IGP Solution Evaluation & Optimization Working Group: Offshore Wind Study

Meeting Summary (January 22, 2021)

Under an interagency agreement with the Bureau of Ocean Energy Management (BOEM), the National Renewable Energy Laboratory (NREL) is conducting a study to evaluate the cost of implementing floating offshore wind near Oʻahu. This effort will be based on NREL's Offshore Regional Cost Analyzer (ORCA) model using up-to-date floating offshore wind technology information. As part of an effort to tailor the ORCA cost model assumptions specifically to Hawaiʻi, BOEM and NREL sought input from the Solution Evaluation & Optimization Working Group (SEOWG) and Stakeholder Council for the Hawaiian Electric Company, Inc. (Hawaiian Electric) Integrated Grid Planning (IGP) process.

The SEOWG and Stakeholder Council were convened on January 22, 2021 via WebEx, with a technical presentation provided by NREL and a guided discussion to obtain stakeholder input. There were approximately 60 participants; the list of participants is included at the end of this summary.

INTRODUCTION

Opening remarks were provided by Colton Ching, Senior Vice President of Planning and Technology for Hawaiian Electric. He explained that the meeting with the IGP SEOWG and Stakeholder Council was convened based on an opportunity identified by the Hawaiʻi State Energy Office (HSEO) through coordination with BOEM and NREL on their floating offshore wind study for Hawaiʻi. Recognizing the potential value of the study analysis and results to the IGP process, HSEO also wanted to support NREL's efforts to incorporate stakeholder input into the study. Hawaiian Electric agreed that the SEOWG and Stakeholder Council would be an appropriate forum to seek stakeholder input, based on the existing framework and technical background of the various stakeholders. In turn, NREL's study is expected to provide valuable information for development of the generation resource portfolio for the IGP process.

Colton then introduced Scott Glenn, Chief Energy Office for HSEO. Scott provided further background, explaining that HSEO has been actively monitoring developments related to offshore wind, and recently met with BOEM and U.S. Department of Energy (DOE) staff to discuss offshore wind and other energy resources in Hawaiʻi. He explained that although offshore wind is specifically identified as a resource option in Hawaiian Electric's Power Supply Improvement Plan (PSIP), there is not a clear pathway to permitting and building an offshore wind facility in Hawaiʻi. Although there are still many issues that need to be resolved at both the federal and state level, HSEO is focused on ensuring there is adequate due diligence regarding both the technical and permitting aspects of offshore wind. Since being contacted by BOEM and NREL regarding the floating offshore wind study in Hawaiʻi, HSEO has helped to provide input on the scope of work and coordinate with Hawaiian Electric. Scott reiterated that this coordination, along with stakeholder input, will help NREL improve their cost assumptions and model analysis for Hawaiʻi, thereby resulting in information that is more useful for IGP and other renewable energy planning efforts.

Scott introduced Matt Shields, Offshore Wind Analyst with NREL, and explained that he would be providing a technical presentation of the specific study tasks and cost model customization, interspersed with opportunities for discussion. Scott emphasized that the intent is to provide an opportunity for stakeholders to engage directly with NREL to share their expert knowledge and provide input to the cost modeling process.

PROJECT SUMMARY

Matt began by providing an overview of NREL, explaining that it is one of 17 national labs under the DOE operating budget and the only one exclusively focused on renewable energy. NREL is fundamentally a research organization, but partners with industry, academia and government organizations to advance renewable energy and help bring technologies to market in the most efficient manner possible. Their offshore wind program has been in place for approximately 20 years, and addresses the technological, economic, and social feasibility of offshore wind in the U.S. He noted that the program has recently been focused on floating offshore wind, which is a good fit for potential projects in Hawai‘i.

