

PRIMRE: A Vision for a Portal and Repository for Information on Marine Renewable Energy

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Abstract— The sharing of knowledge, experience, and lessons learned facilitates solving common problems and accelerating the development of the MRE industry. In order to increase the dissemination of such information, the US Department of Energy, through its national laboratories has engaged the international MRE community to understand online information needs. Six thematic needs were determined: outreach & communication, discoverability, data integrity, tools & codes, accessibility & security, and best practices & guidelines that lead to a vision for an online information system: PRIMRE (the Portal and Repository for Information on Marine Renewable Energy). PRIMRE is an online framework that will enable all MRE stakeholders to store, organize and access broad sets of information, data, and tools. The PRIMRE framework aims to be a centralized collection and dissemination point for MRE information, an access point to discover and access online tools, a place to discover existing knowledge, and an honest and neutral broker for the use of existing data.

Keywords— Data, sharing, repository, community, marine renewable, energy, hydrokinetic, metadata, PRIMRE

I. INTRODUCTION

The Marine Renewable Energy (MRE) industry is at a pivotal time in its development lifecycle. The commercial viability of emerging technologies hinges largely on the ability of the MRE community, including MRE developers, researchers, academics, stakeholders, labs, funding agencies and regulators, to work together to share knowledge, experience, and lessons learned towards solving common problems and accelerating technology development and acceptance. Data and information play critical roles in all aspects of technology development, from early state concept development through certification and commercialization (Fig 1).

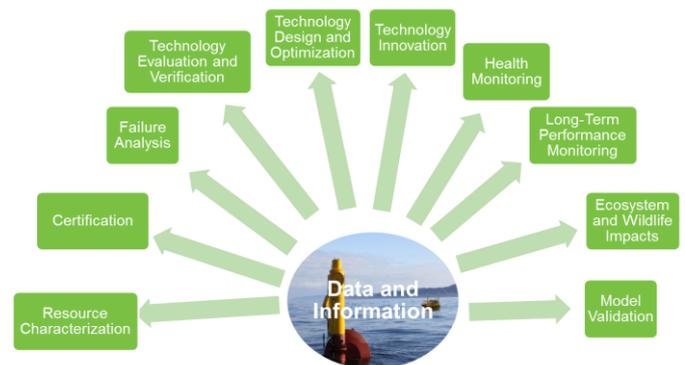


Fig 1. Data and Information are critical in all aspects of MRE technology development and commercialization

Unfortunately, despite significant global investments in technology development, environmental research, testing and deployment of many technologies, data and information is difficult to find. While there is an abundance of data and information available online, they are located on many disparate sites, making discovery difficult. In many cases, hard earned testing data, cost information, and domain knowledge is lost as early stage companies dissolve and people move to other fields. For a lot of the available data, there are questions about quality and accuracy because of lack of accepted industry best practices and limited use of standards. Finally, data processing codes, data, and project or technology information are often not made public. As a result, the broader MRE community cannot learn from past investments and often repeat the same learning and development steps; thus, increasing cost, risk and development timelines.

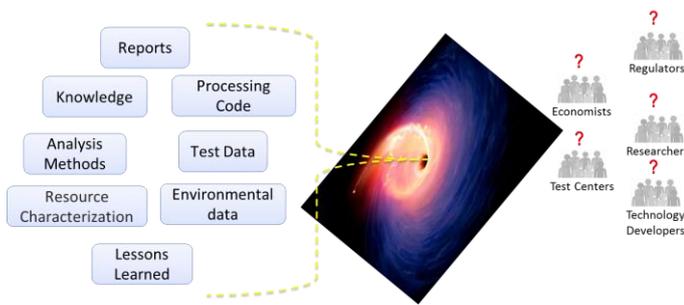


Fig 2. Data, information, and knowledge are often lost and not available to help advance the MRE industry

The US Department of Energy (US DOE) Water Power Technologies Office (WPTO) is addressing the challenge of storing, curating, and accessibility of MRE information by sponsoring development of MRE databases and information portals such as Tethys, OpenEI Water Power Gateway, MHK Data Repository (MHKDR), the MHK Instrumentation Database [1-4], and open source codes that are hosted on various repositories. These sites host a wealth of information (news articles, reports, links to databases and tools, and information for stakeholder engagement), but without coordinated efforts, they are only a step towards facilitating global discovery and knowledge dissemination.

