Dr. Alison LaBonte
Marine and Hydrokinetic Energy Technology Lead
U.S. DOE Wind and Water Power Program

Dear Dr. LaBonte:

We greatly appreciate the willingness of the U.S. Department of Energy's (DOE) Wind and Water Power Program leadership to engage with the emerging marine renewable energy industry in the United States and to share the Program's analyses of the sector. We submit this document as our written response to the issues discussed at our November 14, 2014 meeting at DOE as the first of many steps in building a stronger, more collaborative dialogue with the Program.

The marine renewables sector has tremendous potential. However, during this critical phase of industry development, the rate at which that potential is realized depends strongly on the level of public support and the leverage it provides on private investment. We recognize and appreciate that robust, competitive levelized costs of energy and material market sizes are needed for defensible DOE programmatic requests and planning activities. We also recognize that growing the Program's investment requires a compelling vision, akin to such DOE initiatives as HydroNEXT and SunShot. In this spirit, we have identified several refinements to the cost of energy analysis which industry believes would better reflect the future competitiveness of the marine energy sector. In addition, we offer an alternative path to commercialization in utility-scale markets which leverages near-term commercial opportunities in distributed power generation markets.

We hope that this "strategic roadmap" can lay the groundwork for an open and inclusive marine renewable energy visioning process with DOE in the coming months. The new Marine Energy Council, operating under the auspices of the National Hydropower Association, is positioned to lead this effort and serve as the unified point of contact with the Program moving forward.

Organizations and individuals that contributed to the response

- Aquantis, Mr. Charles Vinick, CEO
- Columbia Power Technologies, Mr. Reenst Lesemann, CEO
- DNV GL – Energy, Mr. Jarett Goldsmith, Project Manager
- 48 North Solutions, Inc., Mr. Cam Fisher, Principal
- Hawai'i National Marine Renewable Energy Center, Dr. Luis Vega, Manager
- Northwest National Marine Renewable Energy Center, Dr. Brian Polagye, co-Director
- Ocean Renewable Power Company, Mr. Chris Sauer, CEO
- Oregon Wave Energy Trust, Mr. Jason Busch, Executive Director
- Oscilla Power, Mr. Rahul Shendure, CEO
- Resolute Marine, Mr. Bill Staby, CEO
- Re Vision Consulting, Mr. Mirko Previsic, President
- Southeast National Marine Renewable Energy Center, Ms. Susan Skemp, Executive Director
- Strategic Marketing Innovations, Mr. PJ Dougherty, Vice President
- Verdant Power, Mr. Ron Smith, President

While all parties may not endorse each point contained herein, this document is as close to an industry consensus as possible within the timeframe allowed by this initial process.

cc: Mr. Jose Zayas, Program Manager, Wind and Water Power Program
Mr. Hoyt Battey, Market Acceleration Lead, Wind and Water Power Program
Mr. Ryan Sun Chee Fore, Marine and Hydrokinetic Technology Manager, Wind and Water Power Program

Introduction

Opportunity

Marine renewable energy resources have the potential to provide cost-effective, reliable, carbon-free electricity along with much-needed jobs in coastal and urban communities, as well as a strong worldwide market for job-creating export of U.S. goods and services. These marine energy resources can meaningfully contribute to a robust, diverse portfolio of renewable energy generation sources in a more sustainable energy future. However, energy technology and infrastructure advancement requires large, sustained public support that leverages private investment necessary to achieve market readiness. This is particularly true for new technologies where, dollar for dollar, DOE support can play a greater role in accelerating development than for mature generation technologies, such as solar or wind energy. Early-stage DOE investment is critical to moving the marine renewables industry forward, both through direct technology advancement and attracting necessary private capital.

Industry Engagement with DOE

Particularly during a time of tight budgets, the marine energy industry is excited to have the opportunity to engage with DOE in discussions regarding increasing and shaping the support provided by the Program. A vital element of this engagement is the opportunity to provide regular updates on industry progress and challenges, as well as candid feedback on how the U.S. marine renewables industry values and leverages the Program's investments. Through this process, the capabilities of the DOE National Laboratories and academic institutions can be more effectively mobilized to overcome challenges faced by industry, while the useful technology development and demonstration funding opportunities provided by the Program are sustained and expanded.

