warranted. Another example of concerns

PHOTOS COURTESY OF THE BUREAU OF RECLAMATION.

related to aging infrastructure has to do with seismic events. We know more about the probability of an earthquake of a given magnitude and the response of the dam to that loading. Our current knowledge and understanding are used to identify dams that require modification to reduce the risk.

Hydro Leader: Tell us about your budget ceiling and Congress's role in funding the program.

Miguel Rocha: The budget ceiling, which is the upper limit of funding that we can request for dam safety modifications under the Reclamation Safety of Dams Act, has been increased over time. When we approach that ceiling, we will ask Congress to provide additional authority. Currently, the budget ceiling stands at $2.3 billion. There is also a provision that allows us to index the ceiling as costs escalate. The inflationary period of the last couple of years has led to increases in the ceiling to reflect higher costs.

Congress, through the normal appropriations process, provides us money. Our budget is included in the president's budget request, which is transmitted to Congress. Our most recent budget request was slightly over $210 million. Additionally, in 2021, we received an additional $500 million through the Bipartisan Infrastructure Law. That's available to use for the larger modification projects that I talked about, such as the one at B. F. Sisk Dam.

Additionally, we must undergo a congressional approval process each time we determine that a modification is necessary at one of our dams. We let Congress know that we're taking action by preparing a modification report. In the report, we lay out the alternatives and state which one we prefer. Congress has 30 days to object. If it doesn't object, then the project is approved and we can move forward. Reclamation's commissioner has the authority to approve projects with a cost of less than $27 million—in those cases, we just need to notify Congress that we're moving forward.

Hydro Leader: Is there a need for the budget ceiling to be increased?

Miguel Rocha: With the $2.3 billion we currently have available, we're not looking for an increase. I think $2.3 billion will cover us for the next few years.

Hydro Leader: What results has the dam safety program had?

Miguel Rocha: We're focused on managing our dams' risks to the public while ensuring that they continue to deliver the many benefits they're designed to deliver. Reclamation's dams bring water to over 31 million people and provide irrigation water to 10 million acres that produce 60 percent of the nation's vegetables and 25 percent of the nation's fruits and nuts. Reclamation is the second-largest producer of hydropower in the United States and manages 249 recreation sites with 90 million visits per year. Our dams contribute $63.8 billion to the economy and support 486,000 jobs.

All of Reclamation's high-hazard dams have undergone multiple comprehensive reviews under the 8-year review cycle, and we are continually evaluating our understanding of risks and the need for modifications. We have completed over 90 modifications since 1978 and have 10 modifications ongoing at dams across Reclamation's inventory. We continue to expeditiously reduce risks at Reclamation's dams as necessary.

Hydro Leader: Is there anything else you'd like to discuss?

Miguel Rocha: We support several trainings on dam safety. Each May, we offer a training for federal, state, local, and county government employees on safety evaluations of existing dams. It covers how to perform inspections on dams and some of the basic concepts of evaluating dams. It also covers the basic threats to dams and potential failure modes. In partnership with the U.S. Army Corps of Engineers, we also offer a training on best practices in risk analysis. We teach participants the most common ways to evaluate a dam from a risk perspective. They learn how to identify potential failure modes and quantify the risks.

We also receive funding to support a working group for all the U.S. Department of the Interior agencies that own dams, including the Bureau of Indian Affairs, the Bureau of Land Management, the National Park Service, and the U.S. Fish and Wildlife Service. We provide an annual dam safety training for those agencies. The topics change each year, depending on needs and interest. One initiative that we're starting in that group is to offer a training specifically for dam operators. Finally, we also participate in industry conferences to ensure that we're sharing our best practices and knowledge as well as learning from others.

Hydro Leader: Tell us about your vision for the future of the dam safety program.

Miguel Rocha: We want to continue to focus the program to ensure that Reclamation dams do not present unreasonable risks to people, property, and the environment. We're focused on executing the Bipartisan Infrastructure Law funding that we've received and making sure that our projects, such as the modifications of the B. F. Sisk Dam and Bull Lake Dam, are successful.

Miguel Rocha is the chief of the Bureau of Reclamation's Dam Safety Office. He can be contacted at mrocha@usbr.gov.

2023 Education Calendar

USSD continues to offer top-level education through workshops, webinars, and annual conferences. Webinars and workshops are offered live, and many are available on demand through USSD's Learning Center (https://training.ussdams.org).

These high-level learning opportunities address the needs for all sectors of the industry including consultants, contractors, dam owners, academia, etc.

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October 3-5 Denver, CO
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- Role of Instrumentation in a Dam Safety Program
- Dams in Revit
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Webinars

Early Contractor Involvement
July 20, 2023

Consequences and LifeSim: An Overview for Dam Owners and Dam Safety Practitioners
August 17, 2023

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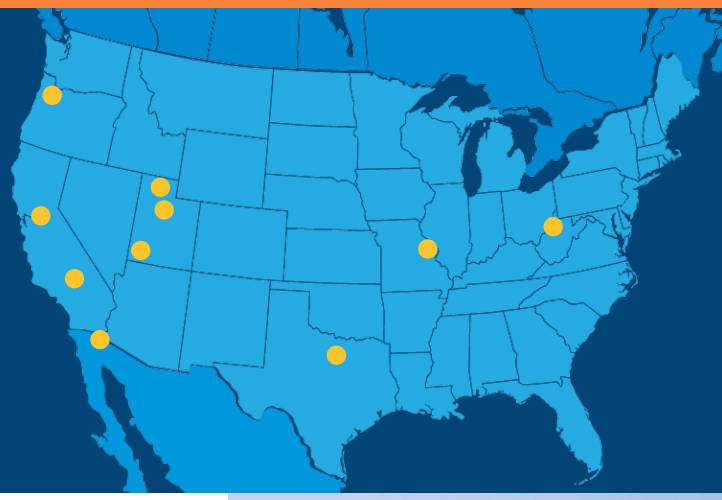

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The Water Power Technologies Office: Marine Energy's Next Wave

Energy harnessed from rivers and oceans can power the blue economy, which includes uses for fish farming and desalination in addition to providing a clean energy alternative to remote coastal communities. Will devices that can power the grid be far behind? In this interview, Tim Ramsey, the marine energy program manager at the U.S. Department of Energy's (DOE) Water Power Technologies Office (WPTO), and Elaine Buck, a marine energy technology manager at WPTO, talk with Hydro Leader *about the potential of U.S. resources and marine energy's next wave.*

Hydro Leader: Please describe your backgrounds and tell us how you came to be in your current positions.

Elaine Buck: I am a marine energy technology manager at WPTO. My area of focus is called *system design and validation*. That's really a fancy term for in-water deployments and the testing of wave and tidal devices. I started here in September 2021. Before that, I was the technical manager at the European Marine Energy Centre in Orkney, Scotland, which is where the wave and tidal industry started. Before that, I worked in oil and gas. It's been wonderful to be part of the trajectory from fossil fuels to renewable energy, specifically in marine energy.

Tim Ramsey: I've been in government most of my career. I started with DOE in 2005, first as a contractor and then as a federal employee. When DOE launched its marine energy program in 2007, I moved there to work as a project officer. I am currently the marine energy program manager, a role I've held since 2017.

Hydro Leader: Tell us about WPTO.

Tim Ramsey: WPTO supports research into, development of, and testing of new technologies to advance marine energy and next-generation hydropower and pumped storage systems. Our budget has grown from $10 million in 2008 to appropriations of $120 million for marine energy and $59 million for hydro for 2023. Our workforce has grown along with that. We started with just a handful of people, and now, if you include our contractors and fellows, we have nearly 80 people.

Hydro Leader: How far has the industry progressed in the goal of delivering marine energy to the grid?

Tim Ramsey: We haven't seen a lot of grid-connected devices to date in the United States, but many are on the horizon. Unlike hydropower, which has been powering the grid for nearly 150 years, marine energy is still in its infancy. A lot of work needs to be done to understand how to harness power from the ocean and rivers in an economical way such that the devices can withstand the harsh marine environment for 15 or 30 years. We have a lot of work to do to develop better materials, better components, and better power takeoffs and to improve installation, operation, and maintenance procedures. We need to build and deploy more devices. You must get them in the water to test them; tank and lab testing only gets you so far. We're currently funding the building of a lot of devices, but getting them in the open water is expensive and time consuming. That's why we're trying to provide better and cheaper access to testing infrastructure across the country for marine energy. We've brought down the levelized cost of electricity quite a bit in the last 10–15 years, but there is still a lot of work left to be done.

