Developing a Marine Energy Workforce Pipeline

Preprint

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***Abstract*—Marine Energy is a nascent, but growing industry and will need a strong workforce to be successful. This paper examines the resources and programs needed to achieve the industry's goals.**

Keywords— workforce development, STEM, education, training, jobs

I. Introduction

Marine energy technologies play an important role in the growing renewable energy industry. To spur innovation and promote growth in this exciting technology area, the industry needs to inspire the next generation of marine energy workers. Despite increasing interest in marine energy, the nascent stage of the industry presents workforce pipeline challenges, including a lack of worker with experience, a lack of awareness of the roles in the industry, and competition with other industries for workers. The difficulty hiring is evident in other industries as well, such as solar, where 44% of employers stated it was very difficult to find qualified applicants, the highest percentage ever recorded in the Solar Jobs Census [1]. Further, marine energy companies indicate that many new workforce entrants lack necessary industry knowledge when starting their jobs. The marine energy industry has expressed the need to strengthen the workforce pipeline by increasing relevant work experiences for students, industry engagement in schools, marine energy coursework, and hands-on learning opportunities. 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 U.S. Department of Energy does not 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 [2]. If these goals are to be met, a trained workforce is needed.

While there is not sufficient data 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 [3].

Additional global projections 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 and maintenance and up to 14,000 temporary jobs in manufacturing** could be created by 2035 to deploy 10.5 GW [4].
- The IEA-OES International Vision for Ocean Energy stated that 300 GW could be deployed and **680,000 direct jobs created globally by 2050** [5]. 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, the market is 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 [6]. This growth has not come without challenges. When asked about their experience "finding qualified workers," more than four out of five employers across energy technologies reported at least "some difficulty" [6].

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, 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. There is still not a steady flow of research funding or jobs in this sector, and there are minimal marine-energy-focused degree and training programs to address these shortcomings. There is still work to be done with research, development, and demonstration of technologies, and awareness of marine power and its role.

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
- Manufacturing and supply chain
- Ports and staging
- Maritime construction
- Operations and maintenance

The roles will include engineering, surveying and scientific monitoring, finance, permitting, legal, public relations and marketing, management, technicians, service and trade workers, and operations and maintenance technicians, among others. Many of the skills needed for these roles are transferable from other sectors such as oil and gas, especially soft and nontechnical skills. Jobs like project management, supply change management, civil engineering, marine engineering, geotechnical engineering, quality assurance and quality control professionals, installation managers, and environmental surveyors can all be transferred to marine energy fairly easily [7,8].

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 Water Power STEM to Workforce 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 to best support the needs of the U.S. water power workforce.

The Water Power STEM to Workforce project supports the development of new educational resources where gaps currently exist, including curricula and training, to support an evolving marine energy workforce and increase awareness of marine energy opportunities. The goal of this work is to grow the marine energy workforce (incorporating multiple disciplines and having a diverse makeup), increasing numbers of new marine energy students and new hires in the industry, utilizing different methods in STEM activities and the inclusion of marine energy in other renewable STEM activities. The project aims 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.

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 career.

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, the National Ocean Sciences Bowl, IKM 3D, the Foundation for Water Energy Education, 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 possible in alignment with WPTO objectives. 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. Various mechanisms are used to distribute these resources through stakeholder outreach and communication efforts, including web portals, online career maps, and virtual, interactive web applications.

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 awareness about the industry, few postsecondary courses on marine energy, and unclear 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 or pursuing jobs in the industry.