As part of the study funded by BOEM, NREL is tasked with using the ORCA model and current technology information to evaluate the cost of implementing floating offshore wind in Hawai‘i. In addition, NREL will produce visualization materials to convey the current state of floating offshore wind technology. The resulting information will be integrated into the NREL and HSEO visualization tools (Engage and Cambium). The study results will also be provided to Hawaiian Electric and the broader public through a final, published report. Matt then provided additional details regarding the scope of the cost model and explained that the analysis will include the resource area surrounding O‘ahu. He stressed that the study does not involve development of a specific project, nor identification of when, where, or how an offshore wind project will be built in Hawai‘i. The study also does not include detailed environmental, social, cultural or workforce development studies, nor identification of preferred vendors, suppliers, operators, or labor. Furthermore, he noted that the study will not address the impact of offshore wind on ratepayers.

Matt then explained that the goal for the meeting is to discuss the cost modeling approach and the specific assumptions that may be used to tailor the model to Hawai‘i. Following the meeting, NREL will distribute notes to the participants for review and comment, to ensure that all input has been accurately captured. Matt also invited participants to reach out to him directly to share additional thoughts or feedback. He requested that all comments be provided by February 5, 2021 to allow NREL to finalize the modeling approach and cost assumptions by the beginning of March (per the deadline established with BOEM). He explained that stakeholder input will be incorporated into the model to the extent possible, but stressed that there may be some factors that cannot be quantified based on model limitations. However, input that cannot be incorporated into the model will still be discussed in the report.

Matt then provided an overview of the ORCA cost model, beginning with a description of levelized cost of energy (LCOE), which is the key metric used in the model. He explained that LCOE is an annualized value that incorporates both capital and operational expenses as well as energy production, thus providing a basis of comparison across projects with different capacities, technologies, and cash flow profiles. For the purposes of the current study, LCOE will be used to illustrate how cost and energy production varies around O‘ahu. He then described the various modeling parameters and how they can affect LCOE; these include technology and project characteristics (e.g., turbine rating, project size, and spacing), location characteristics (e.g., wind speed, water depth, distance to port, etc.), and time (e.g., anticipated changes in supply chain, technology innovations, etc.). He also provided an overview of the model structure, including the various spatial data and technology assumptions that are used as inputs.

Scott then asked for any questions or comments from the meeting participants. Questions and comments included the following:

- A participant stated his understanding that (1) the first time the general public will be allowed to comment is after the report has been finalized, and (2) that there would be no further opportunity for stakeholder input after February 5, 2021. Matt explained that NREL’s scope of work does not

include outreach to the general public. He emphasized the the study is not based on a specific project or location, but rather is intended to provide technical information. He noted that outreach to the general public typically occurs when a specific project is being considered. Matt also confirmed that February 5, 2021 is the deadline for stakeholder input to be considered in the modeling effort, based on the schedule established with BOEM. However, he explained that the draft report will be sent out for peer review and stated that there may be an opportunity for stakeholders to participate in the peer review process.

- A participant asked how the cost model accounts for different water depths. Matt responded that the model incorporates a variety of parameters that are influenced by water depth. For example, a project sited in deeper water may require more mooring lines and/or heavier anchors (which affect capital costs), but may also have stronger wind resource (which affects energy production). Matt noted that the report would include a discussion of senstivities as related to water depth.
- A participant asked if the model would produce a single LCOE or if the LCOE would vary based on different options. Matt explained that the model would identify LCOE on a grid for the entire resource area, resulting in a "heat map" that shows how LCOE varies spatially around O'ahu.
- A participant asked if the model allows for some sensitivity or scalability as related to project size and the number of landing cables needed to address reliability issues. Matt responded that the model can be used to run sensitivities, although some parameters are easier to address than others. It is relatively straightforward to run sensitivities for different project sizes; addressing different numbers of landing cables is more difficult based on the structure of the model. He noted that the report would discuss sensitivities for key parameters. As an example, he referenced a recent study conducted for California which included sensitives based on project size and location; a link to this study is provided in the slide deck.