Elaine Buck: European tidal and wave developers have been able to push hard on the progress of their full-system development. Europe has had more experience putting equipment in the water, and it has done a good job putting mechanisms in place to fund open-water deployments. Currently, tidal energy installations and performance testing are more advanced than they are for wave energy.

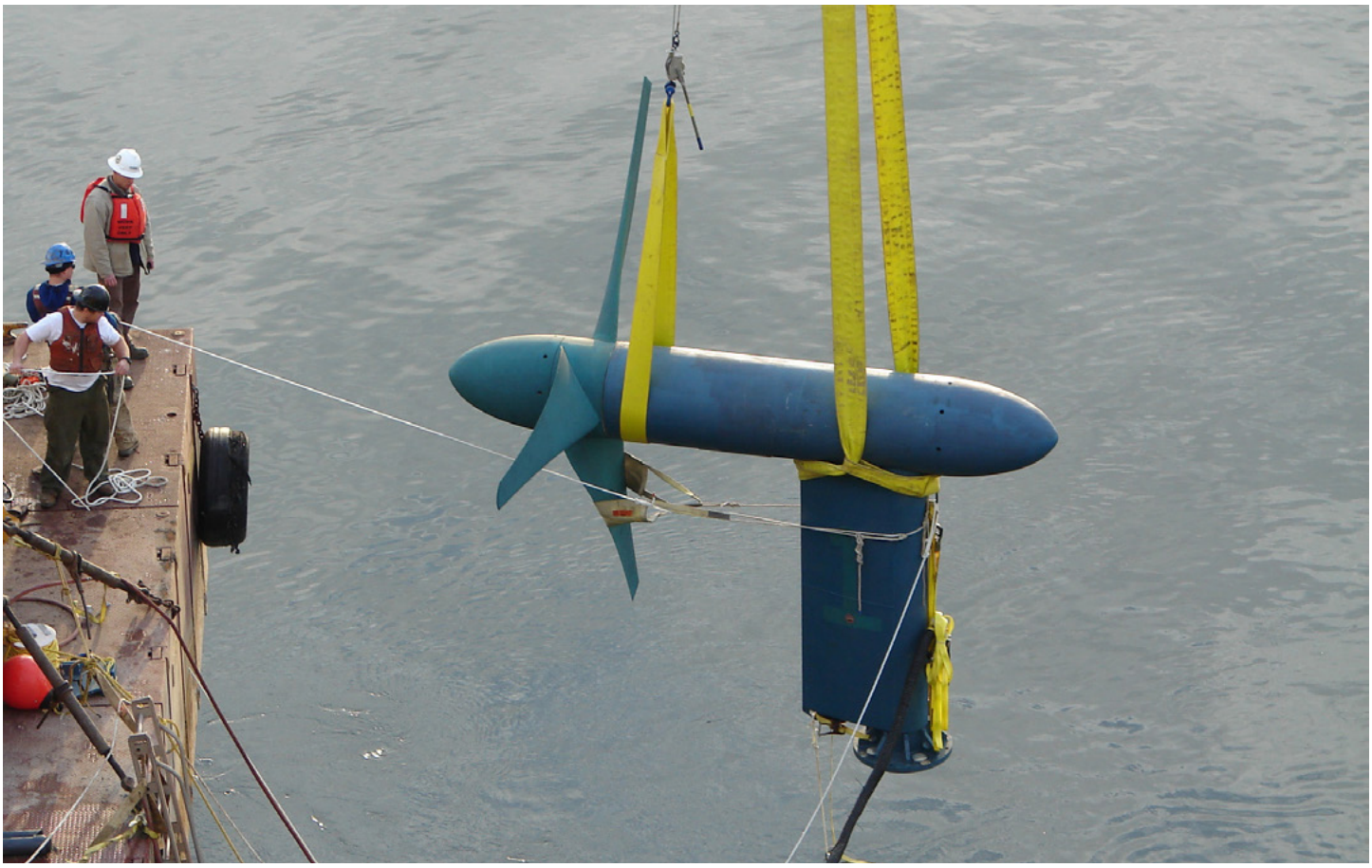
Because of the size of the marine energy resource in the United States, especially the wave energy resource, there is a lot of potential here. Since 2010, the budget for wave and tidal system development in the United States has increased. The PacWave test site, currently under construction off the coast of Oregon, is going to be the catalyst to stimulate real in-sea deployments with several developers that are homegrown in the United States. It offers a great opportunity to support this industry in its journey toward commercialization.

Recently, several U.S. tidal projects have connected to the grid. For example, a tidal turbine deployed in 2020 by Verdant Power at the Roosevelt Island tidal energy site in New York generated more than 275 megawatt-hours of energy during its first 6 months in the water. Ocean Renewable Power Company's RivGen device is expected to be installed and connected to the

Ocean Renewable Power Company's RivGen device in Igiugig, Alaska.

PHOTO BY BRIAN POLAGYE, COURTESY OF THE DOE.

The installation of a Verdant Power tidal turbine at the Roosevelt Island tidal energy site in New York.



The tidal turbine is lowered into the East River.

PHOTOS PHOTO COURTESY OF THE DOE.

grid in Maine soon. At the U.S. Navy's Wave Energy Test Site (WETS) in Hawaii, there have been wave energy converters connected to the grid, but not for long-term performance demonstrations. The WETS site is a good jumping-off point for developers; the wave action at the PacWave test site along the Oregon coast is tougher. When PacWave is online, we expect to see progress with companies like CalWave as they get connected to the grid. It's going to take more time to get that site up and ready, but I expect that in 2024 and 2025, when those devices are installed, they'll be connected to the grid and will start to prove power-output performance.

Hydro Leader: Please tell us about the concept of the *blue economy*.

Tim Ramsey: When the DOE's marine energy program started back in 2007, we were solely focused on grid power. How can we build large devices, connect them to the grid, and produce as much energy as possible? Since then, we have realized there are many other uses for energy, particularly out in the ocean where the resource is. That includes powering ocean observing systems; recharging autonomous and unmanned underwater vehicles; and supporting offshore aquaculture, fish farming, and desalination. The blue economy is made up of all these end uses and even more. Devices that generate power for blue-economy applications tend to be smaller and cheaper than those intended to supply the grid, so it gives us an opportunity to learn more quickly and keep rolling those improvements into the next generation of devices. We're still focused on the grid, but it's no longer our sole focus.

Elaine Buck: Another goal of powering the blue economy is to build resilient coastal communities. Marine energy resources and even desalination plants could be located near areas that have unreliable grid connections and water infrastructure. Many coastal communities have lost traditional industries such as paper mills. It would be huge for these coastal communities to have access to renewable energy sources, such as wave and tidal generation, as alternatives to diesel and fossil fuels, which many remote coastal communities are dependent on.

Tim Ramsey: One of the things we haven't discussed is the potential benefit of marine energy as a complementary resource to the grid, especially in remote areas or northern latitudes. It complements wind and solar generation profiles quite well because marine energy tends to peak in the winter months. If we can prove device performance and reduce economic risk to the point that these devices become palatable for remote communities and their investors and lenders, river-energy devices may be the best option. That's what we're working on, and I think we're close. We've done a lot to bring that risk down with some of these deployments.

Hydro Leader: Tell us more about WPTO's Powering the Blue Economy initiative.

Tim Ramsey: Around 2016, we started researching what it would look like for marine energy to provide power for desalination. We went to conferences and talked to people. We started learning more about the ocean observation community, and professionals in that sphere told us about the fish-farming community. That outreach organically grew into this initiative, which is now deeply embedded into our program. Our *Powering the Blue Economy* report, released in 2019, captures feedback from blue economy stakeholders and identifies potential opportunities and challenges for marine energy in different ocean applications. This report and subsequent activities demonstrated the compelling need for energy innovation in the blue economy. We've run challenges, competitions, and funding opportunities to support research and development and engage innovators developing new technologies in this space.

Elaine Buck: People initially thought that if we made smaller devices that generated at the kilowatt scale, we could just scale up to the grid scale or the 1-megawatt scale, but that's not always the case. We're starting to see developers optimize their designs at the kilowatt scale, focusing on lessons learned during installations, and we are working with our partners to identify what further research is needed and where the gaps are.

Hydro Leader: Tell us about recent advances in marine energy and how you see its use expanding.