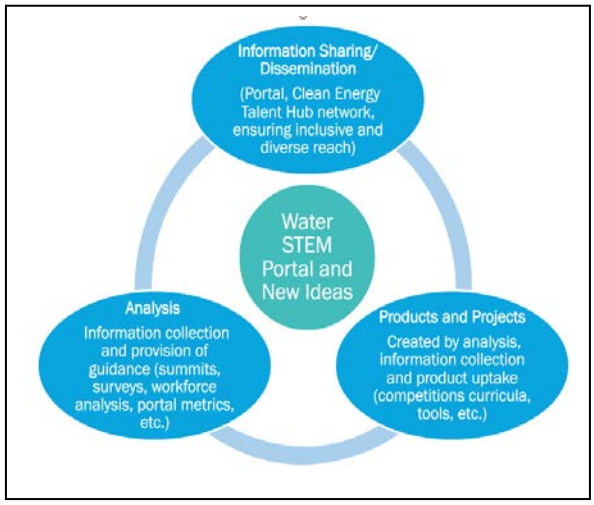

Fig. 1. NREL has conducted a series of surveys to understand marine energy workforce challenges

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. In 2019 the STEM project team reached out to U.S. postsecondary 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 21 schools known for their involvement in marine energy research that responded to the curricula survey, only four schools offered marine renewable energy undergraduate or graduate degree programs. Eight offer it as a specialization, 11 do not offer a degree in marine energy, and only 12 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 conclusions from the educational assessment are as follows:

- There are some marine energy majors, but most marine energy specific programming comes from specializations or as a part of another course.
- There is an increasing desire from students to learn about renewables and marine energy, but funding is a challenge for most schools surveyed.

WPTO, NREL, and the Hydropower Foundation shared the educational assessment results with educators and industry professionals at the 2019 Waterpower STEM Workforce Summit at the NHA'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 Summit 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. postsecondary 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 conclusions from the student survey are as follows:

- There is a strong interest in learning more about marine energy, but beyond college, many students have no idea where to learn more about it.
- Students need more information on jobs, skills, and projected job growth of the industry.

As a follow-on to the student survey, in 2021, the project team surveyed the U.S. marine energy industry. The 35 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—likely those in advanced degree programs. 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 conclusions from the industry survey are as follows:

- Most student hires have limited to no knowledge and hands-on experience of marine energy, but do have the relevant skills and abilities when entering the workforce.
- There is a lack of understanding about the electrical grid, system operations, and environmental issues.
- Lack of experience and familiarity with marine energy is a recruiting challenge.

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 developed Renewable Energy Discovery (REDi) Island, which is a web-based interactive educational app featuring a virtual world powered entirely by water power technologies. The app hosts videos and curricula to teach about water power technologies and potential careers.

Another key event is MECC. This event challenges postsecondary, undergraduate, and graduate students from a variety of academic programs to solve ocean energy challenges with engagement throughout the full academic year, concluding in a multiday event. The goals of the program are to inspire students to innovate in and accelerate an emerging industry and to enable students to network with marine energy professionals, learn about marine energy careers, and gain insights into marine energy's potential to contribute to a clean energy future. There are four concurrent challenges that each team competes in:

1. Business Plan Challenge
2. Technical Design Challenge
3. Build and Test Challenge
4. Community Connections Challenge

About 20 teams are selected yearly to compete with the chance of receiving cash awards and the grand prize. Among participants so far, there is agreement that MECC increased interest in pursuing a career in renewables or marine energy (87% at least somewhat agree) and that MECC was important in attaining a related job after graduation (86% state it was at least somewhat important).

Water Power STEM to Workforce project activities are ongoing. Beyond those mentioned, the team is creating marine energy career maps to help people enter into STEM and non-STEM industry careers. The project is also developing industry job and economic data, and 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 United States. This report will be publicly available and can be used by academia and funding agencies to prioritize workforce development and education efforts. There are also plans to update the STEM portal regularly and enhance engagement with underrepresented communities who may not traditionally see or be aware of marine energy as a viable career opportunity.