The US DOE WPTO recently sponsored the MHK Data Community project, which is a joint effort between the National Renewable Energy Laboratory (NREL), Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (Sandia) that aims to:

- 1) Engage the international MRE community to develop an understanding of the online tool and data
- 2) Improve existing databases and portals to better meet these needs
- 3) Coordinate efforts with the international community to ensure consistency and collaboration in development of online repositories and tools

II. NEEDS

During the first year of the MHK Data Community project, the focus has been on reaching out to the international MRE community to understand the needs for online information infrastructure and data products, define the gaps in the existing online infrastructure and content, and recommend solution pathways. To start this work, several workshops were held to engage the international community. One workshop was held in connection with the International Marine Renewable Energy Conferences/Marine Energy Technology Symposium (IMREC/METS 2017) in Washington D.C. on May 3, 2017. Another workshop was co-located with the European Wave and tidal Energy Conference (EWTEC 2017) in Cork, Ireland on August 29th, 2017. Outreach and engagement is an ongoing effort throughout the duration of the project, and thus additional workshops were held during the second year of the project, including during METS 2018. Additionally, an online MRE data needs webinar was held on February 27, 2018 under the support of the International Energy Agency (IEA) Ocean Energy Systems (OES)

Technology Collaboration Programme, with the particular aim to engage the international community and identify if OES should play a role in data and information sharing[5,6].

Additionally, the multi-lab team is hosting an online MRE data survey in order to directly ask the MRE community about their data and information needs. So far the survey has been taken by participants representing a broad range of organizations and countries (Fig 3 and Fig 4).

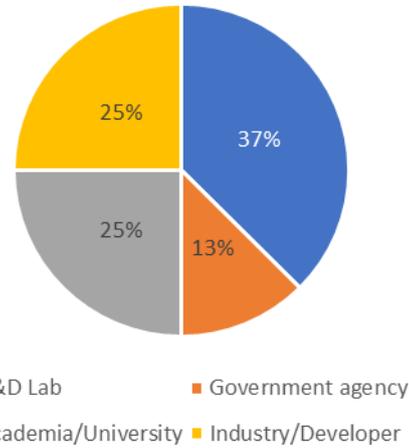


Fig 3 MRE Data Survey Responses by Organization

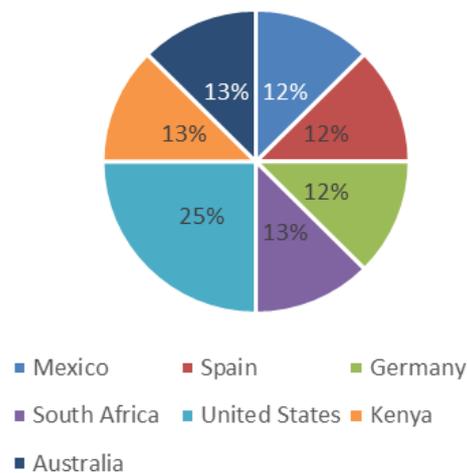


Fig 4 MRE Data Survey Responses by Country

Based on the findings from these workshops, and the online survey, the multi-lab team analysed and compiled the identified needs into six themes (Fig 5):

- **Outreach & Communication:** online information sources where the public can learn about MRE technologies, their impacts and challenges. There is also a need to for a site where the community can learn about current events and read the latest news.
- **Discoverability:** search tools and systems with comprehensive metadata the enable MRE reports, data

and other information to be quickly identified and downloaded.

- **Data Integrity:** consensus methods of data quality assurance that enable a high-level of confidence in subsequent use and curation activities that review data, information and metadata for accuracy, and adherence to accepted practices. This should also include archiving of older information, so it can be retrieved as needed.
- **Tools & Codes:** open source codes and data products, such as data processing codes, simulations, and GIS tools that can be developed and advanced by the community to benefit the community.
- **Accessibility & Security:** develop the framework and structure for online information repositories that allow sharing of reports, code and other information with levels of security appropriate to protect confidential information but share within specified groups. In addition, capabilities to share information, experience, and knowledge.
- **Best Practices & Guidelines:** consensus guidelines on meta data, units, file formats, and file types that will allow information sharing between projects and between countries.