Elaine Buck: We're still at the stage of single device testing and demonstration. Once we prove single device performance, technology developers will be able to manufacture at scale and commercially deploy arrays. Once we reach the point of installing arrays, we will have to deal with challenges related to single devices interacting with each other, their configuration or layout, and how to maintain the arrays. Those are all challenges we have not dealt with yet. The industry is also looking at hybrid systems, such as tidal or wave energy integrated with offshore wind systems.

Hydro Leader: Please tell us about your announcement of a $45 million funding opportunity for advanced tidal and energy development in the United States.

Elaine Buck: In October 2022, the DOE announced a notice of intent to use Bipartisan Infrastructure Law funding to advance tidal and river current energy. The initial funding amount was $35 million, and in January 2023, we added another $10 million. We're focusing that funding on two topic areas: grid-scale development and community-led projects to evaluate tidal energy opportunities.

The first topic area will provide up to $35 million to support the development of a pilot tidal and/or current

technology demonstration site in state waters. Topic area 1 is broken down into five phases. Phases 1 and 2 are dependent on getting a site permitted, which takes about 3 years. We will select two sites to enter into phase 1, and at the end of phase 1, we expect to select the site that has the most significant promise to move to completion as a commercial site. We've reviewed concept papers and will receive full applications at the end of July. We'll go through the selection process during the fall and expect to have our two sites ready to contract at the beginning of 2024 so that they can start site development. Once we finish phases 1 and 2, the site development moves into phase 3, which is site mobilization. That's the onshore development of the site. It is about pulling supply chain companies together and setting up the business entities and operations that will install the tidal or current energy technologies in phases 4 and 5. Phase 4 is the full commissioning and fabrication of the tidal or current device, and phase 5 focuses on testing and operations. The device is deployed and tested for about 3 months, and then the entity moves straight into operations.

Topic area 2, which builds on the DOE's Energy Transitions Initiative Partnership Project, will provide up to $10 million to support a community-led tidal and/or current energy planning and development project in the United States. It offers an opportunity for communities to investigate the potential for incorporating tidal energy as an energy solution. This topic area is also broken down into similar phases. We received concept papers in July, and those who submitted concept papers are eligible to submit an application by October 19.

Hydro Leader: Tell us about the Marine Energy Collegiate Competition that the DOE hosted at the National Hydropower Association's Waterpower Week event in Washington, DC.

Tim Ramsey: We have actually held the Marine Energy Collegiate Competition since 2020, although COVID-19 forced us to hold the first three online. This year's competition, which was also held in conjunction with the Hydropower Collegiate Competition, included some neat side events before the conference started. At a speed-dating-style event, students had 5–7 minutes to talk with representatives from industry, government, and academia. At the awards ceremony later in the week, you could feel the energy in the room. The students' passion for the work they were doing was exciting to see. I think the competition will go a long way to spark the next-generation workforce's interest in hydro and marine energy.

Elaine Buck: Marine energy will probably look completely different in 20 years, and those innovations are going to come from this cohort of bright young engineers and researchers. The inspiring technologies that they developed, the projects that they put together, and the diversity of the teams gave me confidence in the future of our program. I'm passionate about diversity, equity, and inclusion, and especially in bringing more women engineers into marine energy, so I was excited to see the number of women who were part of the teams.

Hydro Leader: What is your vision for the future?

Elaine Buck: I think we are at the apex of the marine energy program's potential. We're doing a lot of strategizing internally about exactly what that looks like. It could be a simple question and change of perspective about how we develop and fund WPTO's Marine Energy Program. For instance, beyond extracting energy from the ocean, what can our technology do to improve the condition of our seas and rivers? The oceans are under significant pressure, and we're starting to look at and talk about whether our work can help to alleviate that. In terms of system design, we're looking at being able to generate energy at smaller scales through material innovations. Instead of traditional mechanical, linear, direct-drive power takeoff systems that convert energy and deliver it to the grid, we're investigating materials embedded with energy converters at much smaller scales, even micro scales. For example, in March, WPTO launched the Innovating Distributed Embedded Energy Prize, which will award up to $2.3 million to competitors investigating novel technologies for harnessing and converting the power of ocean waves into usable types of energy. The prize seeks to foster the development of distributed embedded energy converter technologies, which combine many small energy converters, often less than a few centimeters in size, into a single larger ocean wave energy converter.

Tim Ramsey: I see some huge opportunities in the next couple of years to have a positive effect on the industry. The tidal and current energy funding opportunity will provide a significant milestone in that it will be the first time we've developed multiple systems for a site. The PacWave test facility will be coming online at the perfect time. Looking at the next year or two, we have an opportunity to make huge leaps in the industry that I think will have a multiplier effect. H

Tim Ramsey is the marine energy program manager at the U.S. Department of Energy's Water Power Technologies Office.

Elaine Buck is a marine energy technology manager at the Water Power Technologies Office.

Both can be contacted at waterpowertechnologiesoffice@ee.doe.gov.

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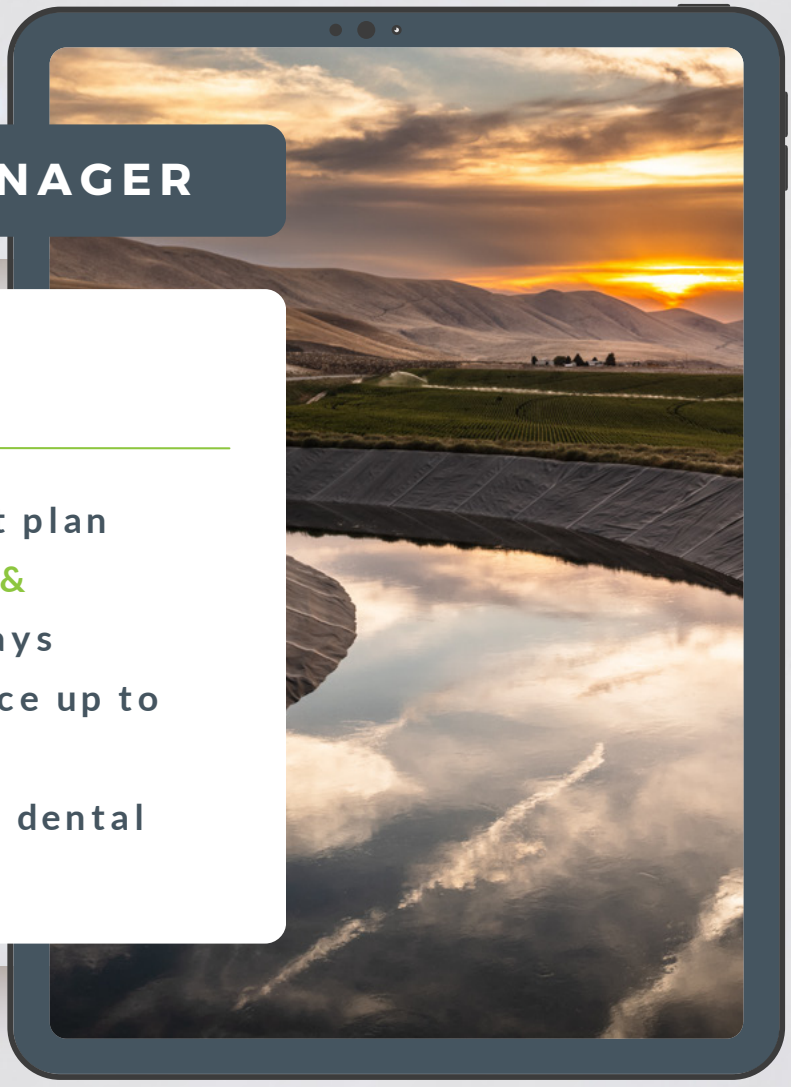

