Using Human Centered Design to Develop a National Research Landscape for Marine Energy in the United States

Samantha J. Quinn, Dr. Shana L. Hirsch

Abstract— **The University Marine Energy Research Community (UMERC), sponsored by the United States (U.S.) Department of Energy's (DOE) Water Power Technologies Office (WPTO), works to facilitate connections between U.S. researchers, industry and government research laboratories in order to close common foundational research gaps and challenges. UMERC uses Human Centered Design (HCD) methodologies to create a research landscape to identify these gaps and challenges, with the aim of connecting university researchers with private-industry developers. This process started in 2022 and will continue to be iterated through the lifetime of the UMERC project. This paper introduces the project, provides a background on HCD, and describes the HCD methods that were used to develop the research landscape. The discussion reflects on the value for understanding and developing innovation communities such as UMERC.**

Keywords—**Human Centered Design, Research Landscape, Marine Energy**

I. Introduction

IN 2021, the United States Department of Energy (DOE) Water Power Technologies Office (WPTO) awarded the Pacific Ocean Energy Trust a Collaborative Agreement to act as the Coordinator of a foundational research network for marine energy innovation. This network was ultimately named the University Marine Energy Research Community (UMERC). The current project, which runs from May 2021-April 2025, aims to facilitate connections between U.S. university researchers, industry, and government research laboratories working on marine energy research and development. Marine energy in the US is defined as a renewable power source that is harnessed for the natural movement of water, including waves, tides and river and ocean currents. Marine energy can also be harnessed from differentials in salinity, pressure, and temperature gradients. UMERC's goal is to close common gaps in foundational research that are prohibiting the pathway to technology innovation, and ultimately commercialization. This work begins with identifying and understanding what those gaps are, and to do this, we turned to human centered design (HCD) methods.

The UMERC program is now in its second year, and membership has risen to over 200 active participants who take part in conferences, workshops, and an online community. Prior to UMERC, marine energy researchers and industry developers relied on their own connections to draw members. UMERC is therefore fostering innovation in the marine energy sector by creating a knowledge-based community or innovation ecosystem. A community of this kind does not usually emerge on its own, so one of the first steps for UMERC was to create a community of practitioners who are focused on a common problem-space – in this case foundational research needs for marine energy.

To achieve this goal, UMERC held a series of workshops to create a Research Landscape (Landscape), which identified current challenges, gaps, research capabilities as well as uncovering additional questions about where the sector is headed. A human-centered design (HCD) approach was used throughout the three-workshop series. This paper describes the HCD methods that were used, and reflects on their value for understanding and developing innovation communities such as UMERC.

II. Background

At its most basic, design is about "the conception and realization of new things" [1]. Design methodology is participatory and performative, aimed at facilitating the "emergence of new or unexpected avenues and openings" [2]. While many methods are probabilistic and re-produce existing problems, design methods, at their most basic, are possibilistic, opening up possibilities through "solution spaces" through creative exercises [2,3]. In this way, a designerly approach can highlight perspectives and values that may often be missed. The field of design is now

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evolving to address existing challenges such as innovation and engineering for energy transitions, as well as challenges for societal transformation [4]. HCD is one field where these participatory design methods are being readily embraced.

For our purposes, HCD is a problem-solving and design technique that uses human perspective and emotion to develop solutions. HCD includes both theory and methods, and since the mid twentieth century, has become a field in its own right. The field of HCD emerged from multiple disciplines, including the broader field of design, anthropology, engineering, psychology, and human-computer interaction [5]. What draws all of these diverse streams together is the idea that the goal of design be done for humans (or users), so that the outcomes are appropriate for the people the design is for. This is in contrast to designing for organizational, efficiency, or profit-oriented outcomes, which often leave marginal populations (ie. disabled or diverse communities) out of the design process completely. HCD therefore includes the users, in our case, the marine energy innovation community, within the design process so that their needs, values, and preferences are embedded within the outcomes [6].

capabilities of the foundational research community. From this, we would create a "research landscape" which described areas of inquiry and collaboration across the marine energy field.