Conclusion Summary

- The Levelized Cost of Energy (LCOE) analysis presented by the Program in November 2014 is too conservative. The industry recognizes that LCOE analysis for emerging industries is extremely difficult and has made several suggestions for a more rigorous, revised analysis that supports a lower LCOE.
- The industry recommends that the Program should begin to develop second-generation resource assessments to address unquantified uncertainties in the first-generation assessments.
- Both wave and current resources can meaningfully contribute to a sustainable energy future. However, the relative disparity in technical maturity between waves and currents requires different approaches for Program support of these generation technologies.
- DOE should support the demonstration in distributed commercial markets of technologies that can be game-changers in utility-scale markets. This support could be modeled after elements of the successful DOE Wind Turbine Verification Program and structured to account for differences in the market readiness and availability of test facilities for wave and current energy technologies.

Adjustments to Levelized Cost of Energy Analysis

Background

The industry consensus is that DOE's November 2014 assessment of LCOE is too conservative to suitably reflect the trajectory of the U.S. marine renewable energy industry.

- Most U.S. developers are predicting opening costs of less than $400/MWh for small arrays, consistent with feed-in tariffs and production incentives being developed around the world for this sector. Two case studies, from Canada and the UK, are provided in this response to support this assertion. This is also consistent with the Bloomberg projections cited by the Program.
- Deployment of marine energy technologies at utility scale (100+ MW) would allow projects to compete directly with offshore wind, which is presently at costs above $200/MWh.
- Beyond that, there are credible technology innovation pathways that can lead to LCOE levels below $150/MWh[1], both based on learning curve assessments and bottom-up analysis of cost and performance. This is in line with the targets of $120-150/MWh stated in the recent component advancement funding opportunity announced by the Program.

Most of the industry concerns with the 2014 DOE assessment are grounded in the baseline cases for wave and tidal[2] used for the study, which do not adequately consider the rapid pace of technology transformation or economies of scale at the device/deployment level. Choosing the right starting point and appropriate device/deployment scales are of critical importance to enable this emerging industry to compete with other renewables on a levelized cost basis.

Evidence for Lower Baseline LCOE

The DOE LCOE assessment is based almost exclusively on the European SI Ocean report and does not contrast these findings to other studies or direct observations of situations where feed-in tariffs have attracted industrial support and provide an objective break-even point for early demonstration projects.

- *Canada – Developmental Tariff:* In November 2013, the Nova Scotia Utility Board approved a "declining block" Developmental Tariff. Feed-in rates were set at $455CAD/MWh for 1MW - 5MW scale projects and $375CAD/MWh for 5MW - 10MW projects. In December 2014, four developers were approved to build out 17.5 MW of tidal power under this scheme. The decision-support documents provide cost breakdowns for deployments at these scales, which were established through an industry consultation process[3]. At a present exchange rate of 0.85, this represents an LCOE of $386/MWh at a 5 MW scale and $318/MWh at a 10 MW deployment scale.

[1] The industry notes that raising capital in private markets often requires credible techno-economic analysis supporting a long-run target at or below $100/MWh. In the US, private financing is unlikely for 100+ MW supply curves at $150/MWh in many markets.

[2] As discussed in the strategic vision portion of this document, the industry would recommend that DOE consider tidal, river, and ocean currents as an aggregate market. The LCOE response focuses upon tidal energy, rather than ocean or river current, to mirror the 2014 DOE LCOE calculations. Europe lacks substantial ocean current resources and has not assessed its river current potential to the same degree as the US. Consequently, European LCOE analysis and market support in the current energy space tends to focus solely on tidal energy.

[3] http://www.canlii.org/en/ns/nsuarb/doc/2013/2013nsuarb214/2013nsuarb214.html

- *United Kingdom– Contract for Difference:* The UK government, through the Department of Energy & Climate Change, established a rate structure that guarantees rates for wave and tidal energy. This program replaces the earlier Renewable Obligation Certificate (ROC) program, a support mechanism that was funded by a carbon trading scheme. Rates were set at 305 UK pounds/MWh for wave and tidal[4]. At an exchange rate of 1.51, this yields a representative LCOE of $460/MWh for wave and tidal.

These Canadian and UK early-adoption price-points are in agreement with U.S. developer LCOE projections for similar scale arrays. LCOE adjustments for U.S. markets based on resource power density, such as those made in the 2014 DOE LCOE analysis, are not considered to be relevant for these early adopter arrays. This is because LCOE for early deployments is primarily driven by early technology improvements and device/deployment scale, as long as power density stays within reasonable ranges of the original design point of the deployed machine[5].

