
11 Summary and Conclusion



Powering the Blue Economy: Exploring Opportunities
for Marine Renewable Energy in Maritime Markets

April 2019

11. Summary and Conclusion

This report outlines the information gathered in a fact-finding effort to identify potential applications and markets for marine energy technologies beyond utility-scale, grid-connected power generation markets. The year-long effort involved engaging with key stakeholders and information sources to explore evolving power needs and use opportunities at sea and along the U.S. coastlines. The fact-finding effort for this report specifically focused on identifying available information on high-level energy and project requirements, market dynamics, challenges to market entry, paths to market, and further analysis and technology research and development (R&D) needs.

The marine energy resources considered in this report included ocean waves, tidal, river, and ocean currents. The wide range of potential applications for these marine energy resources spans onshore, nearshore, and open-ocean, grid-connected, and autonomous energy systems. Depending on the application, marine energy generation could serve as a sole energy source or be integrated into a hybrid marine energy system, which might include wind, solar, diesel, and storage to meet differing annual load requirements. Marine energy technologies could be applied to a wide range of applications, with energy vectors including both electrical power (e.g., electrolysis, battery charging, and community microgrids) and mechanical power (e.g., reverse osmosis, compressed air, ice, and sediment transport).

Power at Sea and Resilient Coastal Communities

The various marine energy markets explored in this report were grouped into two different thematic areas (Figure 11.1). A portion of the applications identified in this report are focused on providing power at sea in off-grid and offshore locations to support a variety of ocean-based activities, which we refer to as Power at Sea markets. Power at Sea markets include ocean observation and navigation, marine aquaculture, seawater mining, underwater vehicle charging, and marine algae. The other markets are more coastal in nature and concerned with energy and water needs of remote, island, rural communities, and bases, on or close to land; we refer to these as Resilient Coastal Communities markets. Resilient Coastal Communities markets include desalination, isolated communities, and coastal resiliency and disaster recovery. Organizing around these groups can help support stakeholder network formation, interdisciplinary coordination, and interagency cooperation that is needed for identifying high-priority shared goals across the blue economy, as well as codevelopment of energy and maritime market technologies.

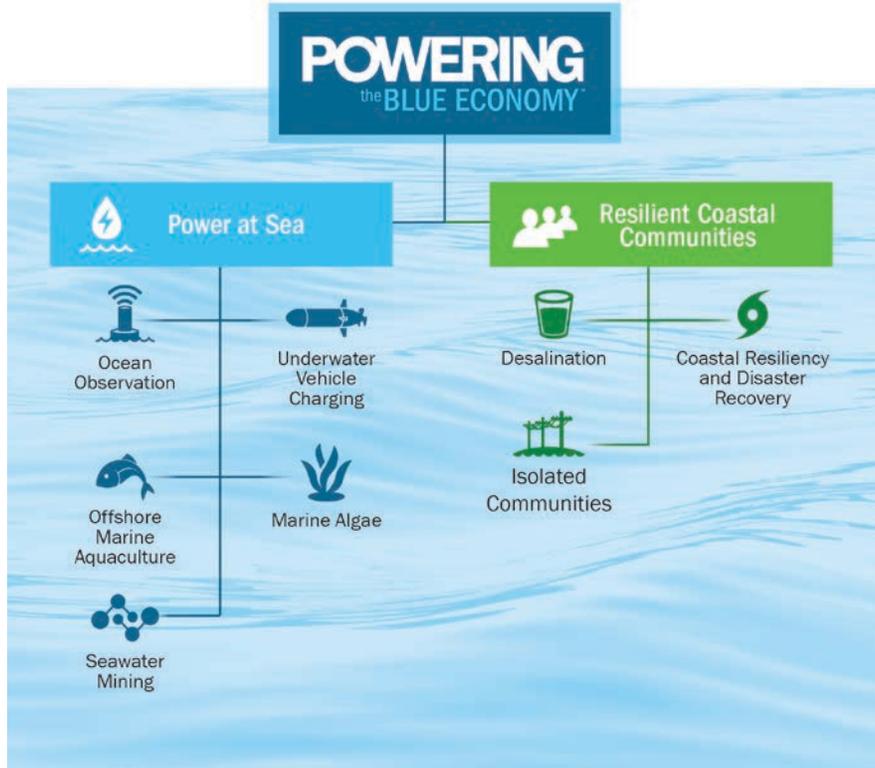


Figure 11.1. Marine power applications explored in this report

In terms of distance from shore, each marine energy market qualitatively spans different ranges of applicability from nearshore to the deep ocean, with implications for marine energy integration (Figure 11.2). The identified ranges are qualitative because the applicability of a market to different regions will continue to change as technologies and markets evolve. Distance from shore is an important consideration when discussing environmental conditions (e.g., water depth), access to shore-based resources (e.g., grid power access), and ease or mode of access to project sites (e.g., port and vessel availability).