TASK LIST, SCOPE OF WORK, AND DELIVERABLES

Matt then briefly reviewed the specific tasks in NREL's scope, including (1) coordination and interaction with BOEM, Hawaiian Electric and HSEO; (2) customization of the cost model; (3) cost modeling results; (4) incorporation into Engage/Cambium visualization tools; (5) conceptual floating wind graphics; and (6) reporting and dissemination. As part of these tasks, Matt explained that the ORCA model will be populated with current information, including market prices and technology trends, and will be further customized for Hawai'i based on stakeholder input. The model will be used to generate LCOEs for the resource area surrounding O'ahu (both for the baseline year as well as for future conditions); in addition, a more detailed cost breakdown will be generated for three specific study areas. The results will be compiled into a draft report, which will be circulated for peer review. The final report will be published and made available to the general public. He reviewed the schedule for these tasks, including key deadlines related to customization of the cost model (March 9, 2021), preparation of the draft report (July 9, 2021), and completion of the final report (October 9, 2021).

COST MODEL CUSTOMIZATION

Matt explained that the focus of the meeting is customization of the cost model for Hawai'i. In addition to identifying the specific study areas, NREL is seeking stakeholder input regarding five key assumptions in the model; these relate to the port facility, proximity to alternative supply chains, grid connections, wind resource, and hurricane risk. Matt then specifically discussed each of these factors; for each, he provided

background information and NREL's current understanding, an overview of how the assumptions could affect the cost model results, and specific questions to help solicit stakeholder input.

Study Areas

Matt reiterated that the cost model will be used to generate the LCOE across the resource area surrounding O'ahu, which includes the offshore waters between the 3-nautical mile mark (i.e., limit of state waters) and the 1300-meter depth contour. He noted that the study will not exclude any specific areas, such as those used by Department of Defense (DoD). He emphasized that NREL is aware of concerns about competing uses, such as those involving DoD, but explained that the study is intended to simply provide the LCOE for offshore wind around O'ahu (not to delineate specific project locations).

In addition to identifying the LCOE throughout the resource area, the study will also include a more detailed analysis for three specific study areas. Matt explained that the areas northwest and south of O'ahu have already been identified by BOEM as call areas (i.e. official regions of interest for development of offshore wind energy); as such, these have been included as study areas. Based on the wind regime, NREL is suggesting the area east of O'ahu as the third study area. He explained that these three study areas are expected to have substantially different LCOEs, based on differences in energy production, installation costs, capital costs, and operations and maintenance costs.

Matt then sought input regarding the three study areas, with specific questions related to particular sensitivities or other activities associated with these areas. For example, he noted that Ka'ena Point was previously identified as a culturally signficant area through outreach conducted by BOEM in 2016. He also acknowledged comments regarding potential conflicts with DoD activities. Questions and comments included the following:

- Scott noted that the study results are intended to be incorporated into HAVEN, which is an advanced visualization tool used by HSEO and Hawaiian Electric. He explained that HAVEN has not been actively used during the COVID pandemic, as it involves people gathering together around a table, but it will be reintroduced once there are no longer safety concerns.
- Scott noted the wind resource map shown in the slide deck is based on old data, and that updated information will be used for the study. Scott also conveyed a comment from a meeting participant that the two BOEM call areas shown on the map were identified based on unsolicited bids from offshore wind development companies. He stated that HSEO has not heard from the company that proposed the project near Ka'ena Point (north of O'ahu) since 2016, and suggested that this location may not be important to include as a study area.
- A participant asked if DoD issues such as training areas (ocean range, aircraft approach to training areas) and radar interference will be considered. Matt explained that the study is not intended to delineate or identify project locations, and therefore will not exclude specific areas used by DoD. However, these considerations would be noted in the report. The participant noted that at some point, DoD would like to provide information regarding sensitive areas (e.g., Navy activities above and below the water), but noted that this information cannot be shared publicly. Scott acknowledged the comment and noted that BOEM has been in contact with the Navy regarding these concerns. Necy Sumait, Chief of the Renewable Energy Section for BOEM reiterated that the NREL study is intended to provide cost information for the resource area. Moving forward, if there are specific areas that appear favorable for offshore wind, BOEM would conduct outreach and would specifically address competing uses (including DoD activities) at that time.