IV. Discussion and Conclusion

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

NREL and WPTO 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

Several recommendations follow from the work that has been done through the Water Power STEM to Workforce Project:

- Incentivize marine energy market growth through technology incubators and partnerships between educators and private sector to support development of new companies, investments, and jobs.
- Leverage funding resources to bring the cost of marine energy down through fundamental research, joint-university projects, internships, grants, and fellowships.
- Create shared curricula, making marine energy topics more financially viable for a broader audience through a resource hub that includes educational materials, current events, news, research, and jobs.
    - Partner with academic, industry, and nongovernmental organizations to develop and disseminate curricula to increase accessibility of up-to-date information on marine energy industries, technologies, operations, and markets (e.g. cross-institution certificates).
- Establish online certificate program for marine energy as a concentration within engineering or related disciplines to benefit academia more cost-effectively, making curricula more widely available
- Analyze future marine energy market and workforce needs in the United States to inform curricula and education programs that help students, educators, and workers prepare for a future blue economy.
- Better define career paths/competency maps to help educators guide students into hydropower and marine energy careers (STEM and non-STEM).
- Partner with industry, academia, and underrepresented groups to improve targeted outreach and recruiting to support a diverse workforce.

With funding from 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.

Comprehensive List of Programs and Projects

The following is a comprehensive list of programs and projects under the Water Power STEM To Workforce Project.

- STEM portal
    - Information-sharing portal is designed to help spur innovation and growth in the marine energy technologies industry and support workforce development.
    - Includes research, data and analysis, resources, network/career building, prizes and competitions, and tours.
- Day-in-the-life videos
- Marine energy educational program map
- Marine energy site tour map
    - 6 virtual tour locations, 73 tour locations overall.
- Career competency maps
- REDi Island
- Ocean energy exhibit at Mystic Aquarium
    - Ocean energy exhibit in Mystic Aquarium in Connecticut with interactive mechanical models, animation showcasing seven ocean energy technologies, and kiosks with day-in-the-life career videos games and quizzes.
- Story-telling videos
- Marine energy curricula
- Spark Squad comic books
- Immersive water experience
- Dialogue events
    - Partners in industry transfer knowledge to the classroom; trying to initiate collaboration with industry and universities.
    - "Educating the educators" to make sure that marine energy is on the radar of students.
- Clean energy technology hub-and-spoke concept
- Incorporation of water power education in after-school programs in disadvantaged communities
- Workforce analysis reports
- Marine Energy Collegiate Competition

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References

[1] Interstate Renewable Energy Council, "National Solar Jobs Census 2022" (July 2023), available at http://www.SolarJobsCensus.org.

[2] National Hydropower Association; Marine Energy Council (2021). Commercialization Strategy for Marine Energy. Available: https://www.hydro.org/wp-content/uploads/2021/04/NHA_MEC_Commercialization_Strategy_Marine_Energy.pdf

[3] Jimenez, T. and Tegen, S., 2014. "Economic Impact of Large-Scale Deployment of Offshore Marine and Hydrokinetic Technology in Oregon." National Renewable Energy Laboratory, Golden, CO, Technical Report NREL/TP-5000-61727. U.S. Department of the Interior, Bureau of Ocean Energy Management, Pacific Region, Camarillo, CA, OCS Study BOEM 2014-664. 35 pp

[4] European Commission, Directorate-General for Maritime Affairs and Fisheries, "Blue energy : action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond : communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions and impact assessment synopsis," Publications Office, 2014, https://data.europa.eu/doi/10.2771/32703

[5] Huckerby, J., Jeffrey, H., de Andres, A. and Finlay, L., 2016. "An International Vision for Ocean Energy." Version III. Published by the Ocean Energy Systems Technology Collaboration Programme: www.ocean-energy-systems.org

[6] Keyser, David. 2023. "United States Energy and Employment Report 2023." U.S. Department of Energy. DOE/OP-0020. https://www.energy.gov/sites/default/files/2023-06/2023%20USEER%20REPORT-v2.pdf

[7] Robert Gordon University Energy Transition Institute. 2021. "UK Offshore Energy Workforce Transferability Review." Available: http://www.rgueti.com/wp-content/uploads/2021/05/workforce-transferability-report.pdf

[8] IRENA and ILO. 2021. "Renewable Energy and Jobs – Annual Review 2021, International Renewable Energy Agency, International Labour Organization," Abu Dhabi, Geneva. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Oct/IRENA_RE_Jobs_2021.pdf