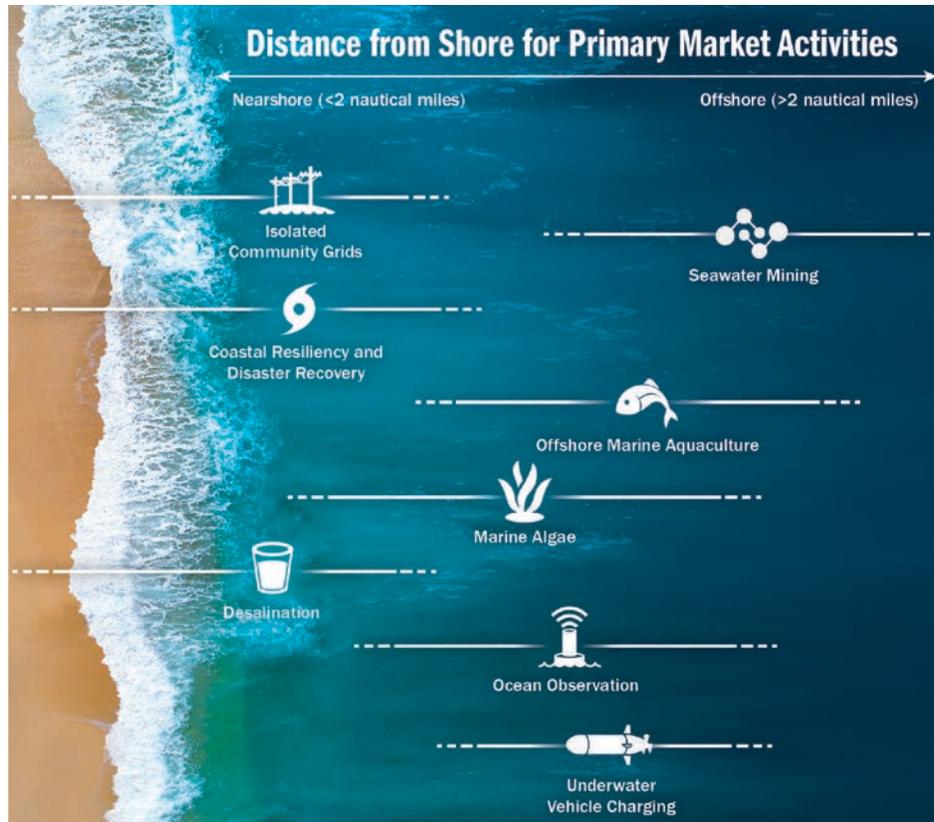


Figure 11.2 Qualitative map of the distance-from-shore application ranges for Power at Sea and Resilient Coastal Communities markets

Geographically, the Power at Sea markets are relevant across most U.S. offshore regions and from nearshore to deep water, given broad evolving activities in ocean exploration and potentially growing markets for offshore marine aquaculture, marine algae, and seawater mining. Significant ocean observing campaigns are ongoing in the Atlantic, Gulf of Mexico, and Pacific offshore regions and would be well served by new marine energy technologies that could extend the scope and life of these missions, thereby providing longer environmental time series and allowing data collection in areas not previously sampled. The markets for marine aquaculture, marine algae, and seawater mining are relatively nascent in the United States and could be supported by marine energy. Technology attributes, such as the ability to operate in variable- and low-energy environments, codesign to leverage developing project requirements, and flexibility to accommodate an evolving permitting process would be highly valued in these markets.

Major commonalities across Power at Sea markets include:

- Located out to distances far from shore, such that cabling and access to terrestrial-based energy is expensive and difficult to deliver. Typically, these locations have limited low-cost power options.
- Need to reduce fuel (e.g., diesel and new batteries), supply chain costs, and risks, including ship and personnel time, and cost to deploy and retrieve equipment.
- Power is mission critical for many applications and failure to supply power could lead to complete loss of the system, with redundant power systems being needed. To conserve power, instrument sampling rates and duty cycles are commonly set to lower-than-desired levels to extend battery life, with the impact of reducing temporal and/or spatial resolution of data.