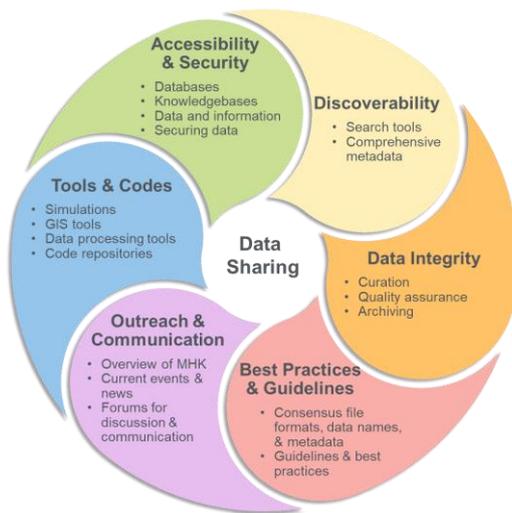


Fig 5 Six major themes for online information needs as collected from the MRE community

III. PRIMRE

A vision for an online information system has been developed to be responsive to the needs expressed by researchers, developers, regulators and other stakeholders. Organized around the six thematic areas, the data vision is aimed at providing measurable benefit to the MRE community. The vision has been named PRIMRE: the *Portal and Repository for Information on Marine Renewable Energy*.

PRIMRE will enable practitioners who collect engineering, resource characterization, and environmental effects information on marine renewable energy projects to store, organize and access information that will support the commercial development of the MRE industry. PRIMRE seeks to:

1. Establish an information and data portal that will bring together a set of existing data repositories, knowledge bases, and resource atlases. These individual databases and repositories commonly serve a single purpose, collecting data that are used to support, for example, resource characterization, device testing, modelling, project siting, and permitting of MRE devices and arrays. PRIMRE will provide consolidated access and integration of these individual databases to maximize the utility of the data they contain.
2. Support development and online access to tools that facilitate data input, quality control, data discovery, analysis, and reporting of MRE data, with an emphasis on testing data collected for devices.
3. Provide easy discovery and integration of data through tagging data and information sets with annotations, assessments of quality and relevance, and preparing reporting templates.
4. Act as an honest broker to facilitate the availability of data and information that meets the needs of MRE projects and research studies. PRIMRE will connect existing databases and datasets to the MRE projects that can benefit from the information, and to researchers and other stakeholders who play other supporting roles for the MRE industry.

As designed, PRIMRE will consist of four functional areas:

- 1) an information portal;
- 2) papers and report discovery tools;
- 3) databases and repositories; and
- 4) tools and code repositories.

Information Portal: PRIMRE will be accessible through a common entry point to provide quick access to information. Built upon the OpenEI framework, originally developed in 2009, the PRIMRE entry point leverages nearly a decade of experience in information dissemination and data management architecture to provide information in a manner that is accessible, customizable, and adaptable to the changing nature of emerging MRE technologies. (Fig 6)

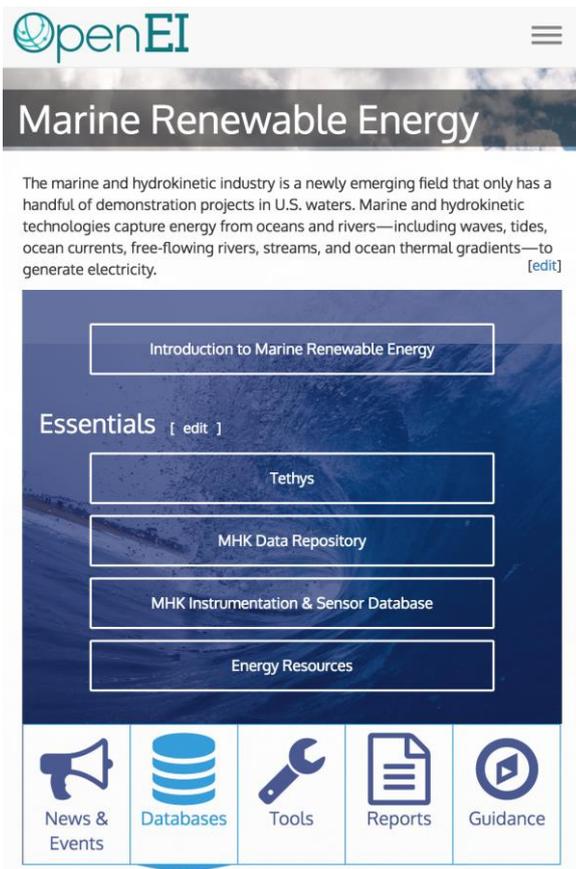


Fig 6. Example of PRIMRE Entry Point.