The Canadian and UK support programs have created significant traction within the global industry, leading to scheduled deployments of arrays with a capacity of 5MW – 10MW over the next few years. As such, these data points are the most authoritative from an industry perspective. LCOE for early commercial arrays also includes risk premiums that normally are accounted for in the cost of capital. This means that the early adopter markets established through feed-in-tariff incentives are likely conservative indicators of LCOE. While a national feed-in tariff is unlikely to be adopted in the U.S., various states are developing feed-in tariffs and renewable portfolio standards that would provide break-even market support for early-stage marine renewable energy deployments with power prices in the range of $300-$400/MWh.

Technical Feedback on LCOE Analysis and Methodology

Plant rating should be 100 MW or more. DOE LCOE calculations are based on a plant rating of 10 MW. LCOE baseline calculations for offshore wind and other utility-scale renewable energy technologies are typically established at a 100 MW – 500 MW level, which provides economies of scale[6]. Anticipated LCOE reductions as a function of plant scale were studied during the Reference Model effort and were shown to have an average cost reduction of 47% (49% for wave – RM3, and 45% for tidal – RM1)[7] when plant size increased from 10 MW to 100 MW. This reduction is achieved solely through scale effects, without applying improvements to the core technology. Given that the LCOE estimates will be compared to other renewables by stakeholders across the energy industry, it is critical that the scale used be commensurate with those used for traditional cost projections.

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[4] Investing in renewable technologies – CfD contract terms and strike prices: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263937/Final_Document_-_Investing_in_renewable_technologies_-_CfD_contract_terms_and_strike_prices_UPDATED_6_DEC.pdf

[5] As an example of exceeding this condition, the high power density at the Minas Passage site in Nova Scotia, which will serve as an early adopter site for tidal power in Canada, is presenting significant engineering challenges that have resulted in cost increases that outweigh performance increases for several technology developers.

[6] Examples of this, beyond mass production benefits for marine energy converters, include amortization of balance-of-plant costs associated with tooling and O&M vessels, submarine cables and electrical infrastructure, and shore stations.

[7] Source: RM1 and RM3 LCOE assessment spreadsheets: http://energy.sandia.gov/energy/renewable-energy/water-power/reference-model-project-rmp/reference-model-documents/

Device rating should be based on MW-class machines. Individual device scale is critical for cost-competitive marine renewable energy systems. Given that industry has successfully demonstrated MW-scale devices (wave and tidal), LCOE should be based on the MW-scale designs, not pre-commercial prototype scales. MW-scale machines were successfully demonstrated by Atlantis (1.5 MW, tidal) and Aquamarine (0.8 MW, wave) in Europe[8]. There are no resource intensity differences between Europe and the U.S. that would indicate or justify a lower device rating for U.S. deployments.

Plant capacity factor should not be reduced based on an industry maturity assumption. The plant capacity factor in the 2014 DOE LCOE calculations was reduced by 5% based on an assumption that the U.S. industry is less mature then the European industry. The machine capacity factor is a function of machine rating and resource power density, not industry maturity. One could argue that availability might differ for early-stage prototypes, but many of the lessons learned are global in nature and have been absorbed by the U.S. industry. No distinction should be made between European and U.S. capacity factors or availability.

Scaling of LCOE to resource should consider all relevant cost drivers. One of the ReEDS model inputs is a correlation between LCOE and resource strength. In reality, LCOE is highly site-specific and developing direct comparisons among different sites is difficult to carry out without performing at least a preliminary siting study. Such an approach should include a wider range of parameters that are considered LCOE drivers for marine energy systems, including: (1) extreme loads that can increase structural cost, (2) operating in severe environments that may increase operational costs, (3) certain costs (such as the powertrain) that remain relatively constant on a $/kW (or $/kWh) basis, and (4) siting factors such as distance to grid, port, and other relevant infrastructure. These drivers have all proven to be relevant for offshore wind development. Overall, incorporating these considerations leads to a different correlation curve between resource power density and LCOE, such that lower power-density sites may have a more attractive market adoption profile within ReEDS. An example of a correlation curve that considers such effects can be found in a recent DOE funded study[9]. In addition, adjustments to the industry learning rate could, if necessary, be incorporated into a revised ReEDS analysis.