- Existing power sources available include solar photovoltaics, wind, diesel generators, and single-use or rechargeable batteries.

The Resilient Coastal Communities markets are more broadly relevant geographically across the United States, including desalination and coastal resiliency and disaster recovery. Isolated power systems have relevant geographies spanning primarily Alaska, Hawaii, and U.S. island territories.

Major commonalities across Resilient Coastal Communities markets include:

- Applications are nearshore, with load near or onshore.
- Visual (viewshed) impacts are an important consideration.
- There may be some challenges to acceptance and permitting for some nearshore markets.
- It is easier to have redundant power sources in these markets.
- Energy for these applications is a significant percentage of overall project cost.

The set of industries targeting coastal/onshore versus offshore/deepwater technology development opportunities are generally different from one another in terms of regulations, stakeholders, engineering needs, data availability, equipment needs, workforce, and research communities. However, opportunities for marine energy within these broad market categories possess several commonalities that could inform similar technology advances, including effective stakeholder and interagency engagement; alignment with supporting industries and clusters; and necessary R&D, testing, and validation capabilities at national labs and university partners.

Organizing functionally around these themes could support network formation and interdisciplinary coordination needed for codevelopment of energy and maritime market technologies. Tapping into existing and emerging networks could provide new engagement opportunities for marine energy specialists, access to knowledge, and opportunities in crossover markets. The same is true for the Resilient Coastal Communities theme—there are existing networks and resources focused on sustainable coastal development, energy/water needs of island communities, and rural infrastructure modernization that could be approached so as to leverage opportunities and expertise across multiple markets.

Finally, organizing around these themes can reveal opportunities to invest in cross-cutting technologies and R&D that support all markets within a given theme. For example, progress is needed in operational reliability, resource assessment and forecasting, integration of marine energy production with storage (e.g., microgrids at sea), and novel deployment and maintenance strategies. This kind of cross-cutting research could create multiple innovation pathways across many markets. Similarities can be anticipated between near and offshore markets, including installation, operation, and management constraints and concerns; marine energy device archetypes that may have desirable traits based on location; marine energy device survivability concerns; the types and needs of customers; and energy storage challenges.

Power Needs Across Markets

All eight of these markets are to some degree growth-limited by energy. For some markets, marine energy could replace an existing energy supply chain that might be more expensive, such as ship travel to replace batteries in ocean observing systems. For other markets, marine energy could provide local energy abundance not currently attainable by other means to enable new innovation pathways and create opportunities that would not otherwise exist.

As identified in this study, the existing and evolving applications span wide power needs from watts to megawatts, and substantial distances from shore, along with variable energy requirements and tolerance to

intermittent power over days, weeks, months, years, and between years. There is a better understanding of energy needs and limitations in near-term markets than for emerging and future markets, where significant uncertainty still exists. For example—analysis and Request for Information comments for this report indicate offshore aquaculture is a rapidly emerging industry driven by global factors, such as protein availability, but there is not a clear picture of the overall need for energy in this market. Energy needs for mineral mining and marine algae production are unclear—many of the present concepts for these applications largely take advantage of ocean temperature, upwelling, or ocean currents to circulate water across farming operations. There will likely be a need for additional electrical or mechanical power that might be provided by marine energy, but the degree to which marine energy could outcompete other sources, like solar or offshore wind, is less clear. This is not to say that these markets are not suitable for marine energy, only that additional analysis is needed to understand appropriate innovation pathways.

Marine Energy Value

Numerous unique attributes of marine energy that could be valuable enablers for blue economy markets were identified. These attributes can be broadly organized within the groupings of marine energy “resource-focused” attributes and marine energy “technology-focused” attributes, which are discussed in greater detail in the individual chapters and summarized here.