- A participant asked if the model incorporates bathymetry and topography (beyond just depth and distance from the shore). Matt responded that these factors are considered, but at a fairly coarse level. Specifically, the model addresses these factors by excluding areas with unsuitable slopes. However, modeling the impact on cost (e.g., differences in design or equipment) is beyond current modeling capabilities, in large part due to a lack of industry data associated with these conditions. Matt noted that these are considerations that can be discussed in the report.
- A participant asked if similar studies will be conducted for other islands or counties in Hawai‘i. Scott explained that the current scope does not include analysis for other islands, but noted that HSEO would welcome working with BOEM to analyze additional areas should there be available funds in the future. Another participant noted that in order to be cost effective, offshore wind projects must have a relatively large output (e.g., 400+ megawatts). As the neighbor islands do not need this much generation, offshore wind is not practical in these locations. Matt agreed that economies of scale are critical for offshore wind energy projects.
- A participant asked if the Governor’s office has been engaged regarding correspondence with other state agencies. Scott stated that HSEO has been engaging with other state agencies and they are aware of the study. He also noted that the Governor has engaged DoD to let them know he is interested in resolving issues related to the call areas.
- A participant stated that based on discussions with the developer that proposed offshore wind in the area near Ka‘ena Point (north of O‘ahu) as well as first-hand knowledge of the north shore community, there is no chance that an offshore wind project would be constructed in this location. As such, including a study area in this area would be a waste of funds.
- A participant asked if active controls (such as GPS positioning) could be more effective than using mooring lines. Matt responded that he is familiar with this technique, but believes it is a riskier technology and hasn’t gained much traction in the industry to date. In addition to the added cost and maintenance complexities, other issues may include changes in power production and potential effects on navigation. There is not yet definitive information indicating that active positioning would be cost competitive or more effective than mooring lines (or other passive connections). The participant suggested that active controls could allow for wind energy facilities to be sited in depths greater than 1300 meters. Matt stated that this may be possible, noting that research is starting to focus on wind energy technology in deeper waters. However, the current thinking is that the use of mooring lines at depths up to 1300 meters is not unrealistic.

Port Infrastructure

Matt explained that in 2016, BOEM commissioned a study to identify ports that could be used for offshore wind along the west coast and Hawai‘i (based on requirements related to accessibility, staging and storage, assembly/manufacturing capabilities, navigation channels and air draft, and availability). This study identified two facilities that could potentially be used to support offshore wind in Hawai‘i — Honolulu Harbor and Barber’s Point (Kalaeloa) Harbor.

NREL plans to review the 2016 BOEM study and other available literature to better understand the characteristics and limitations of these ports, as well as to identify upgrades that would be needed. They also plan to discuss the options with the State of Hawai‘i Department of Transportation (DOT). For purposes of the model, a single port would be selected to support build out of an offshore wind facility at any given location within the resource area. It is possible to consider ports on other islands, but the current understanding is that either Honolulu Harbor or Barber’s Point (Kalaeloa) Harbor would be the

most suitable option. Matt explained that the port selection will affect LCOE primarily through changes in installation and O&M costs based on distance between the project location and the port. Matt noted that the model will not include the cost of port upgrades, workforce/job development, or detailed installation logistics; however, these requirements would be discussed in the report, as appropriate.