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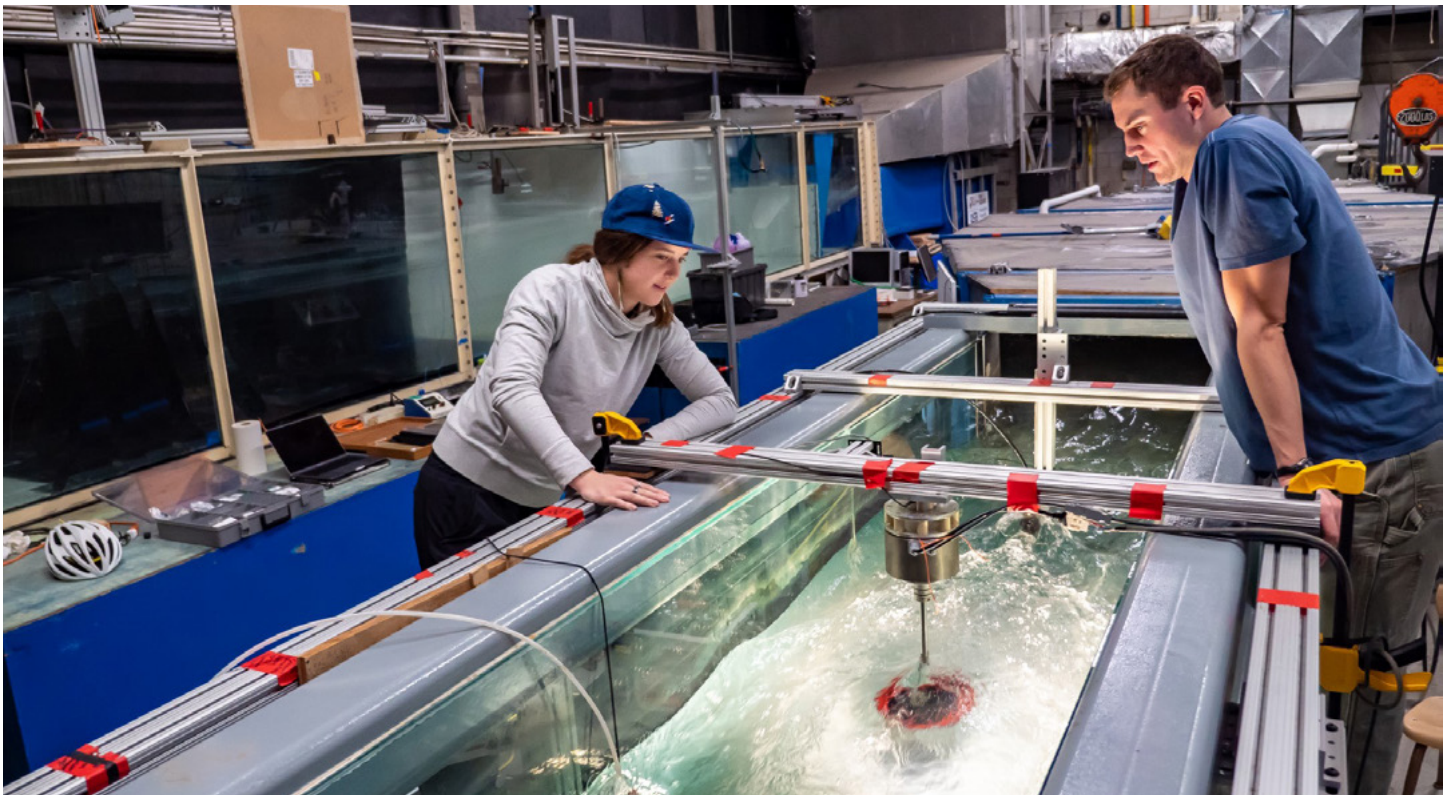
Shana Hirsch: Catching the Currents at the Pacific Marine Energy Center



Researchers at the UW Marine Renewable Energy Laboratory conducting an experiment on a cross-flow turbine.

The Pacific Marine Energy Center (PMEC), one of four National Marine Energy Centers in the United States, supports research and development in the marine energy sphere. In this interview, Hydro Leader *takes a deep dive into the center's activities with Codirector Shana Hirsch.*

Hydro Leader: Please tell us about your background and how you came to be in your current position.

Shana Hirsch: I came to this position a little sideways. I went back to school in my late 20s and studied environmental politics and policy. I ended up getting a PhD in water resources at the University of Idaho. I focused on hydropower dams, the ways in which climate change is affecting salmon runs in the Columbia River basin, and how to mitigate that through restoration. When I finished my PhD, I came to the University of Washington (UW) because I was working on a project with someone in its Human Centered Design & Engineering Department. After years of focusing on terrestrial hydropower, I was interested in looking more to the ocean—to marine energy and alternative renewable forms of energy that had less of an effect on fish and rivers. I got interested in marine energy when I found some folks at UW who were involved in PMEC. I reached out and shared my interest in marine energy, and they were excited to meet right away. I am now the codirector of the organization that I approached just 5 years ago.

Hydro Leader: Please introduce PMEC.

Shana Hirsch: PMEC was founded in 2008 by the U.S. Department of Energy's (DOE) Waterpower Technologies Office (WPTO). It is one of four national marine energy centers in the United States. We're a consortium of universities that include UW, Oregon State University, and the University of Alaska Fairbanks. Our goal is to support innovation and foundational research in the marine energy sector, specifically around responsible innovation in marine energy technologies. We have university researchers, faculty, and a network of industry partners. We're like a land grant extension service, in a way, because we support marine energy in any way that we can with our university expertise.

Hydro Leader: What kind of entities do you partner with?

Shana Hirsch: We support small entrepreneurial organizations and engineers who are trying to develop marine technologies. For instance, there are a few companies in Seattle that are developing wave or tidal energy devices. We also have connections with state and regional government agencies such as Washington State's

PHOTOS COURTESY OF PMEC.

Maritime Blue Initiative. That's a part of the Washington State Department of Commerce, which tries to support innovation in the marine sector. We have connections with a lot of the institutions on UW's campus, such as the Nippon Foundation Ocean Nexus Center, which promotes equity in the ocean globally. We also work closely with researchers in the navy; at the DOE; and at national labs, such as Pacific Northwest National Lab and the National Renewable Energy Laboratory.

Hydro Leader: Would you provide more information on PMEC's research into and development of marine energy projects and technology?

Shana Hirsch: We have testing facilities and capabilities at each of our institutions, and they're all a little different. At UW, we have facilities to support wave and tidal energy research. For instance, we have vessels that can tow tidal devices or that can support environmental monitoring research areas of potential development. There's a lot of research going on in Alaska, where tidal energy devices are being used in river and estuary environments to power microgrids for small villages. In Oregon, we have the Hinsdale Wave Tank, which is a large wave-energy testing tank. We are also supporting research that's going on around PacWave, the first offshore grid-connected wave energy test site in the United States. PMEC researchers have done a lot of work there to engage with local communities and fishermen about what wave energy might look like and the benefits it could have for communities. Our research is all about understanding all aspects of these technologies. We work on tasks such as connecting devices to the grid, improving our use of electronic control systems, and improving power takeoff. We also research their social and environmental effects and benefits. For instance, we do research on how to mitigate environmental impacts on fish and marine mammals.

Hydro Leader: How is PMEC funded?

Shana Hirsch: We're really focused on research, so our projects are funded through research grants. Most of that comes from WPTO. Here at UW, we also get funding from the navy, the National Science Foundation, the university itself, and the College of Engineering.

Hydro Leader: What kinds of projects do you currently have underway?

Shana Hirsch: We have 130 people working on projects that span social science, the environment, and engineering. We hope to get new facilities, including a new wave testing tank. There are folks working on using monitoring devices called microfloats to try to characterize the resources around fast tidal currents and see if they are appropriate for specific devices. My own research is in social science, so I focus on trying to understand how to support innovation. One project that I just wrapped up was called "Analyzing the U.S. Marine Energy Technological Innovation System." The yearlong project was about trying to understand what is going on in marine energy in the United States and what is needed to support innovation in the sector.

PMEC researchers testing a turbine off the research vessel Russell Davis Light.

Hydro Leader: Is there anything you would like to add?

Shana Hirsch: There is a lot of marine energy resource potential out there. There's a lot of excitement in the community of people who are working on this technology. I think we're approaching a time when these technologies will start to be commercialized. To decarbonize, we need all types of renewable energy in our portfolio. People should be looking to wave and tidal energy to fill some of these needs.

Hydro Leader: What is your vision for the future?

Shana Hirsch: My vision is a completely decarbonized energy and transport sector. We need electricity, we're going to need a ton of hydrogen, and we need to get a lot of technologies online. We could have wave and tidal energy taking advantage of resources in remote areas to power local communities. We could make and store hydrogen to power vehicles. I think we need to start thinking about decarbonization as an exciting challenge. For me, that's the hope of the future. I want to inspire students and other young people to get involved in this transformation. H

Shana Hirsch is the codirector of the Pacific Marine Energy Center. She can be contacted atslhirsch@uw.edu.