The United States is fortunate that it has diverse and abundant marine energy resources. Forecastable, energy-dense waves, tides, currents, and rivers can be found throughout the Exclusive Economic Zone and off the continental United States, Alaska, and Hawaii, and island territories. To date, most research into the marine energy resource potential has been focused on applicability to the grid electricity market. The focus has thus been on high-intensity resources close to shore that have the prospect of providing the lowest levelized cost of energy to a continental grid power market. This report focuses on cataloging and investigating the nongrid market opportunities for marine energy and puts a broader lens on the assessment of the resource. As new markets and interests emerge, different attributes of resources and relevant conversion technologies may become clearer. Emerging markets might also open opportunities in ocean thermal energy conversion, salinity gradients, or other marine energy resources.

There are various unique technology-focused attributes of marine energy that could be leveraged to provide a new source of energy to blue economy markets, including the ability to provide both electrical and mechanical power, potential for lack of surface expression, opportunities for codesign with other application infrastructure, common supply chains with other ocean industries, and the ability to provide resilient power during disruptive events. Direct use of mechanical energy requires no conversion to electricity, potentially increasing system efficiency and reducing use of critical materials (e.g., no rare-earth elements). Water itself serves as the raw material input across multiple applications (e.g., desalination, hydrogen production, mineral extraction) and can also provide ambient water cooling at low project cost (e.g., data centers). From a mechanical perspective, marine energy devices can also dampen platform motion and/or reduce waves, with benefit to several applications (e.g., shoreline protection, aquaculture). In addition, the unique high-energy density and subsurface characteristics of the marine energy resource could result in smaller form factors for generation technology and designs with no surface expression, with implications for ease of deployment, survivability, visual impact, and security.

Marine Energy Market Potential

This report provides available data and information, along with stakeholder input, across multiple potential marine energy markets. Publicly available market data and forecasts are incomplete for the total sector; the energy-related equipment/services/contracts portions; portions of each market for which marine energy is relevant; and relevant portions of each market that marine energy could hope to capture, especially for nascent or nonexistent markets. As outlined further in the upcoming Recommended Next Steps section, additional analysis of the evolving project requirements and scenarios for marine energy competitive positioning is needed.

Although this report does not make projections and estimations to fill in these gaps, based on available information it is clear that, collectively, the existing markets are presently in the billions of dollars market size range, with the present and future possible markets also estimated in the billions of dollars. Available market information that was identified in the report is outlined in each chapter and summarized in Appendix C.

The eight different markets featured in this report range from existing robust markets through prospective future markets, with significant activities in emerging markets, some of which marine energy could help enable. As outlined in Table 11.1, this understanding of market maturity and readiness helps to build a picture of what applications may have nearer-term possibilities and which applications might be riskier markets.

Given the evolving nature of the blue economy, the opportunity exists to innovate and develop new marine energy technologies that are tailored to meet the needs of specific markets. Thus, there are multiple choices for marine-energy-generating devices that might fit one application better than another. Marine energy is playing within an opportunity space that consists of other energy sources, including diesel, batteries, solar, and wind. Marine energy has to provide a benefit for the particular application that is more competitive than, or complementary with, the existing forms of available energy. Application-by-application case studies would help to determine the most suitable existing and future markets for marine energy integration, taking advantage of the unique strengths that marine energy technologies can provide.

Table 11.1 Perceived Blue Economy Market Readiness

	Near Term	Emerging	Future
Power at Sea			
Ocean Observation and Navigation	X		
Underwater Vehicle Charging	X		
Offshore Marine Aquaculture		X	
Marine Algae		X	
Mining Seawater Minerals and Gasses			X
Resilient Coastal Communities			
Desalination	X		
Coastal Resiliency and Disaster Recovery		X	
Community-Scale Isolated Power Systems	X		

Stakeholder Engagement

Stakeholders in these markets are as varied as the markets themselves. Any given market may include regulators, insurance providers, technology developers, private investors, and customers. For this report, emphasis was placed on end users and potential technology development partners, as both groups are believed to be of the most interest to marine energy technology developers.

In established blue economy markets, it is relatively clear that the major stakeholders and customers are larger companies or government organizations. For example, ocean observation clearly has critical stakeholders within the National Oceanic and Atmospheric Administration (specifically within the U.S. Integrated Ocean Observing System, Ocean Exploration, and the National Data Buoy Center), the National Science Foundation, and the U.S. Department of Defense. In contrast, desalination is largely driven by local and regional utilities.