Utilization of ReEDS for marine energy technologies has important limitations. ReEDS is a capacity-expansion model that is driven by the economic viability of different future electric generation mixes. ReEDS is considered to be a suitable tool for the assessment of generation options, and this industry is supportive of its use. However, tools such as ReEDS that attempt to predict scenarios 20 to 50 years into the future have historically under-predicted the impact of (successful) new technologies because the future is modeled as a “linear extrapolation” of historical trends. In addition, ReEDS does not model Alaska and Hawaii, which are critical early adopter markets for marine energy technologies. As such, the industry urges DOE to use the outputs of analytical tools, such as REeDS, with an appropriate level of caution, considering the unique characteristics of these emerging resources. Because of model input uncertainties, analytical tools can suggest unreasonably optimistic or pessimistic market trajectories.

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[8] DCNS, Alstom, Voith Hydro, Andritz Hydro, and Siemens have also demonstrated MW+ tidal turbines.

[9] The Future of Wave Power in the United States, Page 45

A Simple Representative Example for an Alternative LCOE Assessment

While it is difficult to establish a LCOE baseline that is representative of all technologies under development in the United States, the following provides a baseline case that aligns more closely with industry expectations and DOE's stated target of $120-150/MWh by 2030.

For baseline 10 MW small array costs, LCOE levels are taken to be consistent with the tariffs set in the UK at $460/MWh for wave power and tariffs set in Canada at $390/MWh for tidal power. As established by the reference model benchmarking efforts, a 49% reduction in LCOE is used to scale from a 10 MW plant to a commercial 100 MW plant. This yields an LCOE target of $234/MWh for wave and $198/MWh for tidal. This corrects the baseline inputs to consider appropriate deployment scales and allow for direct comparison to other renewables, but does not consider the benefits of technology improvements.

Cost reduction pathways from these realistic baseline cost levels can credibly reduce the cost of electricity to less than $100/MWh through a combination of learning curves and targeted investments in transformative technology research, development, and demonstration. A recent article on cost reduction pathways in wave energy conversion outlines where such reductions can be achieved[10].

Vision for Strategic Direction of Marine Renewables in the U.S.

Challenge

Market conditions in the U.S. are substantially different from Europe (e.g., lack of feed in tariffs, limits to local infrastructure). This presents additional barriers to utility-scale adoption of marine renewable resources. DOE's current strategy is to support technologies that have (1) a practical resource large enough to substantially contribute to U.S. energy demands and (2) a LCOE that can be shown to be cost-competitive in the near-term, as supported by robust techno-economic analysis.

The industry recognizes that DOE resource assessments conducted to date suggest that wave energy is the only marine renewable resource that, in isolation, can significantly contribute to U.S. energy and environmental drivers – particularly for states on the west coast. However, wave energy is further from adoption by utilities. Large-scale application of wave energy in the U.S. requires demonstration and substantial long-term cost reductions achieved through a combination of technology advancement and learning rates.

Notwithstanding the recently released funding opportunity for component performance advancement, there is a critical need for a near-term, sustained and higher level of federal and private sector support for the marine renewables sector to maintain a viable technology pipeline and attract new, innovative entrants. Under the current level of support, potentially transformative concepts needed to reduce LCOE to the threshold required for large-scale adoption could lose their path to market and the industry will likely face significant contraction prior to a traditional technology convergence. However, increased levels of support will enable the industry to grow on the backs of demonstrated successes by marine renewables, and learning from various failures.

[10] Cost Reduction Pathways for Wave Energy, IEA-OES Annual Report 2012, pg. 108

Elements of Strategic Vision

A strategy is required to grow the industry and give DOE a credible path to bringing marine renewables "on roadmap" at utility scale. We suggest that this strategy should have the following elements.

Marine renewables are on the cusp of commercial viability in distributed settings where power is expensive (e.g., remote communities and industrial facilities, military facilities, aquaculture, desalination, offshore platforms, islands and urban centers with high power costs). These are distributed applications with broad potential for U.S. developers and represent near-term payoffs for private sector investment. Technologies that harness various marine energy resources have shown promise in this area, with current technologies closest to commercial viability in these markets.