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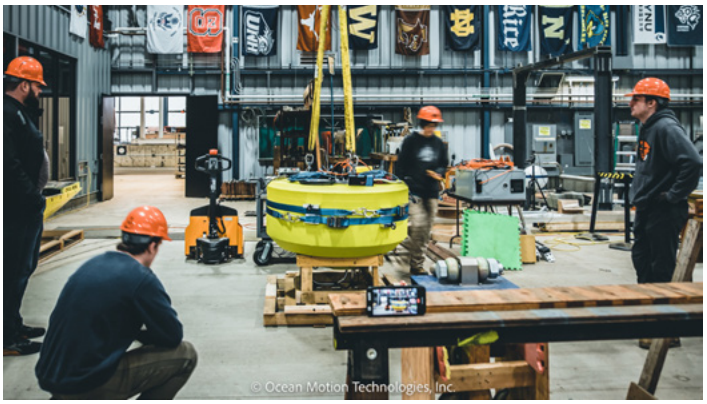
Samantha Quinn of the Pacific Ocean Energy Trust: Supporting Research and Idea Sharing in Marine Energy



Ocean Motion Technologies personnel prepare the company's wave energy converter for testing at Oregon State University's Hinsdale Wave Research Laboratory.

POET Executive Director Jason Busch gives the opening speech at the 2023 OREC Conference.

The Pacific Ocean Energy Trust (POET) supports the research and development of marine energy and offshore wind with a focus on the U.S. Pacific Coast. It does so through policy work, by providing fast-track funding for testing as the network director for the Testing Expertise and Access for Marine Energy Research (TEAMER) program, and by holding several conferences. In this interview, Hydro Leader *talks with POET's program director, Samantha Quinn, about how the organization helps bring together university researchers with industry innovators to advance our sustainable energy future.*

Hydro Leader: Please tell us about your background and how you came to be in your current position.

Samantha Quinn: As a college undergraduate, I studied business and economics. Right after I completed my undergraduate studies, I got a job as a contractor for the U.S. Department of Energy's (DOE) Water Power Technologies Office (WPTO). I worked there for about 3½ years. At the time, I didn't know much about marine energy, but I had some great mentors. When it was time for me to figure out what I wanted to do next, I decided to get a master's degree in economics, focusing on marine energy. I went to the University of Edinburgh in Scotland, a leader in marine energy, and got to work with some great academics there. I ended up working in Scotland for a few years after I graduated and then moved back to the United States in 2016 to work at Oregon State University. Through that, I found my way to POET in 2020. I became the program director in 2023.

Hydro Leader: Please introduce POET.

Samantha Quinn: POET grew out of the Oregon Wave Energy Trust, which launched in 2007 as a nonprofit. It got state funding to help advance marine energy and provided funding to technology developers. After several years, the group wanted to work on other types of offshore energy and to expand its focus beyond Oregon to the broader region. The organization became POET in 2015.

Today, we have a staff of five that does advocacy and policy work and works on some federal projects. Our goal is to find sustainable solutions to climate change with offshore energy, which includes marine energy; offshore wind; and the colocation of different types of renewable energies, such as offshore wind and wave or solar and wave. We are also looking at the potential implementation of marine carbon dioxide removal, such as the deep-sea storage of carbon dioxide or the creation of aquaculture farms of algae to remove carbon from the atmosphere. This is definitely a new topic for me, so I'm looking forward to learning more. We also work with regulators and power companies to figure out what infrastructure updates need to be done to ensure a sustainable energy future.

Hydro Leader: Please tell us about the TEAMER project.

Samantha Quinn: TEAMER is a WPTO-sponsored program for which POET is the network director. We have over $10 million in testing support funds to provide to technology developers and researchers in the marine energy community. Testing is critical to advancing marine energy, but it's also very expensive. This program is trying to make it more accessible and to accelerate the funding and reporting process. We review applications three to four times a year and then send money directly to selected facilities. We then work with both the test support recipient and the facility to set up a test plan, do the actual testing, write a post-access

PHOTOS COURTESY OF JACK PAN, OCEAN MOTION TECHNOLOGIES.

report, and upload the data so that they are accessible to other researchers and developers.

Hydro Leader: How many facilities do you have, and where are they located?

Samantha Quinn: POET itself does not have any facilities, but the TEAMER program facility network has about 50, including national labs, universities, and private organizations. Many facilities have several capabilities, so it is difficult to provide an exact number. The Pacific Northwest National Lab, for instance, does environmental work, but it also has an open water facility and a wet lab and does some modeling work. Within each of the physical facilities, there are several capabilities. I'd say we have more than 100 different capabilities.

Hydro Leader: Please tell us about some of the projects that have come through the program and have been put into production.

Samantha Quinn: One of the ways that we hope researchers and developers leverage the TEAMER program is through an iterative process. For instance, they test their code or design at a facility, iterate based on the lessons they learn, and then apply to TEAMER again to test the new changes. One company that has used TEAMER in this way is Ocean Motion Technologies, a wave-energy developer based in San Diego, California. It has worked with our program four times so far to support its research and development. The first two rounds of technical support focused on numerical modeling and system optimization. These results benefited the building of a physical device that was tested at Oregon State University's Hinsdale Wave Laboratory. The Ocean Motion team is currently working on a gap and optimization analysis based on the wave tank test at Hinsdale. It will leverage all the new information to update its design, and we welcome its future TEAMER applications for more testing.

Hydro Leader: What other projects are you a part of?

Samantha Quinn: The other project that I primarily work on is the University Marine Energy Research Community (UMERC). The goal is to connect marine energy researchers with private-sector technology developers, to identify the research needs of developers, and to figure out how these gaps can be filled. UMERC holds a yearly conference. Each year, we hold the conference in a different place to attract new people, and we also try to colocate with another event. This year, the conference is on October 4–6, 2023, at the University of New Hampshire. We're colocating with the kickoff of the Marine Energy Collegiate Competition. We had our first UMERC conference last year in Portland, Oregon, colocated with both the Marine Energy Technology Symposium and the Ocean Renewable Energy Conference.

UMERC also hosts workshops and seminars. Last year, we created what we called a *research landscape* for the U.S. marine energy sector to help visualize what people are working on as well as where the gaps lie. We recently hosted a seminar with the Monterey Bay Aquarium Research Institute about using marine energy to power oceanographic sensing instrumentation. Most of our workshops and seminars are recorded and can be found on our website's media center, so I definitely urge readers to check them out.

Hydro Leader: POET just hosted its annual Ocean Renewable Energy Conference (OREC). How did the event go?

Samantha Quinn: We were really pleased with the event. We changed the location and time of year for the first time in years, and we were delighted to have about 150 attendees. We had a profusion of knowledgeable speakers from the national labs, private-sector technology developers, and academia. A highlight for me was listening to the technology developers describe their trajectories. There will be a lot of deployments over the next few years, which will be big stepping stones for the U.S. marine energy sector.

We will be holding the next OREC conference in May 2024 in Portland, Oregon. We're excited because we'll hold a meeting for the DOE's and national labs' Marine Energy Collegiate Competition at the UMERC conference in October this year and the final competition at the OREC conference next year. The cool thing about that is that you get to see all the students and hopefully the upcoming marine energy innovators. I've been in this field for 15 years, and you can get a little bit jaded sometimes, so it's cool to see their enthusiasm.

Hydro Leader: What is your vision for the future?

Samantha Quinn: I hope to see the TEAMER program continuing. We just passed 100 projects, and I'd love to see at least 100 more. I want to see some good collaboration between universities and the industry on risk mitigation, deployment, and testing. Right now, the United States is focused on testing: PacWave will come online in the next couple of years, and a few deployments will soon take place at the Wave Energy Test Site in Hawaii. I am excited to see more and more deployments of all scales. We need to get devices in the water and see what they can do to reduce our dependency on fossil fuels, to reduce emissions, and to move the United States toward a broader, more-balanced energy portfolio.

Samantha Quinn is the program director at the Pacific Ocean Energy Trust. She can be contacted at info@pacificoceanenergy.org.

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Alden Research Laboratory: Hydro Modeling and Beyond

A physical hydraulic model of a spillway located at a hydropower plant in the southeastern United States.

Founded in 1894 as a hydraulic laboratory, Alden Research Laboratory now provides a wide range of support services for hydro owners, including the structural evaluation of hydraulic structures; flow modeling; fish passage design; and help with relicensing, compliance, and funding applications. In this interview, three of the company's senior staff talk with Hydro Leader *about the company's projects and the enduring value of modeling.*

Hydro Leader: Please tell us about your backgrounds and how you came to be in your current positions.