For emerging markets, it is still not clear who the major players are in some cases, but startups and small businesses clearly play a role. For example, offshore aquaculture in the United States is underdeveloped and there are only a handful of businesses that have, or are seeking, permitting for projects in federal waters. The underwater vehicle recharging market is somewhat of an outlier. Although this is believed to be an emerging market, a surprising number of large organizations like defense contractors, oil and gas majors, and the U.S. Navy are involved. One would expect these groups to be more risk averse to emerging technologies such as these, but mission needs seem to overcome these concerns.

Future markets are more uncertain, and the same is true of their stakeholders. These markets are still largely constrained to conceptual plans or lab research projects in academia and there are few, if any, companies pursuing them at the moment. The major stakeholders for these groups tend to be government and university R&D laboratories.

Benefits to the Nation

This report focuses on significant market opportunities for the application of marine energy technologies, given existing power constraints and other limitations in current and growing markets. Many of these applications and missions are important from a national perspective.

U.S. national security could be enhanced through the development of the markets identified in this report. For example, this could include advanced ocean sensors with longer mission durations and minimal expression; or greater and more resilient emergency response functions in the face of a disaster or a prolonged drought; and the acquisition of critical minerals from the sea. America's trade gap could also be reduced should offshore aquaculture or marine algae industries expand their capacity and development in the U.S Exclusive Economic Zone. Another example is the integration of wave energy converters with traditional coastal infrastructure, such as breakwaters, groins, jetties, and seawalls, where the ancillary value provided by wave energy converters in the further development of the coastal defense and resilience of a particular locality is more significant than the primary value of providing localized electricity generation. Considering the diversity of potential benefits, the various opportunities explored in this report represent significant value beyond economic.

Powering the Blue Economy aligns with the *2017 National Security Strategy*, specifically with the following goals of the United States: “We will improve America’s technological edge in energy, including nuclear technology, next-generation nuclear reactors, better batteries, and advanced computing, carbon-capture technologies, and opportunities at the energy-water nexus. The United States will pursue an economic strategy that rejuvenates the domestic economy, benefits the American worker, revitalizes the U.S. manufacturing state...”. In addition, the report directly supports the President’s Executive Order 13840 on Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States: “It shall be the policy of the United States to:...(d) facilitate the economic growth of coastal communities and promote ocean industries, which employ millions of Americans, advance ocean science and technology, feed the American people, transport American goods, expand recreational opportunities, and enhance America’s energy security.”

All blue economy sectors depend on energy, and in the unique applications outlined in this report, energy innovation can drive growth. Expanding demand for ocean-derived food, materials, energy, and knowledge is driving rapid growth in the emerging blue economy for both ocean-based and nearshore industries.

For example, ocean industries, such as aquaculture, are expanding and moving farther offshore to take advantage of the vast scale of the ocean. Moving farther offshore requires access to consistent, reliable power untethered to land-based power grids. Oceanographic research and national security missions increasingly rely on autonomous sensors and unmanned vehicles that function with limited human intervention.

Closer to shore—rural coastal and island communities often rely on expensive shipments of fuel and water to meet basic needs. Electricity and water are vulnerable to disruption during periods of bad weather or following natural disasters. Removing power constraints and addressing the needs of other coastal and ocean energy end users could accelerate growth in the blue economy and create new opportunities for sustained economic development. Marine renewable energy presents a novel and innovative suite of technologies that could help in removing some of these constraints.

Near-term opportunities could provide early commercial success for marine energy technologies, but also broadly help the nation expand economic development opportunities, revitalize coastal and port infrastructure, increase the diversity and resilience of our power systems, and position the United States to lead in the international development of technologies and projects that responsibly leverage the broad and diverse potential of ocean, wave, and tidal, river, and ocean current resources.

An important and broad advantage of marine energy development in various markets and applications is the value proposition of devices for the electric grid. Maritime markets present opportunities to learn more about the unique value that marine energy devices could contribute to future grid-scale applications. System attributes, such as production capacity, ancillary services, reliability services, and resiliency, are all broad benefits of marine energy deployment. Development of marine energy technologies integrated with various application of Power at Sea and Resilient Coastal Communities could lead to a better understanding of device attributes and their inclusion in future grid expansion and electricity planning. A number of specific advantages to highlight are the deferred or avoided costs of transmission investments to remote, coastal locations; reduced integrations costs; the ability to provide seasonal peaking power; the avoidance of crowded land-based generation siting; and more predictable generation. In addition, for coastal resiliency and disaster recovery applications, marine energy devices can be integrated to provide critical black-start capabilities or other services in the face of grid disruptions or coastal inundations affecting power systems. Finally, marine energy technologies are distributed and decentralized, thereby allowing for deployment in microgrid configurations or providing necessary diversity to local and remote power generation systems. The application and integration opportunities described in this report present unique opportunities to further develop marine energy market value and technological evolution.