The goal of the Research Landscape was to engage with the marine energy research research and development community to facilitate the creation of an initial UMERC Research Landscape. This landscape will help avoid duplication, facilitate collaborations and connections between people and research, identify areas of research and people that are going to be fruitful in the short, medium and long-term. In addition, developing the Research Landscape will contribute to UMERC's three objectives by: 1) Increasing awareness of research: creating the landscape will help us understand what research exists, how the researchers interact, and where the gaps exist; 2) Evaluating and recommending ways to enhance research: each individual will be able to identify their own needs for research (ground-up, not top-down); and 3) Improving coordination and collaboration: each cluster will include individuals with ties to university, lab, and industry.

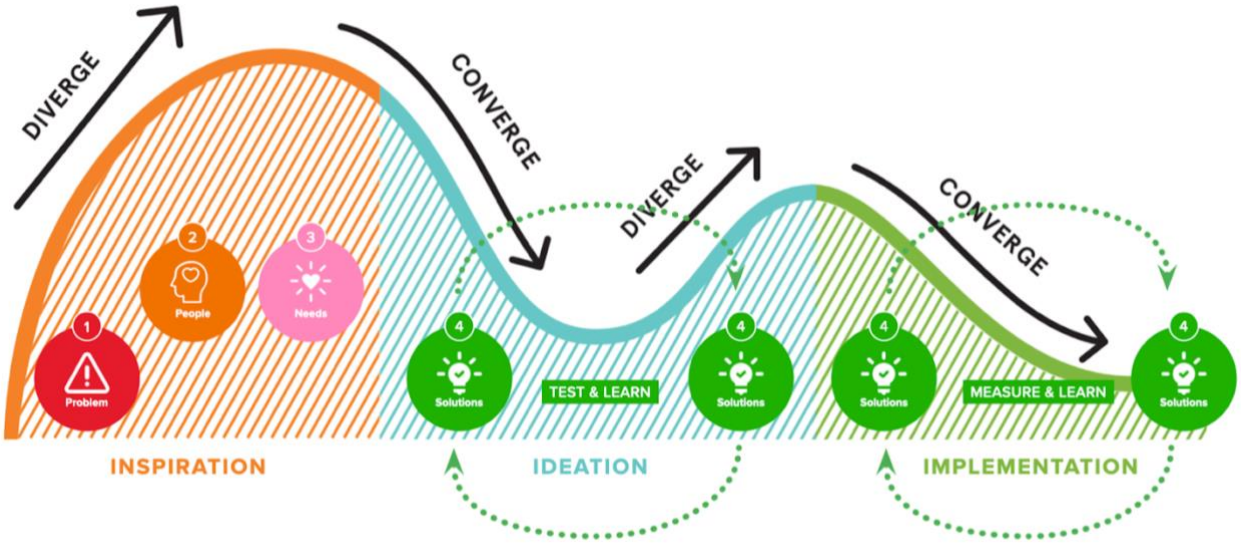

Figure 1: Human Centered Design Process Map [9].

HCD differs from other design methods because it keeps the problem at the center of the process, it involves multidisciplinary teams, and it values multiple perspectives. HCD is carried out with the acknowledgement that values vary from context to context and are subject to change as people and technologies interact over time [5]. At its root, HDC "places our understanding of people, their concerns, and their activities, at the forefront in the design of new technology [7]." HCD also takes a socio-technical perspective, which acknowledges the inseparability of technical and social outcomes and processes [8]. This makes HCD particularly useful for understanding innovation processes in emerging technologies.

