Assessing Social and Economic Effects of Marine Energy: Tools and Recommendations

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I. INTRODUCTION

OVER the past decade, knowledge of the potential environmental effects of marine energy has grown substantially as more devices have been deployed [1]. However, less attention has been paid to social and economic effects of these projects. Chapter 9 of the 2020 State of the Science Report [2] describes what is currently known about social and economic effects in the context of marine energy development and highlights the need for additional data collection to support consenting processes as well as strategic planning. Marine energy projects have the potential to create significant benefits by stimulating economic growth, generating revenue, creating jobs, improving local infrastructure and services, and providing energy security and resilience [3]–[5]. However, if projects are not carefully planned and do not include communities in the development process, there could be adverse effects or changes that do not align with local cultures and community values [6]–[10] or that provide inequitable distribution of costs and benefits [11]–[14].

Collecting social and economic data is necessary to anticipate these effects, and to develop and appropriately site marine energy projects that suitably address community needs, incorporate and address community values, and satisfy consenting requirements [2]. Despite the importance of this information, consistent methodology for social and economic data collection to inform marine energy development is lacking. There is little documentation from past projects, and if documentation exists, it is not often clear how the social and economic data have been collected or analyzed [2], [15]. We review the literature from marine energy, other renewable energy industries, and relevant coastal sectors to identify common metrics, methods, and applicable tools for collecting data on social and economic effects. From this, we synthesize our findings and identify lessons learned that will form the foundations of a methods toolkit and template for data collection. This literature review and the eventual development of the toolkit will enable marine energy projects to identify and understand potential negative effects at the forefront and aid in avoiding or mitigating these impacts.

II. METHODS

To inform best practices and tool development for social and economic data collection for marine energy, literature was collected from marine energy, other renewable energy industries (e.g., offshore wind), and other relevant sectors (e.g., fisheries, marine tourism). This literature was reviewed to identify common metrics and practices for application and to compile existing tools. Sources for initial literature collection included:

- the reference list from the 2020 State of the Science Chapter 9 [2];
- a systematic review on marine energy, offshore wind, and other transferable industries using set terms in Scopus (see Appendix);
- a systematic review on marine energy and offshore wind using set terms in the *Tethys* database (see Appendix);
- a systematic review on *Tethys Engineering* for 'economic tool' and 'economic benefit'; and
- reference lists or other documents shared from several related research projects.

A total of 1169 documents were collected, from which duplicates were removed and the date was limited to 2010 and more recent. The remaining 1061 papers were reviewed by title to determine relevance, and the 489 relevant papers were reviewed by abstract and methods section. A full list of documents reviewed and search terms used is available in the Appendix.

III. RESULTS

The 489 documents that were reviewed represent a breadth of information from various industries, institutions, and locations around the globe on social and economic effects. Industries represented in the literature primarily included marine energy (both generally and specific technologies), offshore wind, and other renewable energies (Fig. 1). The literature review comprised documents from 44 countries, with the most documents

coming from the United States (n = 104) and the United Kingdom (n = 71). 558 unique metrics were identified, from which levelized cost of energy (LCOE), employment, vulnerability, gross value added (GVA), and cost were the most commonly used (Fig. 2). Fig. 3 shows a Sankey diagram that was developed to visualize the many-to-many relationships between different methods used and the most common metrics. Due to the complexity of the dataset, with hundreds of unique metrics and methods, Figure 3 is an abbreviated diagram of the top 50 metrics and 41 methods. The most commonly used methods for collecting social and economic data are surveys, various analyses, case studies, models, and interviews.

IV. Discussion & Conclusion

The literature review revealed a wide range of social and economic metrics, with few examples of synthesis or truly comprehensive tool or methods development. Economic methods were the most consistently assessed with established metrics and approaches, while social metrics are both emergent and divergent across the literature. Most of the 155 papers from the literature review on marine energy focused on methods or metrics around planning, siting, or technology performance, not specifically assessing the social or economic effects of a marine energy development. This is likely due to the status of the industry, with relatively few deployed devices and an emphasis on testing centers.

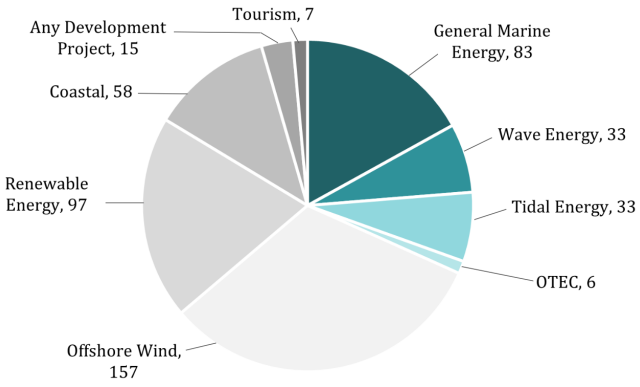

Fig. 1. Sectors or industries represented in the literature review (n = 489). Marine energy documents are shown in varying shades of blue. OTEC = ocean thermal energy conversion.

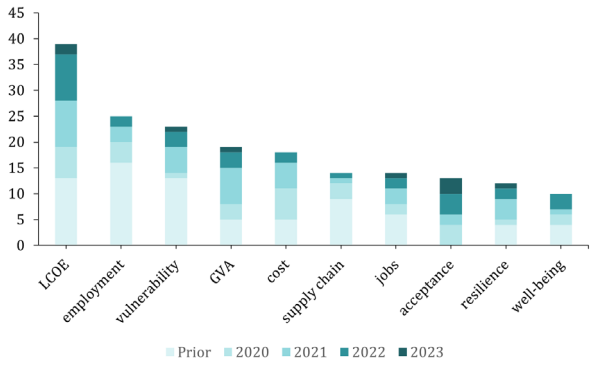

Fig. 2. Top metrics identified in the literature review. LCOE = levelized cost of energy, GVA = gross value added.