Recommended Next Steps

This report outlines how marine energy could be utilized in various applications but does not identify areas where marine energy is most likely to gain market traction or where the largest probable markets are. Defining future analyses and next steps to better understand each market opportunity and the portfolio of opportunities is a critical objective of this report. Techno-economic analyses to further clarify these potential opportunities, along with enabling R&D objectives, are outlined in this section. To compete with and/or be complementary to other energy technologies in these different potential applications, marine energy technologies must exploit their unique attributes and differentiate from other energy sources. For example, for a given application, questions that might be asked include: is a limited surface expression a requirement? Are there significant power needs at potential project sites that cannot be met by cables (e.g., far offshore)? Does distributed resource diversity make the cost/benefit of marine energy attractive (e.g., to complement high-latitude solar irradiation and wind)? Is there a need to de-energize waves or currents to protect at-sea operations?

Marine energy alone, with storage, or in hybrid generation systems may have a value proposition that could contribute to increased mission scale in existing markets or the creation of new offshore markets. Integration of marine energy could enable the cost-effective leveraging of untapped or “stranded” energy and other assets in the ocean and potentially enable/unlock entirely new, as yet unknown, large future markets. The markets identified in this report could create near-term commercial opportunities for marine energy technologies and companies, attract a diverse set of development partners, educate stakeholders and the public, develop a supply chain, and reduce risks and costs. Experience and revenue gained from successes in nearer-term blue economy applications will enable further investment in R&D, an expanding value proposition, and meet the needs of additional markets, including more cost-competitive utility-scale power markets.

Key questions to answer to gain further insight into where, how, and when marine energy technologies may have the best potential for application and market viability include:

- What are the unique and distinguishable requirements of these individual diverse markets that need to be satisfied by the marine energy technologies that are currently available or could be developed in the future? What are the specific energy needs/load profiles for each evolving application?
- What are the unique and distinguishable attributes of marine energy technologies that make them more attractive, cost effective, and socially desirable than or complementary with other energy solutions for each blue economy application?
- Which markets have the highest probability of marine energy market success from technical and economic perspectives? Which markets have the largest achievable size for marine energy? Which applications have the fastest potential time to market? How can marine energy attributes be applied to currently unidentified uses and future markets?
- Which application has the most motivated stakeholders/customers/codevelopment partners and the best access to R&D and project development capital?
- What are the priority challenges to overcome to create options for competing in multiple markets, and what is the best way to overcome them?
- What is the sum of direct and indirect benefits and values for the nation, society, the environment, and the economy beyond direct revenue from energy production—enabled and unlocked by onshore, nearshore, and offshore marine energy?

Recommended Analyses

To address these questions, the following additional analyses are recommended:

- **Market analysis/marine renewable energy design requirements.** Assess detailed project needs and evolving needs over the next 5–10 years. Use project case studies as frameworks to determine energy required for each application, including annual/monthly/daily megawatt-hours, peak power, and average power. Consider site selection for projects, resource modeling, conceptual design, (hybrid) power system design and simulation, project cost and business model analysis, and failure mode, effects, and criticality analysis.
- **Cross-resource and technology hybrid power system assessment.** Explore resource levels, variability, predictability, and power generation alternatives to meet missions including hybrid systems with integrated storage. Determine best opportunities for marine energy to operate alone, with storage, and with storage, solar, wind, diesel, and other technologies.
- **Detailed market opportunity assessments.** Take a deeper look at Power at Sea and Resilient Coastal Community markets to fill in estimate and forecast gaps. Project total sector development and growth (including marine energy enabling potential), energy portion of sector economic activity, and addressable marine energy market opportunity and evolution. Present status and forecast scenarios of evolution of each marketplace, including size, requirements, dynamics, and marine energy technology features, benefits, and costs. Quantify total available market and forecast achievable market share/size. Conduct competitive positioning and business case analyses.
- **Marine energy innovation pathways.** Conduct further analysis to understand how key R&D efforts and learning within near-term markets could create innovation pathways that fulfill more of the needs of related emerging future applications and markets. Consider lower-risk paths to commercialization, such as using initial applications to provide options for potential additional markets (Sinfeld and Solis 2016).