In founding UMERC, we wanted to bring this sensibility to the marine energy research community, and we did this through our first workshops. In these workshops we wanted to understand the gaps and needs of industry, as well as the

III. METHODS

The stages of human centered design include inspiration, ideation, implementation and validation, or testing, in an iterative, or cyclical process that results in ongoing refinement, identified by the peaks and troughs in Figure 1, or the acts of divergence and convergence. The HCD process is known for its iterative path to a solution, which can make it confusing to some participants. Nevertheless, we hoped that the benefits of creating a space for inquiry and experimentation would be worth any discomfort of "not knowing what is happening." In fact, that effective position of "not knowing" is exactly the goal of these methods, however parallel they may seem to more common scientific methods. Our workshop series took this iterative approach, in three stages: 1) introducing the concept of a research landscape and HCD; 2) collaborating to create a

marine energy research landscape; and 3) presenting an initial community-driven marine energy research landscape. All workshops were held virtually through Zoom, due to the ongoing COVID-19 pandemic.

The first workshop "Introducing the Concept of a Research Landscape" was held on November 3rd, 2021 and lasted 1.5 hrs. 123 people attended the workshop, which included 11 developers, 64 university members and the remaining from government agencies, National Labs, and supply chain organizations. The goal of this workshop was to increase awareness of the (then new) UMERC, introduce the concept of a research landscape, introduce HCD, outline future workshops, and solicit feedback. We introduced our vision for a research landscape as collaborative, driven by needs, cutting-edge, and community-created. During the workshop, we conducted some basic polls to understand what fields and projects people were working on and what their hopes were for UMERC and the marine energy sector in general. We also gave a brief introduction to Menti and Miro board, the two applications we would be using for future workshops.

The goal was to create a draft research landscape that the community felt was representative and useful. We again explained HCD and encouraged participants to "embrace ambiguity and trust the process."

During this "convergence" stage of the process, we wanted to make sure that participants understood what the purpose of the landscape was, as coming to a common understanding of the problem space and relevant concepts is the first step in HCD. To reach this goal, we needed to understand how the community defines "representative" and how they define "useful" in terms of foundational marine energy research. We also worked to define our "community" as whoever is present, or engaging with this process, acknowledging that this would change as more people join and more research is done to inform the scope of "community."

After coming to some consensus around the goal of the workshops and these terms, we moved to ideate in break-out rooms, for 60 minutes using Miro and Zoom. We provided a list of research categories as a starting point, and encouraged participants to make sure all the categories listed made sense