With federal support, demonstrations in these early-adopter markets can lead to transformative reductions in LCOE. Commercialization in early-adopter, distributed applications is not the ultimate objective of most developers, nor can it be the ultimate objective of federal support. However, such applications can be a stepping stone to reducing LCOE (technology and "soft costs"). Demonstrations in distributed commercial markets will provide important opportunities for learning and advance technology towards viable utility-scale deployment in grid-connected markets. For example, solar PV initially developed in niche applications (e.g., space craft and satellites), grew into distributed markets (e.g., commercial roof tops), and matured into multi-MW commercial plants. Commercial demonstrations also provide industry with critical practical experience and the insight to recognize the potential impact of transformative technologies. The cost of demonstrating transformative technologies at commercially viable scale in these applications is generally lower than at utility-scale, both in terms of absolute cost and the political/social profile of failures.

Such early stage commercial demonstration support, perhaps modeled after the successful DOE Turbine Verification Program[11] (TVP), would reap many benefits. Because the TVP implementation occurred when the wind industry was more mature than the marine renewables industry is today, this would require a few important adjustments to the program phase structure. For example:

- *Phase 1*: Support for demonstration of transformative technologies at test sites, such as what will soon occur at WETS.
- *Phase 2*: Support for demonstration of technology innovation for grid-tied markets in distributed settings (this has similarities to "Phase 3" of the TVP). DOE support could be commensurate to the level of innovation/risk being taken by the project developer. These demonstrations are an opportunity for companies to showcase their technology in cost-competitive applications, to build their supply chains and to show initial commercial revenue streams.
- *Phase 3*: Support for demonstration of proven technology in grid-tied markets in cooperation with large utilities. In absolute terms, DOE support would still be substantial (as it was in the TVP), but would be relatively lower as a percentage of total project cost.

The benefits derived from this type of program would be substantial.

- Experience in distributed markets builds public acceptance for utility-scale adoption of marine energy technologies in a way that research and development cannot.

[11] Calvert, Goldman, DeMeo, McGowin, Smith, and Tromly (1997) The EPRI/DOE Wind Turbine Performance Verification Program, NREL Technical Report, NREL/CP-440-22486.

- Demonstrations of a broader set of technologies can identify and address problematic "soft costs" prior to technology convergence, when "soft costs" may be locked for a particular technology.
- Demonstrations in distributed markets allow practical resource estimates to be credibly refined in utility-scale markets.
- Commercial projects in distributed markets will need to demonstrate multi-year longevity – this is difficult to do at test facilities with a limited number of berths.
- Demonstration in new environments invariably identifies new technology and operational challenges to be overcome.

Overall, commercial demonstrations of transformative technology in distributed markets can significantly advance Technology Readiness Levels and Technology Performance Levels.

In parallel, DOE should continue to support transformative technology and component developments that can be game-changers in utility-scale markets. Large-scale adoption of marine renewables in the U.S. will likely require LCOE of $100/MWh or lower. The development of new technologies is likely critical to achieving these cost levels. Test facilities must remain an important part of this strategy, but distributed markets could provide early commercial markets to accelerate technology development and convergence, ultimately leading to earlier entry into utility-scale markets.

Tidal, ocean, and river currents should be considered as an aggregate current resource. The first-generation DOE resource assessments indicate that the aggregate potential of tidal, ocean, and river currents is significant. These resources also have high predictability and the persistence of river and ocean currents allows them to offset traditional baseload power generation without energy storage. The technology to harness tidal, river, and ocean resources is fundamentally similar (some developers operate in all three spaces). Support for commercial demonstrations in distributed markets can substantially advance this technology and establish a near-term, self-sustaining market in the U.S.

Current resources are more difficult to assess than the wave resource[12] and the results of the first-generation resource assessments for currents are likely to have high, unquantified uncertainty. Second-generation assessments that are able to apply new understanding to specific regions are likely to result in an upward revision to these estimates. This follows a similar trajectory to U.S. wind resource assessments, which were revised upwards each time the wind resource was evaluated using improved methods, resulting in a vastly different market outlook for wind today than when the sector began development. Similarly, while wind resources were initially considered to be geographically specialized (e.g., California, Texas), technology advancement has allowed economic wind energy development in almost every state. Technology advancement will expand the technically available resource for all types of currents and, in particular, advances in river current technology may produce economic opportunities in every state.