Research and Development

Although more specific, detailed mission and design requirements are described in the application chapters, some common high-level R&D technology objectives identified for marine energy devices include the following:

- **Reliability.** Minimum level of proven availability needed. Marine energy devices will need to operate autonomously for prolonged periods, on the sea surface, at depth underwater, and offshore, with proven reliability and survivability.
- **Efficient installation, operation, and maintenance.** Specialized vessels and equipment drive up costs. Cost-effective, low-risk, and vessel-independent installation methods are needed. Ease of repair with relatively unskilled labor in remote locations is essential for many markets. Some applications will require very long maintenance intervals.
- **Mechanical systems integration.** For some applications, marine energy converters must be integrated into other offshore systems, such as docking stations or aquaculture pens. Co-optimization possibilities and opportunities exist to reduce costs as a result of shared infrastructure. Some applications may not need electricity but might require pressurized air or seawater instead. As an example, desalination requires new designs and research on how wave energy converters can effectively be integrated with pumps, reverse-osmosis systems, and membranes.
- **Electrical systems integration.** Many Power at Sea solutions will involve nano- or microgrids at sea—incorporating marine energy, and potentially solar photovoltaics, and offshore wind, with integrated storage (batteries or accumulators). Effective system designs and controls are needed to meet cyclical needs reliably.
- **Supervisory control and data acquisition system development.** Reliable, high-performance operation of autonomous control and communication systems is needed for remote hybrid power systems, dependable system operations, station keeping, and so on.
- **Designs for effectiveness in low-energy resources.** Many applications within the blue economy are in areas with a low marine energy resource. For very low resource intensities, the hydrodynamics and economics may differ from that of high-energy environments, therefore requiring new innovations in device design.
- **Designs and operation for environmental compatibility and stakeholder acceptance.** Marine energy systems and the systems they power must meet environmental regulations. R&D is needed to understand and provide solutions for potential environmental effects to reach acceptable environmental risk. Social acceptance is related to environmental risk, as well as to interactions with other ocean users. Research and engagement with stakeholders is needed to reduce conflicts with users and gain social acceptance.

Marine energy faces many inherent engineering challenges associated with converting high-intensity resources to usable energy, compounded by the harshness of offshore and deepwater environments. Maritime markets present smaller, scalable, and potentially low-cost iterative design environments that could accelerate the development curve for some technology innovations. Although not all of this experience will be directly applicable to the continued development of larger utility-scale systems, there should be significant relevant learning. The smaller-scale systems, faster R&D cycles, and efficient open-water deployments for blue economy applications will provide near-term experience with engineering and design for customer requirements, manufacturability, transportability, and operability. Some key transferable areas include model validation; hardening, such as system reliability and survivability; installation, operation, and maintenance, including lower-cost installation, operation, and maintenance, with minimal infrastructure and skill levels; reliable operation without human intervention over extended periods of time; performance, including control systems, hydrodynamics, and design principles; interconnection with microgrids and derisking of electrical

equipment and components; open-water validation and operation experience; supply chain development; understanding potential environmental effects; and determining stakeholder acceptance of new technologies.

The Future

Marine energy technologies have numerous attributes that may offer a unique value proposition to different present, evolving, or future activities in the blue economy. Although work remains, there is potential to contribute to increased mission scale and growth in existing markets and to contribute to the creation of new economic, scientific, and defense activities. Explored through partnerships with emerging ocean industry and government partners, marine energy could be transformative for the blue economy, enabling significant new value from the ocean for the nation. Beyond the markets analyzed in this report, new and high-impact applications for marine energy likely exist on the horizon in the blue economy, thus continuing to widen the scope of potential applications and markets. Big and creative “blue sky” thinking is required to advance application of sustainable technologies and renewable energy to meet the grand challenges. Significant opportunities offered by the blue economy include the opportunity to contribute to an ocean-based economy that provides social and economic benefits for current and future generations, while restoring, protecting, and maintaining the diversity, productivity, and resiliency of marine ecosystems.

References

Sinfield, J. V. and F. Solis. 2016. "Finding a Lower-Risk Path to High-Impact Innovations." *MIT Sloan Management Review*.

The White House. 2017. *National Security Strategy*. <https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>.