Developing a Marine Energy Workforce Pipeline

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I. Introduction

Marine energy technologies play an important role in the growing renewable energy industry. To spur innovation and growth in these exciting technology areas, the industry needs to inspire the next generation of marine energy workers. Despite increasing interest in the industry, its nascent nature presents a challenge in developing a workforce pipeline. In order to maintain the critical innovation and interest needed, the National Renewable Energy Laboratory (NREL) and the Hydropower Foundation, in partnership with the U.S. Department of Energy's Water Power Technologies Office (WPTO), have been working to understand marine energy workforce needs while developing information and resources to help grow the Science Technology Engineering and Math (STEM) workforce pipeline.

The United States has a goal to reach net-zero greenhouse gas emissions by 2050 and marine energy is set to play a role in achieving this. Although, the US Department of Energy doesn't have specific targets for marine energy installations, the U.S. national trade group, The National Hydropower Association's (NHA) Marine Energy Council, is calling for domestic marine energy deployment targets of at least 50 MW by 2025, 500 MW by 2030, and 1 GW by 2035 [1]. If these goals are to be met, a trained workforce is needed.

While there isn't sufficient data yet to provide a reliable estimate of how many marine energy jobs will be created in the United States, various studies show that marine energy represents an opportunity to grow a new domestic workforce. An NREL report found that deploying 13,000 MW of wave energy converters off Oregon's coast could support 5,900 installation and construction jobs, 29,000 manufacturing and supply chain jobs, and 6,800 operations and maintenance phase jobs [2].

Additional projections globally have shown great potential for marine energy jobs:

- An impact assessment for the European Union Action Plan on Blue Energy estimated that **10,500–26,500 permanent jobs in Operations & Maintenance and up to 14,000 temporary jobs in manufacturing** could be created by 2035 to deploy 10.5 GW [3].
- The IEA-OES International Vision for Ocean Energy stated that 300 GW could be deployed, and **680,000 direct jobs created globally by 2050** [4]. Additionally, this report estimated the creation of **400,000 jobs for the deployment of 100 GW by 2050 in Europe alone**.

Looking at the U.S. energy sector more broadly, prior to the COVID-19 pandemic, energy was one of the fastest growing job markets. Despite the economic impacts of COVID-19, we are now seeing strong growth again. The number of U.S. energy sector jobs grew 3.8% from 2021 to 2022, and clean energy jobs grew 3.9%, outpacing overall U.S. employment, which increased 3.1% in the same time period [5]. This growth has not come without challenges though. When asked about their experience "finding qualified workers," more than four out of five employers across energy technologies reported at least "some difficulty" [5].

At present, given the need for more research, development, and demonstration of marine energy technologies, the marine energy industry needs a workforce that mixes strong ocean construction, nautical design, environmental, and ocean science with an understanding of advanced materials, innovative power system development, and control theory. Additionally, the industry needs to recruit social scientists to perform economic evaluations of the technology and influence policy to reduce deployment and commercialization barriers.

If the marine energy sector is to achieve the domestic targets set by the NHA, jobs will require a combination of specialized training and advanced degrees. A fully functional industry will eventually require jobs across various disciplines including:

- Project Development
- Environmental Monitoring
- Manufacturing and supply chain

- Ports and staging
- Maritime construction
- Operations and maintenance

As this industry expands, there is a critical need to develop a skilled and competent workforce capable of designing, constructing, operating, and maintaining marine energy systems. This paper explores the challenges, strategies and considerations involved in building a robust marine energy workforce pipeline to support the growth and sustainability of this sector.

II. METHODS

The NREL-led STEM and Workforce Development project, funded by the WPTO, began in 2019 to address the increasing need for workforce entries into marine energy along with generating general public awareness. The project includes collaboration with stakeholders, industry, and academia to identify their challenges and priorities and learn how we can best support the needs of the U.S. water power workforce.

Our work has developed programs and resources to engage the marine energy industry and academia and to respond to their needs, primarily in the United States. We have also sought student perspectives on the marine energy industry and surveyed availability of educational courses.

Through outreach and analysis, our goal is to improve accessibility and distribution of educational materials and increase awareness of marine energy as a promising renewable energy. Our efforts have also served to increase the level of public knowledge on the marine energy industry and career opportunities in this sector.