The PRIMRE entry point will provide users with basic information about MRE, including the history, resource potential, technologies, environmental impacts, and challenges. Other public facing functions will include a calendar of events to keep users informed of MRE community engagements, and increase international connections. Direct links to key databases created by governments and industry associations will support data discovery, provide access to open source modelling codes and tools, and provide curated access to the supporting scientific literature and technical reports. By increasing access to information, data, and tools, the MRE community will collectively be able to accelerate technology development and acceptance, as well as reduce duplication of effort and future research costs.

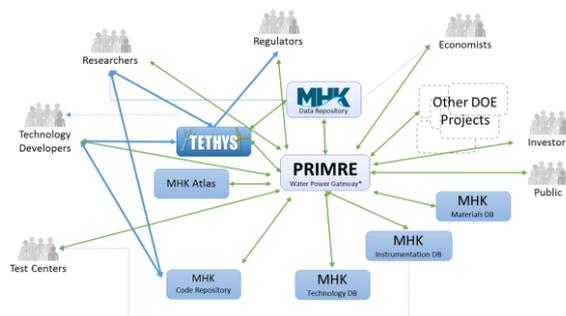


Fig 7 Example of the PRIMRE Entry Point which organized to allow users to quickly discover information they need.

Papers, Reports, and Data Discovery Tools: One of the key components of PRIMRE will be the existing Tethys online knowledge management system [1] that facilitates the exchange of information and literature on the environmental effects of MRE and wind technologies and to support permitting (consenting) of MRE devices in an environmentally and socially responsible manner. Tethys also serves as a common space for wind and marine renewable energy environmental practitioners, proving a collaborative space to interact and solve technical issues related to environmental data collection and analysis, as well as a means to share recent research findings broadly. Tethys is international in scope and widely recognized as the premier source of environmental effects information for MRE development. Also housed on Tethys are metadata records for every in-water test, pilot project, or commercial deployment for which environmental data were collected, to ensure that past learning is preserved and the industry can build upon their successes and insights. The extensive metadata and actively curated knowledge management system allows users to quickly and confidently locate scientific information that meet their needs. Under PRIMRE, Tethys would be expanded to encompass literature and reports on engineering and MRE technologies. Tethys Engineering would follow the form and function of the existing Tethys environmental. Tethys will also expand to house metadata on post-installation monitoring datasets, as commercial development commences. Key linkages between environmental and engineering data will be made within Tethys and to other sections of PRIMRE, allowing users to compile summary data from engineering and environmental data sets, quickly correlating these data by using key variables to locate data sets and specific files that meet their needs.

Another critical component of the PRIMRE ecosystem will be the US DOE funded Marine and Hydrokinetic Data Repository (MHKDR) [3], which currently houses all data generated from marine and hydrokinetic research initiatives funded by US DOE. Built from the ground up to disseminate information, all data submitted to the MHKDR are eventually made available to the public. Metadata from the MHKDR data catalogue are disseminated through a network of data partners to inform the broader MRE scientific community of ongoing research efforts and announce the anticipated release of critical findings. These data are made available to the MRE community to increase collaboration, reduce duplication of effort, and accelerate the adoption of MRE technologies. Other portions of PRIMRE will provide overviews of efforts and outcomes of the IEC (TC 114) standards development effort, as well as progress through other international collaborations, such as IEA Ocean Energy Systems.

Databases: Through prior funded US DOE efforts, several databases have been developed that contain a diverse set of information. These databases include the MHKDR, the MHK Instrumentation Database, the MHK Technology Resources Database, and the MHK Technology Development and Testing Database. Through previous outreach efforts, the

MRE community indicated that it would also benefit from an Levelized Cost of Energy (LCOE) database that would compile information needed to perform a detailed LCOE analysis (e.g. vessel rates by geographic location, wholesale electricity rates by region and time, manufacturing costs, etc.). The outreach effort has also identified many improvements that are needed to increase the functionality and usefulness of the existing databases, such as updating information so it reflects the current state-of-the art and improving data discovery, part of which would be accomplished through the PRIMRE initiative.