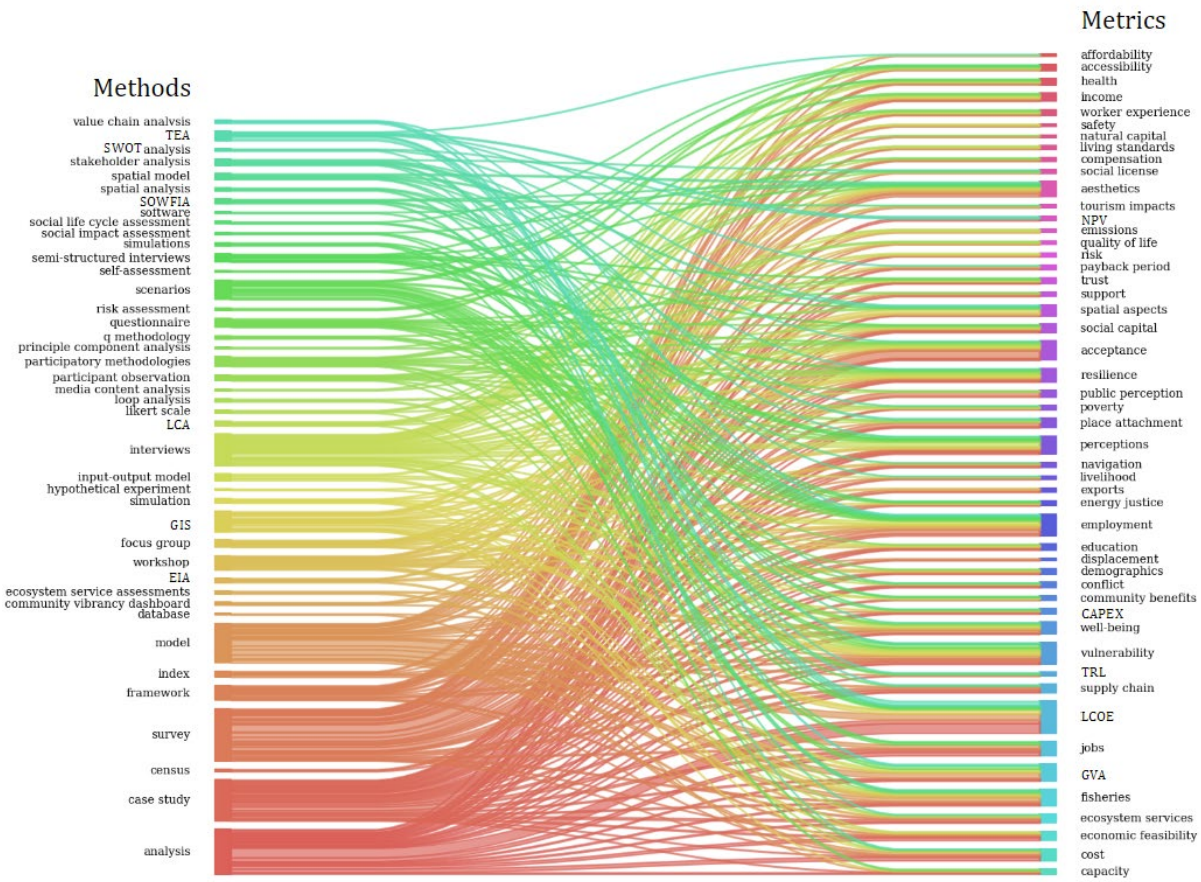

Fig. 3. Sankey diagram of relationships between the methods used for particular metrics. Each line represents an instance of a method-metric pair in a paper from the literature review. Acronyms: TEA = technoeconomic analysis; SWOT = strengths, weaknesses, opportunities, and threats; SOWFIA = streamlining of ocean wave farms impact assessment project; LCA = life cycle analysis; GIS = geographic information system; EIA = environmental impact assessment; NPV = net present value; TRL = technology readiness level; LCOE = levelized cost of energy; GVA = gross value added.

While several tools peripherally related to social and economic data collection exist for marine energy (e.g., GIS analyses or zoning tools [16]–[20], DTOcean [21], WavEC's Oasis tool [22]), the majority are site-specific and are utilized in the planning phase of a project rather than for identification and assessment of the social and economic effects of a development. As an emerging industry, there is a great deal of scholarship for marine energy to learn from in terms of anticipating and assessing social and economic effects. Industries such as offshore wind and other coastal development have been around for much longer and as such have encountered and navigated many of the obstacles that marine energy is facing. Building this social and economic toolkit requires incorporation of this learning from other industries in order to capture and synthesize the best tools and approaches for collecting social and economic data.

Following completion of this literature review, there are several next steps for research and development of a marine energy toolkit. In-depth review of the papers selected for core review is needed to provide additional context and details on the methods and metrics described above. A thorough analysis and compilation of existing and available tools will be conducted, and the literature review findings coupling methods and metrics will be combined with existing tool identification to develop the social and economic data collection toolkit.

By sharing the lessons learned in the process of creating the toolkit, we hope to advance the understanding of the current methods and identification of knowledge gaps related to social and economic effects of marine energy. Building on this foundation of social science literature, we aim to continue to advance the marine energy industry in a way that promotes energy equity, ensures environmental justice, and centers community values and needs.

APPENDIX

A database of the documents included in the literature review as well as specific search terms used is available at the following link:

https://docs.google.com/spreadsheets/d/1ywil0I2ta-pKCmFpQ2o3h6DeIMTaZ845v0HNnoNwt5A/edit?usp=sharing.

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