Stuart Cain: I've been at Alden for 27 years. I started here in 1996, right out of graduate school. My background is in mechanical and aerospace engineering. I started the computational fluid dynamics group back in 1996. I served in a technical role and then in some managerial roles until 2009, when I took over as president of Alden. I operated in that capacity until 2021, when we became part of Verdantas and I became the operations lead for the Alden area. Recently, I transitioned into the role of business development lead for the Alden area.

Greg Allen: I'm an engineer and the department leader of environmental and engineering services at Alden. I started here in 2001. I have extensive experience with fish protection technology evaluations for cooling-water and hydropower intakes, fish passage evaluations and design, debris management at water intakes, and many other aspects of engineering and compliance for hydropower and desalination projects.

Dan Parker: I'm the hydropower practice leader at Alden. I started in the hydro industry around 1985, and I've done everything from environmental compliance and regulatory and licensing requirements to operations and business development. I joined Alden in 2021.

Hydro Leader: Please introduce Alden and Verdantas.

Stuart Cain: Alden Research Laboratory is the oldest continuously operating flow modeling consultancy in North America. We are now part of Verdantas, a nationwide environmental and engineering consulting firm. We opened

PHOTOS COURTESY OF ALDEN.

our doors here in Holden, Massachusetts, in 1894. We were part of Worcester Polytechnic Institute at that time. In 1986, five professors took over the laboratory, and it became a private company, Alden Research Laboratory, Incorporated. We started out as a hydraulics modeling laboratory, doing a lot of work on dams, spillways, conveyance structures, and pump intakes—projects of that nature. We added a flow meter calibration service group in the late 1920s. In 1994, we added an environmental engineering services group that focuses on fish passage and protection issues. In 2012, we opened a small laboratory near Seattle and offices in Portland and Denver. In 2021, we became part of the Verdantas family.

At the Alden group, we have about 75 people, most of them at our Massachusetts facility, which sits on about 32 acres. We have about 175,000 square feet of laboratory space, where we conduct our large physical modeling activities. We also do a lot of work on spillway modeling for dams: modeling the probable maximum flood condition to make sure the spillway capacity is sufficient. We were involved in assessing the Oroville Dam spillway failure. We also create physical models of pump intake structures. Over the last 50 years, we have modeled just about every flood control structure in and around New Orleans, a city prone to extensive hurricane-related flooding. We also do a lot of design work for and structural evaluation of hydraulic structures.

Hydro Leader: What industries do you serve?

Stuart Cain: Our major markets are power, regulatory compliance, environmental fish passage and protection, dam safety, manufacturing, transportation, and water and wastewater. On the water side, we model canals, conduits, conveyance structures, flood control structures, pump intakes, and water treatment facility components. We also conduct studies that address river mechanics and sedimentation issues, and on the environmental side, our expertise is in fish passage and protection. We also support the relicensing of dams and hydroelectric facilities.

Hydro Leader: Please tell us more about your work with hydropower owners.

Dan Parker: We help hydro owners resolve their problems. If they've got a flow problem, we can take a look at that. If they've got a fish passage problem, we can help them find solutions for that. If they've got structural or dam safety problems or concerns about the ability of structures to pass flood flows, we can help them investigate those concerns and provide the independent third-party evaluation that regulators and funding entities require.

We've also tested turbines to see how they perform, both with in-field tests and with prototypes here at the lab. If a hydropower

Jenna Rackovan, a fish biologist at Alden, visits a hydropower site in Massachusetts.

Field technicians work in Wisconsin to evaluate the ability of a fish passage system to safely handle lake sturgeon or similar species.

Jenna Rackovan, a fish biologist at Alden, visits a hydropower site in Massachusetts.

plant installs a new unit and wants to know the performance of that unit, we can do those tests. We're probably one of the few facilities in the country not owned by a turbine manufacturer to have a testing facility of this size on our campus.

Finally, Alden developed the Alden turbine, which is more fish-friendly than traditional turbines. It can potentially offer a hydropower owner a way to avoid having a separate downstream fish passage to safely get fish around a power dam. You're looking at millions of dollars to get fish safely around a dam, so it's a major development to incorporate that benefit right into the turbine.

Greg Allen: We help hydropower owners address fish passage issues at their projects. What is the best way to get fish past a dam? We consult with agencies and complete feasibility studies to determine the best option; then, we develop a design and prepare construction bid documents for upstream and downstream passage projects. We stay current on the latest technologies for fish passage, often testing these technologies in our laboratory and in the field. We also test hydrokinetic turbines in our flumes, both for performance and for how they interact with fish. We can look at how these technologies interact with aquatic species, and we've developed models to predict fish survival through hydropower turbines. Every year, we're improving the design of these projects using all available tools and doing computational fluid dynamics modeling so that we fully understand the hydraulic conditions. Then we can appropriately design the passage structure, using the biological information from telemetry studies, for example, to inform those designs.

Hydro Leader: What topics are you researching that have the potential to improve hydro operations?

Dan Parker: We are working with entrepreneurs to develop a system of curtains, parts of which are permeable to water, to install in a hydropower impoundment. The U.S. Department of Energy has given us funding for that. As we know, some strata of water have oxygen levels that are more suitable for living creatures than others. By putting these combinations of curtains into an impoundment, we can adjust the level that the water that goes through the turbine is drawn from. Those modifications can improve the oxygenation in the water that gets discharged downstream. We can do similar things with temperature and sediment. If we get funding for phase 2, we will design one of these structures with the intent to deploy it in the field.

We're also testing an innovative new fish passage made by a company in Finland. Concrete fish ladders cost millions, if not tens of millions, of dollars to build. Obviously, once you put all that concrete in place, you can't move it around, so if it's not in the most optimum location, you've got an issue. The new device is a barge-mounted structure that floats in the tailrace, attracts fish, and then basically pumps them up over the dam safely. You can move it around depending on where the fish are congregating or where the best location is to help fish pass safely and efficiently over the dam.

We're also testing ways to improve dissolved oxygen levels below a dam. Hydropower owners have an obligation to maintain or improve water quality conditions downstream. One of our engineers looked into using nanobubbles to improve dissolved oxygen. He was able to develop a device that produces a high proportion of nanobubbles from the air that are then injected into the water. That has major applications well beyond improving the oxygenation of water.

Hydro Leader: Are there any specific funding opportunities in the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) that hydropower owners and operators should be aware of?

Dan Parker: This is a watershed moment for hydropower, if I can use that term. A lot of funding that formerly went

PHOTOS COURTESY OF ALDEN.

to other forms of renewable energy is now available for hydropower resources. There are production tax credits and investment tax credits available for existing and new hydropower facilities. The availability of those credits makes a hydro project more attractive to investors.

Going forward, I think we're going to see a lot of reinvestments in the country's oldest renewable energy supply, hydropower. That's huge for a lot of hydropower owners. Many facilities will also be receiving needed maintenance and capital improvements that will help them to continue to operate for another 50–100 years. In addition, there are funds available through the BIL and the IRA for renewable energy projects that reduce greenhouse gases, which some hydro projects can help do. Some hydropower owners may be eligible for those funds. Similarly, there are community development block grants and other types of funding available to municipalities and other governmental institutions that can be applied to renewable energy. For example, we're working with a municipality in the Northeast that is looking at adding hydropower to a dam it owns. We're doing the feasibility study and helping design that facility, and we'll do the permitting and licensing. We're looking at the availability of various funding mechanisms to make that project viable. If it moves forward, it will likely be one of the first new hydropower projects built in the Northeast in quite a long time. We've become more knowledgeable about some of these funding and grant opportunities. We can advise hydropower clients about what is available and assist them in applying for some of these funds.

Stuart Cain: Our customers include government agencies; the owners of hydropower entities or assets; developers; municipalities; and architecture and engineering (A&E) firms that design water treatment systems, pumping stations, and flood control structures. In the Gulf Coast states, for example, we have recently worked with A&E firms to model some of the big structures—including large pumping stations, levees, sector gates, and flood-control gates in canals—that are being developed to protect assets from hurricanes. We are actively supporting many projects supported by infrastructure spending.

Hydro Leader: What services do you offer to help customers with Federal Energy Regulatory Commission (FERC) licensing and compliance?