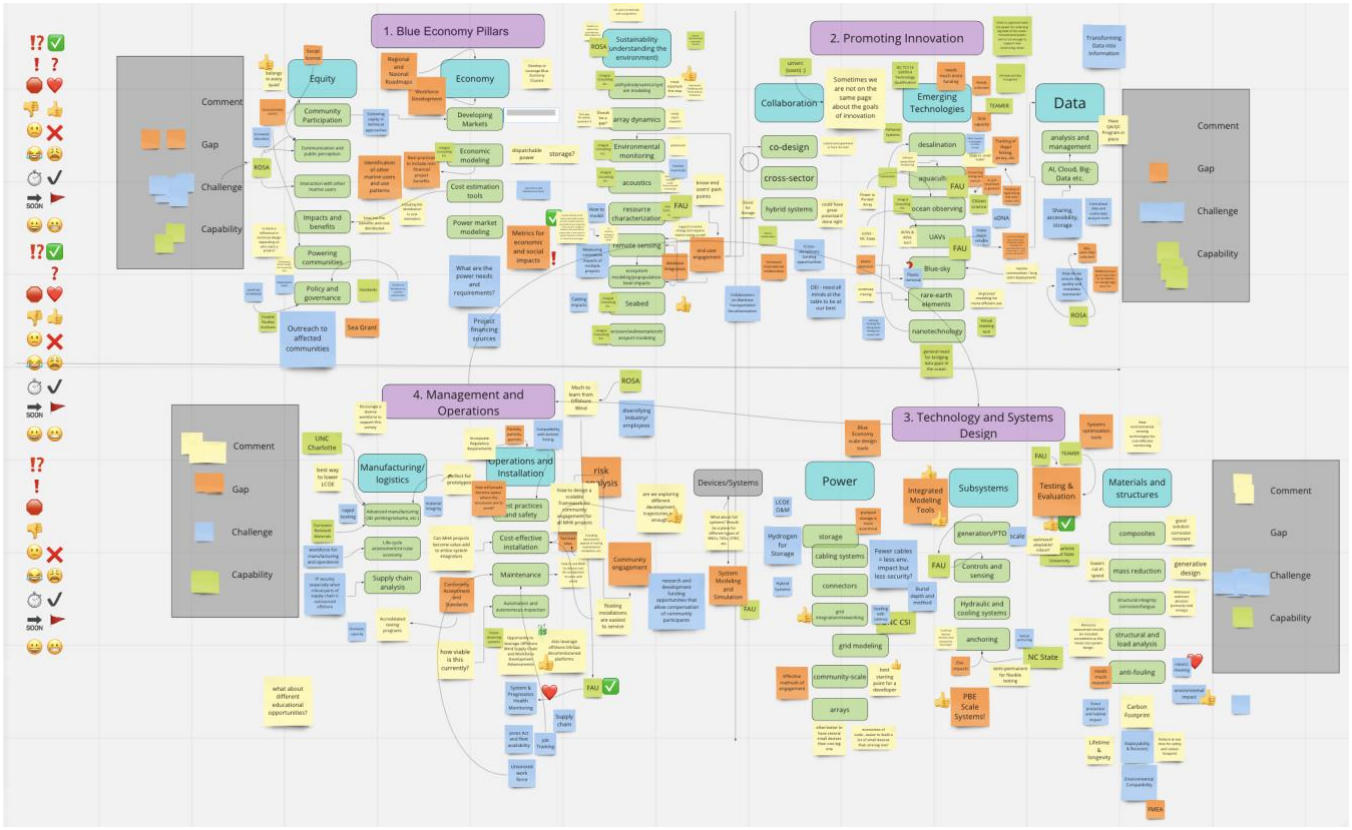

Figure 2: Figure 2: Miro Board used for brainstorming activity to create a research landscape. This figure is intended to illustrate the process, not necessarily the information on the board.

The second workshop in the series was called "Collaborating to Create a Marine Energy Research Landscape", and was held three times in late November and early December, 2021, to accommodate schedules and allow for smaller groups. In total, 75 individuals from industry, National labs and universities participated in the workshop over the three dates and times. This workshop employed many of our HCD methods and utilized both Menti and Miro as virtual platforms for collaborating within Zoom. and were fully representing all research areas. The starting categories included: equity, economy, sustainability and understanding the environment, collaboration, emerging technologies, data, manufacturing and logistics, operations and installation, power, subsystems, and materials and structures.

These categories were derived by examining different programs and information from the DOE, SuperGen Offshore Renewable Energy Hub, European Energy Research Alliance Joint Programme on Ocean Energy

(EERA), and Ocean Energy ERA-NET Cofund, all of which aim at coordinating research and collaboration.

Using these starting points, we carried out a brainstorming and networking activity that involved virtual "post-it" notes within a Miro board. As shown in Figure 2, people were provided with "post it" notes, emoticons, arrows, and the ability to move and add research topics to the boards.

We then used a "carousel" activity that encouraged people to build on and share ideas in a rotation, where the four break-out groups modified each other's boards as they rotated every 10 minutes. We encouraged people to talk and discuss their decisions as they made changes to the boards, as well as add comments in the form of "post-its" or emojis to highlight specific areas that they felt strongly.

We then came together to discuss the outcomes and gave people a chance to locate themselves on the map of themes. This was to ensure that we had captured all of the research activities present, as well as gain connections to individuals working in these areas. We gave participants a chance to arrange the boards into themes that made sense to them. Finally, we ended with a "gut-check" where we asked a series of questions through the Menti app, including what constraints, possibilities, and issues they felt need addressed.

At the end of the second workshop series, we took the outputs from all three workshops and examined them to identify areas of convergence as well as topics that had seemingly been missing from original research categories. We then iterated through several drafts of how to make the research landscape a tool, and to further develop an illustrative representation of the research landscape, as seen in Figure 3.