The project team consists of many partners beyond WPTO and NREL including the Hydropower Foundation, Mystic Aquarium, the NEED Project, Oceans First Institute, Bonneville Environmental Foundation (BEF), the National Ocean Sciences Bowl, IKM 3D, the Foundation for Water Energy Education (FWEE), BW Research, and KidWind. Each partner contributes to the project in unique ways, from providing content for STEM educational portals, drafting water power curricula, creating compelling videos and animations, conducting educational summits and workshops, and performing analysis on jobs, economics, and water power workforce trends.

Fundamentally, NREL's water power team uses the power of leveraging across partner organizations and other funded initiatives to ensure the broadest impact

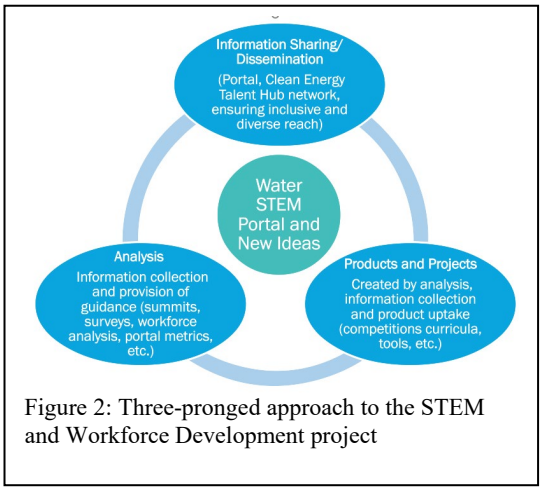

Figure 2: Three-pronged approach to the STEM and Workforce Development project

possible within the available WPTO budget. All insights gained through the analysis in this project are used to develop educational materials and curricula about the marine energy industry to help support and grow the U.S. workforce. We then provide various mechanisms to distribute these resources through stakeholder outreach and communication efforts. The objective of this work is to help educators, students and the general public better understand the technologies, future opportunities, potential impacts and benefits to the grid from the development of marine energy, and the career opportunities in this sector.

All resources developed under this project are publicly available through the STEM web portal.

III. RESULTS

NREL's analysis work to date under this project has been a series of industry, academia, and student surveys seeking to understand their challenges and perspectives on working in the marine energy industry. Our research found that there is strong student interest in marine energy, but it is limited by a lack of industry awareness about industry opportunities and potential career pathways. Professors often struggle to have sufficient funding to integrate marine energy into their curricula or research, creating a feedback loop where students are not getting exposed to marine energy in school and are not prepared for jobs in the industry.

While awareness issues loom large in attracting a new workforce, ensuring potential recruits have the skills necessary to meet the need is a significant concern. The STEM project team reached out to U.S. post-secondary

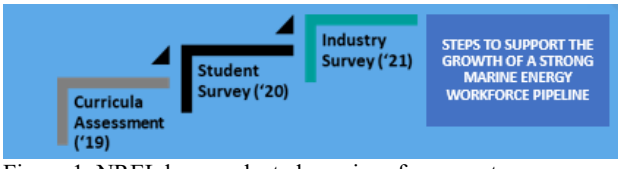

Figure 1: NREL has conducted a series of surveys to understand marine energy workforce challenges.

schools that include marine energy to better understand their educational programs and how to help attract students to work in these sectors. The results were staggering. Of the twenty-one schools known for their involvement in marine energy research that responded to the curricula survey, only four schools offer marine renewable energy undergraduate or graduate degree programs. Eight offer it as a specialization, eleven do not offer a degree in marine energy, and only twelve schools offer a course in marine energy. Schools observe an increased student interest in renewable energy and marine energy topics; however, career paths have not yet been established in marine energy, making it challenging to attract students to pursue this field.

Key data points from the curricula survey are as follows:

- 19% of surveyed schools have a marine energy major, 38% offer a marine energy specialization
- 16% of surveyed schools don't have marine energy courses, 35% include it as part of another energy course
- 48% of surveyed schools offer practical applications in coursework
- 57% of surveyed schools see increased interest in renewable energy and marine energy
- Funding is a challenge for 86% of schools surveyed
- Lack of industry jobs is a factor discouraging students from marine energy degrees
- Maritime academies are experiencing increased demand for their facilities to support marine energy research.