The industry recommends that DOE begin developing second-generation resource assessments for both waves and currents that reduce the unquantified uncertainties in the first-generation assessments and address concerns about resource comparisons raised by the National Research Council's review of the

[12] Unlike wave resources, assessing the theoretical potential of current resources requires an accounting for "back effects" from power generation at a regional scale.

first-generation assessments. These assessments could build on existing efforts by DOE and NREL to characterize early-market marine renewable energy sites.

DOE should support development of wave and current energy, but allow for strategies that accommodate the relative maturity of each resource. Both of these are pre-commercial renewable energy technologies operating in the marine environment. There are a number of areas of overlap and opportunities for innovation to reduce marine project costs for both technologies, particularly “soft costs”. However, harnessing fundamentally different resources results in fundamentally different challenges to overcome.

Wave energy development requires dedicated test facilities and sufficient funding to support rapid innovation. The LCOE of existing prototypes is higher for wave than for current technologies, which are generally considered closer to technology maturity[13]. This is largely driven by current technology’s ability to leverage investments made into wind technology over the past decades.

The relative commercial maturity and baseline LCOE of current energy conversion systems relative to wave energy conversion systems would influence their general entry points into the variant of the Turbine Verification Program described previously. Initially, many wave conversion technologies would benefit from Phase 1 investment, while a number of current conversion technologies could pursue Phase 2 opportunities. This would also allow transformative technology developments to be applied to current energy without constructing MW-scale current test facilities in the U.S.

Common challenges for all marine renewable energy resources provide opportunities for cross-cutting advancement. Many of the challenges for reducing LCOE for wave energy share common elements with current technologies. These include technical challenges such as subsea electrical infrastructure/cabling, moorings, biofouling, materials, advanced controls, and contributors to “soft costs” such as permitting and environmental risks. Cross-cutting learning in these areas can come from the Program’s efforts to advance floating offshore wind energy, as well. Support for a broader range of marine renewable energy resources provides a broader base for innovation and demonstration around these shared elements. However, this cross-cutting advancement should complement necessary device-specific advancements.

Strategic Advantages

The advantages of encouraging distributed, commercial demonstrations in parallel with transformative technology development are substantial. Successful demonstrations in these markets help to deliver stakeholder confidence in a way that research and development cannot. These also offer private sector investors a near-term return on investment, which will increase their support for mid- and long-term investments in research, development, and demonstration alongside the Program’s efforts. In these distributed applications, marine renewables do not require an impractical level of public support to take the first steps towards broad commercial viability.

Test facility support is both a short term strategy to rapidly achieve commercialization of marine renewables, as well as a long term investment for honing a range of related activities and techniques (e.g. resource assessment techniques, moorings, observational technologies, environmental monitoring approaches, and infrastructure). In addition, continued design optimization and testing will be required

[13] For example, MeyGen, the first commercial scale tidal array in the UK, completed $82 M financing at the close of 2014 with a 10-year PPA for a 350-400MW commercial project, using Atlantis 1.5 MW as well as 1.4 MW Andritz Hydro Hammerfest turbines. Operation is to commence in 2016.

to improve performance and increase the endurance to meet long-term LCOE targets. Because of this dual function of test facilities, they will remain a key strategic tool for developing a viable and competitive U.S. marine energy industry.

If only partially successful (e.g., federal funding is reduced before utility-scale marine energy can be realized), this approach could still result in a commercially-viable distributed market that can sustain the knowledge base and human capital in the marine renewables sector for the future, rather than stranding investments. If fully realized, this strategy would produce a vibrant marine energy industry in the U.S. that supports thousands of long-term jobs and provides clean, predictable, and renewable electricity for residences and businesses as an important part of a diverse, sustainable portfolio.

Conclusion

Marine renewable energy resources have the potential to provide cost-effective, reliable, carbon-free electricity and much-needed jobs in coastal and urban communities, as well as a robust worldwide market for job-creating export of U.S. goods and services.

Key Considerations

- The Levelized Cost of Energy (LCOE) analysis presented by the Program in November 2014 is too conservative. The industry recognizes that LCOE analysis for emerging industries is extremely difficult and has made several suggestions for a more rigorous, revised analysis that supports a lower LCOE.
- The industry recommends that the Program should begin to develop second-generation resource assessments to address unquantified uncertainties in the first-generation assessments.
- Both wave and current resources can meaningfully contribute to a sustainable energy future. However, the relative disparity in technical maturity between waves and currents requires different approaches for Program support of these generation technologies.
- DOE should support the commercial demonstration in distributed markets of technologies that can be game-changers in utility-scale markets. This support could be modeled after elements of the successful DOE Wind Turbine Verification Program and structured to account for differences in the market readiness and availability of test facilities for wave and current energy technologies.