Dan Parker: We can help hydropower owners with just about any aspect of regulatory compliance. That's a broad umbrella that includes licensing, relicensing, compliance, modifications, and requests for amendments to the license. For initial licensing, we conduct required studies ranging from environmental studies and fish passage to studies on socioeconomic effects in the region where the facilities are going to be built. Alternatively, if hydropower owners are approaching relicensing or want to make a significant change to a facility, we can help them strategize and prepare a capacity amendment. That document can be quite voluminous, so we can shepherd them through that process. If they get a noncompliance notice from FERC, we can help them investigate that by analyzing the data and comparing the results to the license requirements. We can also support them in discussions with FERC.

Hydro Leader: What is your vision for the future?

Stuart Cain: With our hydraulic modeling and consulting, we try to minimize project risk by making sure that structures, devices, and technology work at a small scale before they are built in the real world. That approach has been embraced in the engineering community for decades. But many young engineers coming right out of school don't necessarily understand the value of modeling and how it can support some of these projects. My vision for the future is to be able to educate the new crop of young engineers on the value of that work. The cost of fixing something that wasn't built correctly the first time far exceeds the cost of a model study during the design process.

Dan Parker: I'd like to see all those engineers that Stu talked about come to work in the hydropower industry. Unless you're an engineer, you don't need a 4-year degree, or even a 2-year degree, to work at a hydropower facility. These facilities are often great places to work in picturesque environments. Whether your interest is in fisheries, like Greg's, or in engineering, like Stu's, or in regulatory compliance, there are all kinds of opportunities. For example, right now, welders and relay technicians are in high demand. There's a place in hydropower for people who have those skills or even have the aptitude for those skills. I'd love to see them join the hydropower industry and start a great career.

Greg Allen is Alden's director of environmental and engineering services. He can be contacted at gallen@aldenlab.com.

Stuart Cain is the vice president and business development lead for Alden. He can be contacted at sacain@aldenlab.com.

Dan Parker is Alden's hydropower practice lead. He can be contacted at dparker@aldenlab.com.

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How Open Hydro Helps Reservoir Operators With Climate Mitigation

Open Hydro has created a platform that helps hydro owners and water suppliers accurately measure the greenhouse gas emissions of their reservoirs. The fully automated solution makes it easier for hydro owners to measure and report their emissions and attract green finance. As cofounders Cristina Diez Santos and María Ubierna Aparicio explain, hydropower can be a pioneer in climate mitigation for the entire water sector.

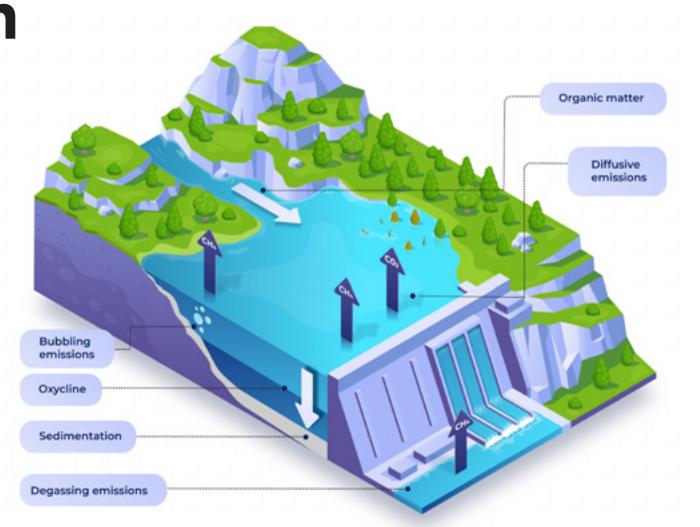
Hydro Leader: Please tell us about your backgrounds and how you came to be in your current positions with Open Hydro.

Cristina Diez Santos: María and I are the cofounders of Open Hydro. I started my career in water infrastructure. I have worked on both the design infrastructure and the business development sides, mostly in Europe and Africa. I got my postgraduate degree in sustainable water resources at ETH Zurich. That led me directly to hydropower, and that's where this journey started. I did my thesis on the Zambezi basin in Africa, and that led me to work at the International Center on Small Hydro Power. From there, I went to the International Hydropower Association, where María and I started working together. We were advancing the state of the art and working on water-energy-nexus issues and other pressing issues for hydropower. Climate mitigation was one of the key topics I specialized in. I saw that there was a big need for the sector to understand carbon emissions, because that topic had big implications for hydro owners' decisions to modernize their assets or even develop new assets. That's what led us to launch Open Hydro in 2021.

María Ubierna Aparicio: Cristina and I are both civil engineers. I specialize in hydraulics and the environment. I have a master of science in civil engineering and a postgraduate master of advanced studies in sustainable water resources from ETH Zurich. I decided to finish my studies focusing on the water energy sector. I had been working on more technical aspects related to climate change, including management and best practice, climate resilience, and greenhouse gas mitigation in hydropower reservoirs. All that background and work with the key stakeholders in the hydropower sector led me to set up and cofound Open Hydro with Cristina so that we could focus on climate-change-related aspects of open water reservoirs.

Hydro Leader: Please introduce Open Hydro.

Cristina Diez Santos: Open Hydro's platform is designed to help decarbonize freshwater systems. Emissions from water are widely underestimated: They represent more than



This diagram demonstrates the sources of greenhouse gas emissions in reservoirs.

10 percent of global greenhouse gas emissions. In particular, the natural decomposition of organic matter in reservoirs emits more than 1 billion tons of greenhouse gases every year. Hydropower is on average a low-carbon technology, but in some cases, hydropower reservoirs can release more than twice the amount of greenhouse gases as the total operational emissions of a company. With that in mind, it is crucial to understand the emissions of all reservoirs. Moreover, companies will have to report the emissions of their reservoirs according to Greenhouse Gas Protocol's forthcoming land sector and removals guidance for reporting land use changes.

We are working on a scalable solution to help companies understand the emissions from the water, and beyond that, we are looking at actions that can mitigate those emissions and monitor them over time. We help demonstrate how sustainability actions help reduce emissions, reduce the costs of mitigation measures, and help companies advance toward their net-zero targets. Beyond hydro owners, we help energy providers and energy consumers that are seeking greener energy. In cases of high emissions, our solution helps hydro owners to find pathways to manage and reduce those emissions. In the cases of low emissions, we help demonstrate that the emissions are low, helping increase the demand for hydropower electricity.

Hydro Leader: What problem or need in the hydropower industry do you see your technology addressing?

Cristina Diez Santos: In the conversations we've been having with operators in the hydropower industry, we found three key challenges. The first was how to assess emissions accurately. Understanding and accounting for emissions from water can be complex—and expensive, if we're talking about doing direct measurements. We offer the first low-cost solution with

IMAGE AND PHOTOS COURTESY OF OPEN HYDRO.

our multimodel approach. Using water quantity and quality data, we can assess emissions accurately at any given point. In that way, we help companies understand how their operations are affecting emission levels. It's something that they can monitor and track over time.

The second challenge industry operators have is data management. Climate reporting requirements are increasing, and it's requiring more and more data. Up until now, most companies that we deal with have stored and managed their data in Excel. That creates certain challenges. First, it might make it more time consuming, less efficient, and more difficult to work across departments or even across companies. Our platform is web based. You don't need to download anything, and it can be accessed anytime and anywhere. It's also built on the most secure infrastructure system, and it's fully automated. This means that companies can choose who can access the data and at what level, and they can visualize their data in a variety of ways.

The third challenge is climate reporting itself. We've seen a big trend from voluntary to mandatory reporting, not just in the United States but globally, following international frameworks such as that of the Task Force on Climate-Related Financial Disclosures (TCFD). With complex sectors like hydropower, it can be difficult to translate those requirements. Our platform is in line with the TCFD and the Greenhouse Gas Protocol recommendations, so it's easy to extract and export the data. Basically, in one click, the data can be extracted and entered into companies' sustainability and environmental, social, and governance, or ESG, reports.

Hydro Leader: Tell us about Open Hydro's hydropower reporting guideline.

María Ubierna Aparicio: We released our climate mitigation guideline in November 2022. It gives hydropower operators an industry-specific framework for reporting their emissions. We developed the guideline using a multistakeholder approach as the first step before we built the platform. We started by setting up a working group; then, we had our guideline reviewed by the TCFD, the World Benchmarking Alliance, and the Greenhouse Gas Protocol so that it would be aligned with those organizations' recommendations.

Hydro Leader: Who are your main customers?