The purple lines and arrows represent values that were seen throughout each research area during the workshop. These are ideas that should be thought of when exploring any of the research areas. These include community, innovation and new technology applications, education, sustainability, blue economy, equity, and collaboration. The blue rectangles represent the main challenges that were identified throughout the workshops, which include: creating marketing and a trained workforce, management and logistics, understanding and protecting the environment, and marine energy engineering, research and development. The yellow rectangles represent 'tools' to help overcome these challenges. Again, these stemmed from the Miro board outcomes and discussions from the workshops. These include education, economics and equity, management and logistics, simulation and modeling, monitoring, and testing. As you can see, some challenges are also tools which demonstrates the need for more innovation and research in order to understand how to use the tools to overcome challenges. Lastly, the remaining squares (in turquoise, orange and green) represent the research and sub research areas, as well as the challenges within those research areas. The main research areas include workforce development, economics, equity, data, IO&M, manufacturing, understanding environmental impacts, resource characterization, materials and structures, hydrodynamics, design, systems, powering blue economy

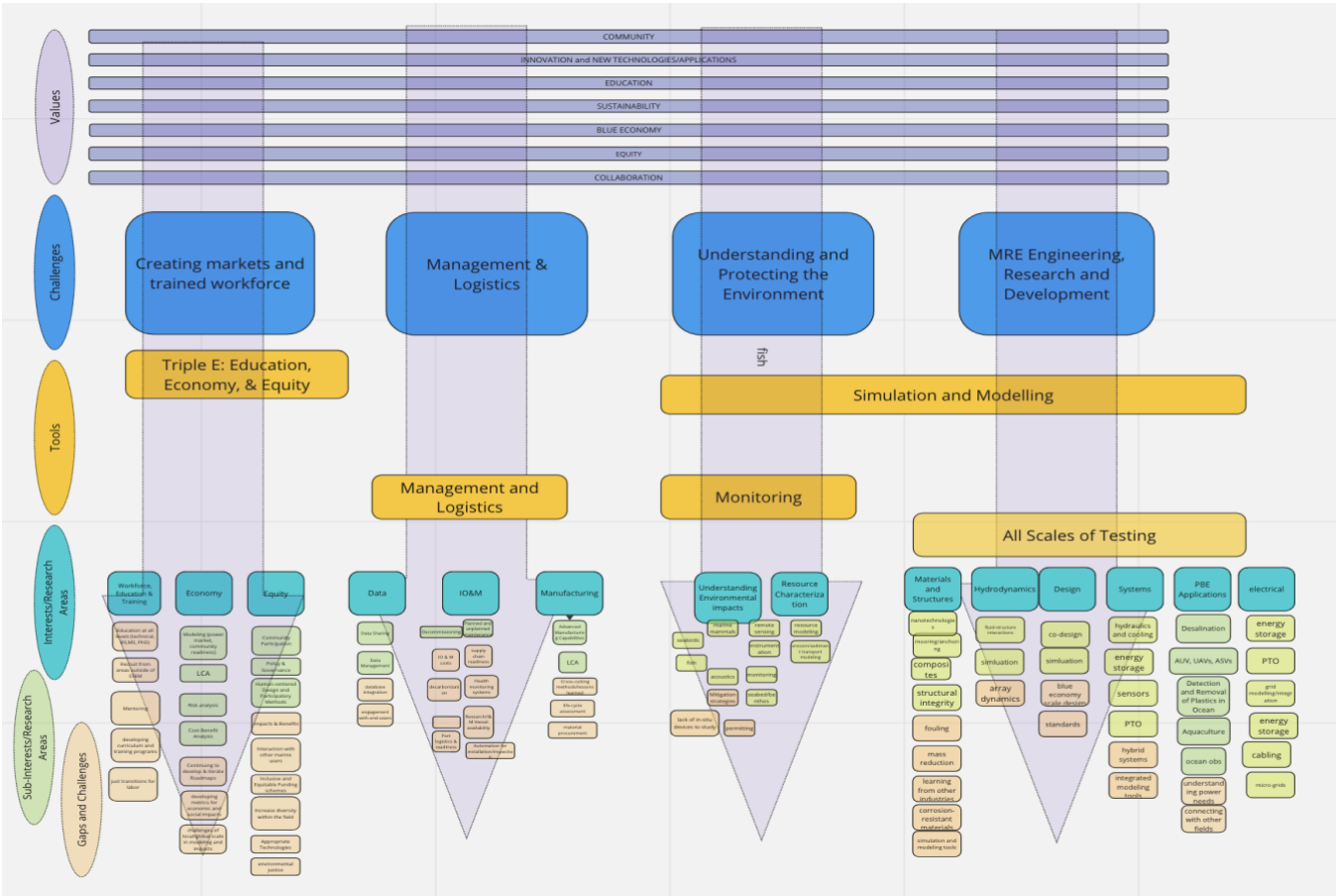

Figure 3: Working research landscape, developed during the second workshop entitled, "Collaborating to Create a Marine Energy Research Landscape."

applications and electrical. It should be noted that these are only a sub-set of topics of which there is current research being carried out with regard to marine energy, and this was an exercise in trying to categorize all of the data from the workshops.

Finally, the third workshop, "Presenting an Initial Community-Driven Marine Energy Research Landscape" was held in late January, 2022. The goal for this workshop was to gain consensus around the landscape as it stood, with the understanding that it can, and will, evolve in the future. Prior to this workshop, we collated the results from the Miro boards into one draft Research Landscape. We presented these findings to the participants and solicited feedback. We incorporated any new feedback into the landscape.

IV. RESULTS

It is through this approach that we are able to identify the current gaps and challenges and through the HCD approach, we will continue to refine the Landscape as current challenges and gaps are retired and new challenges and gaps arise. This will help account for the fast pace of innovation in the marine energy sector, where human-technology interactions are changing as the technology develops, and there are new entrants into the market. With the current state of fluidity in technology design and application, what works at one location may not work at another location.