Recommended Next Steps

To be coordinated by the National Hydropower Association's new Marine Energy Council in conjunction with the Water Power Program:

- *Revise the LCOE analysis.* The industry recognizes that this is a difficult task and looks forward to supporting the DOE efforts in this area. In addition to the points made in this response, the industry could offer its perspectives on learning rates and the potential for LCOE reduction through specific, transformative technology developments.
- *Begin a visioning process for marine renewable energy*. The use of commercial demonstrations in distributed markets to realize the long-term potential of marine renewables is one element of this strategy. Developing a cooperative vision for the future of the marine renewable energy (and a well-defined roadmap to achieve this vision) is as a high priority for the U.S. marine energy industry.

Subject: Response to Industry Feedback

First, thank you to all the organizations and individuals for taking the time to review the material from the November 2014 meeting and for providing a unified industry voice in the feedback. Your efforts are very appreciated by the Water Power Program.

The Program echoes your sentiments that the state of marine and hydrokinetic technologies are at a critical phase. Moving forward, we plan to develop a robust strategic roadmap with active engagement between industry and DOE.

Below we have outlined a response to the industry feedback. There are many areas where we have agreement and some areas where more dialogue is needed.

Informing Program investments and adjustments to Levelized Cost of Energy Analysis:

- Cost Reduction Pathways (CRPs): Prioritizing the CRPs is an area stakeholders are encouraged to provide feedback to the Program on. The Program has already focused funding opportunities on the CRPs identified in the Sandia CRPs whitepapers[1]. Last year, the Program updated the CRPs to inform future planning and requests feedback from industry on the relative impact of Program investments in each of these CRPs to address cost drivers and bring down the cost of energy. Please see the attached "LCOE Analysis Handouts" for the wave and tidal CRPs (bulleted lists for AEP, ICC and O&M).
- Baseline LCOE: In order to adjust the baseline cost, the Program needs data that provide a credible reflection of the cost of technology once built out at full scale in commercial arrays from developers in the industry. The DOE cannot defend energy policies such as tariffs and contracts for difference as credible data sources to inform a statement on the cost of the state of the art of technology today.
- LCOE Working Group: The NHA's recently formed Marine Energy Council may consider launching a LCOE Working Group in collaboration with NREL to collect and aggregate data from U.S. developers on a voluntary basis to establish a baseline cost for consideration by the Program in updating its current analysis.
- The feedback on Cost Reductions Pathways, and aggregated LCOE data will be delivered to DOE by June 30, 2015, if they are to contribute to updates in the Program's strategy and reports.

Vision for Strategic Direction of Marine Renewables in the U.S.:

- The Program agrees that it is important to develop a strategic roadmap with support from industry and the government, but the success of a Vision effort relies greatly on the availability of data. A MHK Vision should be a long-term goal, but in the interim, DOE and the industry should focus on building a functional framework for the exchange of analytical assumptions and data, starting with the baseline LCOE data.

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[1] http://prod.sandia.gov/sand_doc/2013/137203.pdf; http://prod.sandia.gov/sand_doc/2013/137204.pdf; http://prod.sandia.gov/sand_doc/2013/137207.pdf; http://prod.sandia.gov/sand_doc/2013/137205.pdf

- The Program recognizes the importance of strategic planning and has conducted or is currently conducting the following activities: Program Execution Planning, Techno-Economic Assessment, Quadrennial Technology Review, MHK Strategy Request for Information, Biennial Program Peer Review, and external merit review of new laboratory projects. The Program plans to continue encourage stakeholder feedback on strategic planning via stakeholder meetings and review of reports like the Quadrennial Technology Review.

IMREC Stakeholder Meeting

A DOE and industry stakeholder meeting, similar to the November 2014 meeting, will be held at the April 2015 International Marine Renewable Energy Conference. Stay tuned for an agenda and additional information. If you have topics that you would like to discuss at the meeting, please send them to Ron Smith (rsmith@verdantpower.com) by April 17th.

Looking forward to seeing everyone at IMREC!

Alison LaBonte

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