María Ubierna Aparicio: Our platform is being used by electric utilities that own and operate hydropower reservoirs and by the utilities that use reservoir power for their supply service. We work mainly in Europe as well as in Latin America and North America.

To enter the U.S. market, we applied for the Hydrovision Industry Fund, and we were one of the entities awarded. Launched in 2023, the Hydrovision Industry Fund aims to support innovations that will make hydropower more sustainable. We will use the prize money to enter the U.S. market, starting with a communications campaign and outreach to the key players. We will also analyze the regulatory environment in the U.S. market.

Hydro Leader: You offer a demo service. What does that look like for a potential customer?

María Ubierna Aparicio: The demo service provides potential customers with a one-on-one conversation to help them better understand whether our product can meet their needs. We demonstrate our platform, which takes a multimodel approach to help them better understand their greenhouse gas emissions from their reservoirs, comply with international reporting recommendations, and achieve their net-zero targets.

Hydro Leader: Is there anything you would like to add?

Cristina Diez Santos: To reach true net zero, we need to consider water, and that requires us to transform the way we value it. Hydropower is taking the lead, but this is a challenge that affects the entire water industry. The hydropower sector's action in this field presents an opportunity for the entire sector: It is enabling hydropower to be a real leader in climate action. It is enabling us to be the ones who are building solid bridges to other water users and to other industries, such as manufacturing and companies that consume a lot of water. We see this as the first big step to make the entire water industry more sustainable, more climate resilient, and more adaptable so that it can provide the water and energy that we'll need in the future.

Hydro Leader: What is your vision for the future?

Cristina Diez Santos: At Open Hydro, we want to make the planet more water and energy conscious by providing an accurate, science-based platform to allow water and energy users to quantify and mitigate greenhouse gas emissions. We know that water is our most precious resource, but until now, we've failed to figure out how to value it. That's where we come in. Our platform provides a unique advantage by turning climate mitigation costs into business opportunities. H

Cristina Diez Santos is a cofounder and the CEO of Open Hydro. She can be contacted at cdiez@openhydro.net.

María Ubierna Aparicio is a cofounder and the chief product officer of Open Hydro. She can be contacted at mubierna@openhydro.net.

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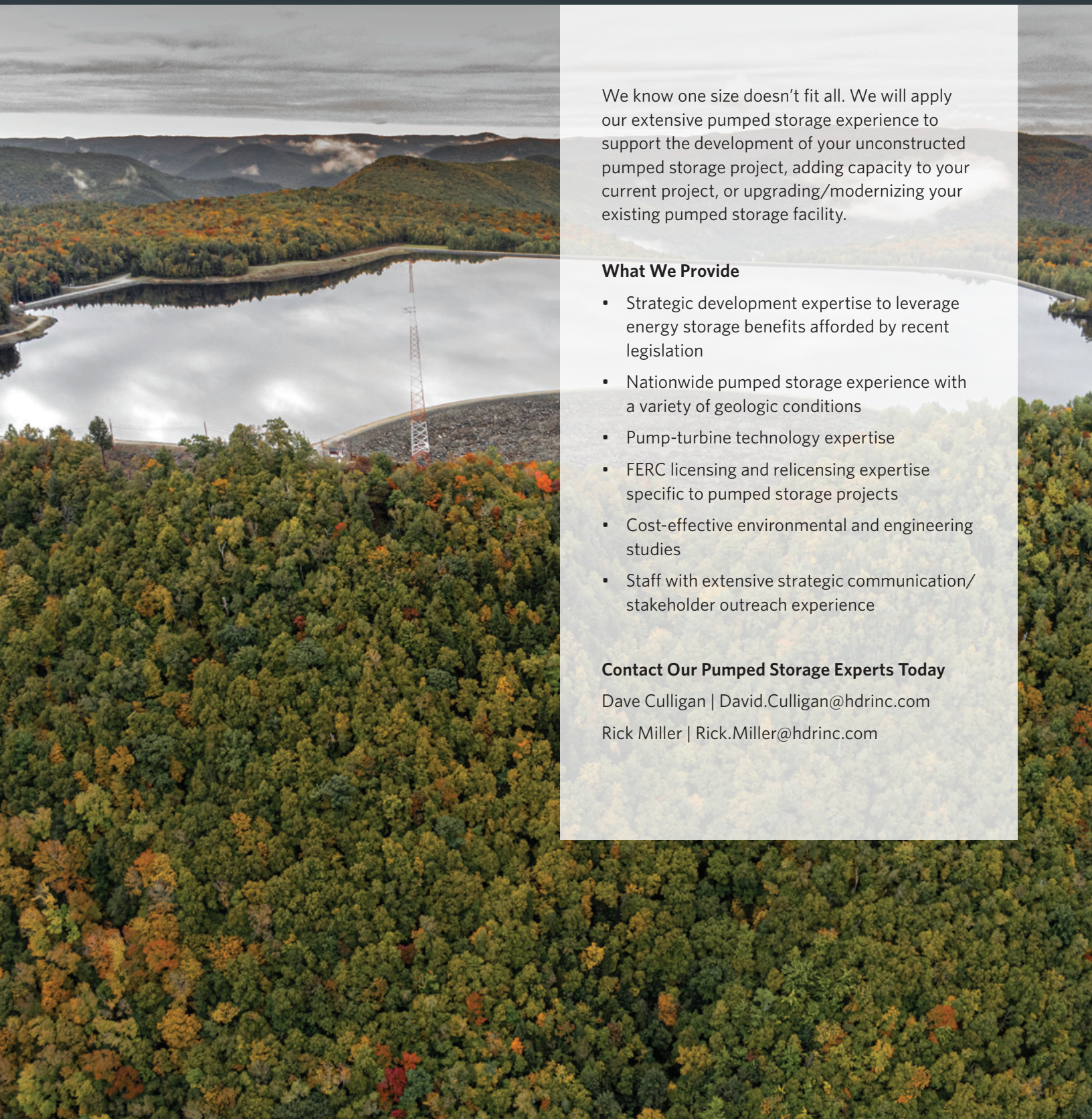

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Hydro Leader

Upcoming Events

July 11–13 Hydrovision International, Charlotte, NC
July 19–21 North Dakota Water Resource Districts Association and North Dakota Water Education Foundation, Joint Summer Water Meeting and Executive Briefing, Dickinson, ND
July 25–26 National Hydropower Association, Northeast Regional Meeting, Springfield, MA
July 27 Water Day at the North Dakota State Fair, Minot, ND
August 2–4 National Water Resources Association, Western Water Seminar, Medora, ND
August 7 North Dakota Water Education Foundation and the Garrison Diversion Conservancy District, Top o' the Day Tee-Off Golf Scramble, Carrington, ND
August 14–16 National Conference of State Legislatures, Legislative Summit, Indianapolis, IN
August 22–24 Colorado Water Congress, Summer Conference, Steamboat, CO
August 24–25 National Hydropower Association, Alaska Regional Meeting, Valdez, AK
August 28–30 Idaho Water Users Association, Legislative Water College, Burley, ID
September 12–13 National Hydropower Association, Alaska Regional Meeting, Anchorage, AK
September 13–14 Nevada Water Resources Association, Fall Symposium, Reno, NV
September 15 Agribusiness and Water Council of Arizona, Annual Meeting and Water Conference, Phoenix, AZ
September 17–20 American Public Power Association, Business and Financial Conference, Phoenix, AZ
September 18–19 Northwest Hydroelectric Association, Fall Hydro Camp, Boise, ID
September 21–22 P3 Water + Energy Summit, San Diego, CA
September 25–27 National Rural Water Association, WaterPro Conference, Aurora, CO
October 3–5 Coalition of Rio Grande Water Users, Inaugural Meeting, Santa Fe, NM
October 4 Oregon Water Resources Congress, Water Law Seminar and Elmer G. McDaniels Memorial Golf Tournament, Sisters, OR
October 10–13 National Hydropower Association, Clean Currents, Cincinnati, OH
October 15–18 American Public Power Association, Legal and Regulatory Conference, Seattle, WA
October 27 Agribusiness and Water Council of Arizona, H2O Golf Tournament, Casa Grande, AZ
November 1–3 Texas Water Conservation Association, Fall Conference, San Antonio, TX
November 8–10 National Water Resources Association, Leadership Forum and Annual Conference, San Antonio, TX
January 23–25, 2024 *Irrigation Leader,* Irrigation Leaders Workshop, Phoenix/Chandler, AZ

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