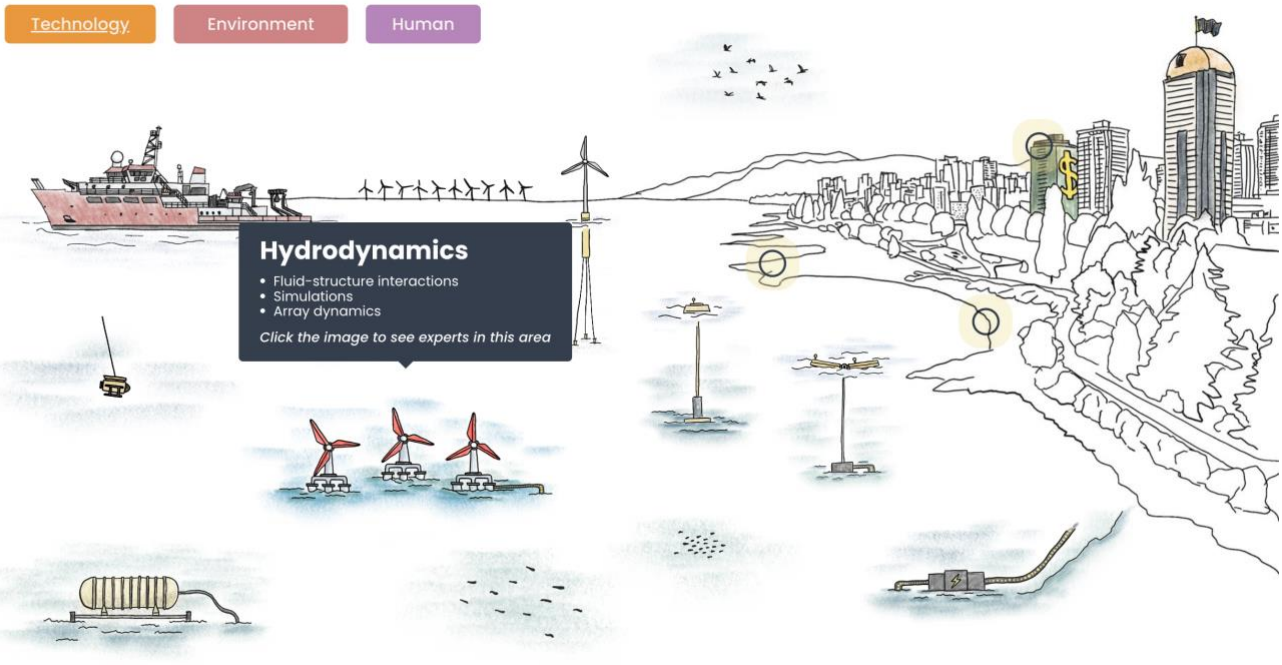

Figure 4: Research Landscape on the UMERC website, https://lanscape.umerc-us.org/.

The result of this workshop series is a dynamic Landscape (Figure 4) that is available online (https://landscape.umerc-us.org/) for people to use as a tool. It is illustrating the sector as whole, and while each topic area or theme is siloed for ease of use and readability, we also hope that there is understanding that all facets of the sector are connected, and therefore, using HCD is crucial to understand the needs and challenges or all working parts of the sector.

V. DISCUSSION

Following our HCD methodology, our cycle of iteration will soon start again. While the current Landscape serves as a benchmark, the next steps include a series of industry-academic brainstorming sessions, with the aim of creating collaborative projects to address challenges, as well as come up with a list of common technology agnostic challenges, in hopes to push future research funding.

What may look like chaos from the Miro Board activity is really a stepping-point to identifying underpinning research that will drive marine energy technologies towards commercialization. This chaos will allow us to understand the challenges, wants, and values that researchers and technology developers aim to understand while carrying out research.

Another valuable takeaway from this activity is the identification of themes or values which run through every aspect of development and research, which can be seen in Figure 3. These include: equity, community, blue economy, innovation, education, sustainability, and collaboration.

These are values that should be discussed and taken into consideration during development. Equity takes into consideration how this will affect any communities or people and how to find the best solution for all involved. Community looks at equity but also the involvement of the community when a project is being discussed or designed. Blue economy is thought on with the ideas of how marine energy can provide sustainable economic growth by using blue resources for energy, and using marine energy to provide energy resources for a variety of applications. Innovation is key to the development of marine energy and should always

be considered. Education examines how we teach people about marine energy from a young age to engage them into the future workforce. Sustainability is a theme or value that should evoke discussion around the life-cycle assessment of devices and developments. And finally, collaboration. Collaboration, the crux of UMERC, is key to ensuring that there is less duplication of effort, more knowledge sharing, and increase community amongst the research community.

Even through this discussion is evident that the values and themes that run through the Landscape are intertwined, highlighting the need for collaboration and continued exercises like the one carried out in this work.

I. Conclusion

Using HCD methods and sensibilities, workshop participants, including individuals from universities, private sector companies and the national laboratories, we able to bring in their individual perspectives to develop the Landscape. Through the HCD process, the workshops revealed a set of values, tools, research interests and gaps and challenges. These were synthesized into what is now the current Landscape that can be found on the UMERC website. The values are themes that should be considered when designing marine energy projects. These include community, innovation and new technologies or applications, education, sustainability, equity, blue economy, and collaboration. The main challenges were condensed into four categories that include creating markets and a trained workforce, management and logistics, understanding and protecting the environment, and marine energy engineering, research and development. The tools are actions that can be carried out to overcome the main challenges. Finally, a list of common research areas was identified under each main challenge area, as can be seen in Figure 4.

The next steps will continue with industry-academic working sessions to further identify the most critical needs for foundation research to ensure the work that researchers are carrying out is beneficial to developers. This will be achieved by holding industry-academic workshops, continuing discussions with the overall sector, and eventually creating specific working groups.

II. Acknowledgement

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