WPTO, NREL, and the Hydropower Foundation shared the curricula assessment results with educators and industry professionals at the 2019 Waterpower STEM Workforce Summit at the National Hydropower Association's Waterpower Week. Industry and academia discussed ways to increase awareness of marine energy careers and methods to support teachers in bringing water power to their classrooms. The summits generated recommendations such as encouraging more industry professionals to participate in the classrooms, framing the message of the marine energy workforce in a bigger context of the blue economy, emphasizing the role marine energy plays as part of a renewable energy portfolio, and providing an online hub of educational resources. This discussion also helped spur the development of the now annual Marine Energy Collegiate Competition (MECC) which challenges undergraduate and graduate students to develop and test marine energy concepts that could provide power to Blue Economy applications. Now going into its fifth year, MECC has exposed approximately 500 students from over 40 universities to marine energy.

In 2020, the project team continued its research into the workforce challenges of the water power industry by surveying U.S. post-secondary students to understand their perceptions and interest in marine energy. While surveyed students expressed a strong interest in renewable energy, many do not see marine energy as a growing field and have a limited understanding of the industry. The students who responded often had little exposure to water power in school and lacked information on careers and the anticipated growth of the industry.

Key data points from the student survey are as follows:

- Students expressed strong interest in learning more about marine energy, seen as a new and developing renewable energy source
- Students are mainly learning about marine energy in college, many have no idea where to learn more about it
- Students associate marine energy with oceans and waves but have limited understanding of the industry and technologies
- Students need more information on jobs, skills, and projected job growth of the industry to consider marine energy careers.

As a follow-on to the student survey, in 2021, the project team surveyed the U.S. water power industry. The thirty-five responding marine energy organizations indicated that while many recent student hires have limited to no understanding of the marine energy industry, there is a small percentage (17%) with extensive knowledge. This suggests the workforce pipeline could be strengthened by increasing relevant work experiences, marine energy coursework, industry engagement in the classroom, and hands-on learning.

Key data points from the industry survey are as follows:

- 83% of student hires have limited to no knowledge of marine energy
- 77% of student hires have relevant skills and abilities when entering the workforce
- Student hires have limited to no hands-on experience
- Students lack understanding of electrical grid, system operations, and environmental issues
- Industry faces competition with other sectors, lack of experience and familiarity with marine energy as recruiting challenges

Taking advantage of technology and a new focus on long-distance learning, the project team gathered educational materials, curricula, teach-the-teacher kits, and "day in the life" videos and housed them on the STEM for Marine Energy portal. This portal, unveiled in August 2020, was a timely product for academia after moving to a 100% virtual world due to the COVID-19 pandemic. The portals' purpose is to be a one-stop-shop for information geared at inspiring the next generation of water power professionals, benefiting academia, industry, and the average water power enthusiast. NREL, in partnership with IKM 3D, has also begun work on the Renewable Energy Discovery (REDi) Island which will be a web-based

interactive educational app featuring a virtual world powered entirely by water power technologies. The app will host videos and curricula to teach about waterpower technologies and potential careers.

The team continues to gather relevant information as part of its STEM dialogue series, a virtual interactive webinar series to inform project content and direction. In 2024, NREL will also publish a Marine Energy Workforce Report detailing the current status of the marine energy industry and diving deeper into specific skills and programs needed to support a healthy marine energy industry in the U.S. This report will be publicly available and can be used by academia and funding agencies to prioritize workforce development and education efforts.

IV. DISCUSSION & CONCLUSION

As interest in renewable energy grows, marine energy technologies will continue to play a growing role in reaching global clean energy objectives. As it is still a nascent industry, developing a marine energy workforce will require a wide range of expertise and face tight competition with other energy sectors. The industry needs to attract and train talent to help develop the workforce pipeline.

NREL and DOE efforts to address these needs must include more programs, improved program accessibility, and an increased awareness of marine energy as a renewable energy career (secondary school, vocational and apprenticeship programs, and undergraduate curricula). There is much more work to be done, but at a minimum, the following must be increased to strengthen the workforce pipeline:

- Relevant work experiences
- Industry engagement in academia
- Hands-on learning
- Marine energy-specific coursework

While it is important to address the technical advancements needed for a successful marine energy industry, other barriers to deployment should be considered when developing workforce and education programs. One key barrier often sited is the unknown environmental effects of marine energy which can result in issues with permitting and financing projects. Although work has been done to understand general environmental effects of marine energy development, it will be important to conduct site-specific environmental monitoring campaigns that collect robust data to ensure devices and installation techniques are not disturbing the environment. Training and educational programs focused on environmental monitoring are needed to ensure success of marine energy projects.

With funding from the WPTO, NREL will continue to develop resources to inspire and educate students of all ages while partnering with key organizations to expand the reach of our work.

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