Tools and Code Repositories: The US DOE has invested in development and release of many open source codes, and online tools to help accelerate development of the MHK community and reduce market barriers. These include the MHK Atlas which helps the community obtain resource information via GIS interface [7]. The USDOE has also funded development of WEC-SIM, an open source wave energy converter simulation code jointly developed by Sandia and NREL [8]. Additionally, the USDOE has funded other open source codes such as: PyTurbSim, SNL-SWAN, CACTUS to name a few [9-11]. While open source code development has proven beneficial to the MHK community as a whole, open source codes are currently hosted on different repositories and servers and can be difficult to locate if one doesn't already know it exists.

To help facilitate sharing of code for data processing and visualization, the US DOE has committed to developing an online open source code repository called MHKiT (Marine Hydro Kinetic Tools) which is intended for open-source community developed software. MHKiT will be seeded with code developed through DOE funded projects and will include guidelines to ensure code is consistent, compatible, and well documented.

In addition to existing tools, this outreach effort has identified additional tools that would benefit the MHK community. One tool is an MRE LCOE estimator which could be an online tool that walks users through the development of an LCOE model, much like tax software does for federal income tax filings. Another tool identified is an MRE energy prospector which is a GIS based tool that can develop annual energy estimates for technologies based on their power matrix/curve.

PRIMRE is also envisioned to provide a framework for users to find online open source data processing and analysis codes. Thus, PRIMRE will be open to the international community to develop, populate and curate. Through developing this framework, we hope the information portal would be useful to the global MRE community.

To ensure that PRIMRE would meet the continuously evolving needs of the MRE community, PRIMRE would be developed so it can easily undergo periodic reviews and revisions to support new content and functionality. Users would be asked to provide structured feedback on the data portal to inform future content.

IV. EXPECTED IMPACTS

PRIMRE, as designed, will realize some key outcomes and impacts that will support and advance the MRE industry. In particular, PRIMRE will act as:

1. A centralized collection and dissemination point for information that will allow the MRE industry, researchers, regulators, and other stakeholders to access a common set of data, information, and knowledge products in the US, and internationally. By starting from the same base of knowledge, decisions on siting, permitting, interpretation of test results, and efficiencies can be facilitated.
2. An access point to discover and access online tools that will support MRE industry and other stakeholders interests to carry out objective analysis of existing data, bring together their own emerging data, and to uniformly move forward the understanding of robust design, testing, permitting, and operating processes in support of the MRE industry.
3. A point of access to existing knowledge gained from the scientific literature, and other media on the state of development of MRE devices, resource characterization, testing results, installation and maintenance procedures, and environmental risks. This access will be made possible by creating and applying a common set of tags, filters, and annotations for environmental and engineering information.
4. An honest and neutral broker for the use of existing data resources through ensuring that the MRE relevant datasets, tools, and links throughout the internet are accessible and familiar to the MRE community. PRIMRE will serve as the platform for a robust outreach and engagement program to encourage sharing of knowledge, experience, and lessons learned towards solving common problems and accelerating technology development and acceptance.

To achieve these impacts, as described in the prior sections, there are several components of PRIMRE (vertical axis of Fig 8) that map to Six major themes for online information needs as collected from the MRE community (horizontal axis of Fig 8).

PRIMRE Component \ MRE Data Needs	Outreach & Communication	Tools & Codes	Discoverability	Accessibility & Security	Data Integrity	Best Practices & Guidelines
OpenEI: Water Power Portal	X		X	X		
Current Events & News	X		X			
Tethys: Environmental	X		X	X	X	
Tethys: Engineering	X		X	X	X	
Data Repository (MHK DR)		X	X	X	X	
MHK Instrument Database	X		X	X	X	
GIS Tools		X		X	X	
MHK Energy Prospector		X		X	X	
Code Repositories		X	X	X	X	X
MHK Data Search Tools			X	X		
Data Best Practices & Guidelines	X	X		X	X	X
MHK Technology Database	X		X	X	X	
LCOE Estimation Tool		X		X	X	

Fig 8 Components of PRIMRE mapped to the six thematic needs

V. CONCLUSIONS AND FUTURE WORK

PRIMRE is still a draft vision that has been developed from a US DOE perspective with input from the international MRE community. While PRIMRE meets many of the online information needs for sharing of knowledge, experience, and lessons learned towards solving common problems and accelerating technology development and acceptance, it is still an early concept. Our hope is that PRIMRE will provide the basis to establish an international framework with shared development.

In the near term, NREL, PNNL and Sandia will continue to engage the international MRE community to update and validate the findings. In addition, several of the components of PRIMRE will be developed to enable online information and data access.

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