Matt then sought input from the participants regarding selection of the port for model purposes. In particular, he asked about previous discussions of ports for offshore wind, limitations of the existing facilities, other major users, and preference for use of an O'ahu port over ports on neighbor islands (e.g., to keep jobs and benefits on O'ahu). Questions and comments included the following:

- A participant asked for clarification as to whether the study would be conducted for a single port or for both ports. Matt confirmed that the study would be conducted for one port, and reiterated that NREL is seeking feedback regarding which port should be assumed for purposes of the study.
- Scott stated that the Na Pua Makani project, an onshore wind project recently constructed on the north shore of O'ahu, used the Barber's Point (Kalaeloa) Harbor. He asked Colton to share information about why this harbor was selected. Colton explained that the decision to use Barber's Point (Kalaeloa) Harbor for the Na Pua Makani project was made by the project developer. However, based on the challenges faced by Na Pua Makani as well as other onshore wind developers in Hawai'i, Colton suggested that key considerations for offshore wind will include draft, linear length of dock-side facilities, logistical and transport capabilities, space for offload and assembly, and utilization time. He emphasized the importance of engaging HDOT, including Harbors Division. This comment was reiterated by multiple participants.
- Cameron Black, who serves as HSEO's liaison to HDOT Harbor Division, noted that HDOT is contemplating upgrades to Honolulu Harbor and provided a link for more information regarding the master planning effort (https://honoluluharbormp.com/). He stated that he is not sure the extent to which the potential upgrades could support offshore wind, but emphasized the value of early coordination with HDOT Harbors Division. Scott offered to connect NREL with HDOT Harbors Division staff (Derek Chow).
- A participant stated that the 2016 BOEM study concluded that Barber's Point (Kalaeloa) Harbor is most suitable to use for offshore wind; other participants expressed support for selecting this port for the model. Others referenced ongoing discussions about the best uses for this facility, noting the possibility of updates to the master plan. As such, there may be an opportunity to incorporate potential plans for offshore wind, underscoring the value of consultation with HDOT.

Grid Interconnection

Matt explained that for grid interconnection, each location within the resource area may have its own unique landing point for the export cable, but it is assumed that the export cable would interconnect with existing electrical infrastructure (e.g., power plants or substations). He acknowledged the complexities associated with grid interconnection, but explained that the intent is to identify facilities that could be reasonable points of interconnection. He noted that interconnection of offshore wind via an existing power plant could allow for that facility to be taken offline. As such, the existing coal-fired power plant (which is planned to be retired in the near-term) could be a good option. He also explained that although none of the existing substations are likely to have enough capacity to accommodate an offshore wind project, there is a cluster of substations on the east side of the island that could be possible interconnection points.

To identify the interconnection point(s) for the model, NREL plans to review the existing grid infrastructure in greater detail, then discuss with the Hawaiian Electric team. Based on preliminary information, Matt suggested that a possible solution could be to assume that any offshore wind project on the east side of Oʻahu would interconnect at one of the nearby substations, while any project on the west side of Oʻahu would interconnect at the coal-fired power plant. He explained that grid interconnection can have a significant impact on cost, as these components represent approximately 13 percent of the LCOE (primarily based on distance between the project site and the point of interconnection). Matt noted that the model will account for the cost of the export cable up to the point of interconnection, but will not include the cost to upgrade or construct new interconnection or bulk transmission facilities; these requirements would be noted in the report, as appropriate.

Matt then sought input from the participants regarding the grid interconnection assumptions for the model, with questions related to specific interconnection points (e.g., power plants or substations), planned upgrades or retirement of existing infrastructure, preferred/suggested project capacities, and estimated transmission/substation upgrade costs. Questions and comments included the following:

- A meeting participant referenced a previous study that identified Iwilei as a good point of interconnection. In addition to wave energy, the analysis also considered debris/garbage, slope, and existing paths through the reef. This location also provides a link to downtown Honolulu.
- Colton explained that previous studies involving off-island generation focused on interconnection at the transmission level (which on Oʻahu is the 138kV system), as this would allow for a more robust and reliable connection. These studies did not consider interconnection at the sub-transmission or distribution level because these components are in a radial configuration and are less robust. In addition, the focus was on interconnecting on the eastern side of Oʻahu because the transmission system in this area is closer to the load centers. He explained that this approach would require expansion of the existing transmission substation (Koʻolau substation), but would improve power flows and reduce the likelihood of overloading the transmission system (as there is no existing generation on this side of the island). He stated that this approach isn't the only option, but was the focus of past studies.

  Colton also explained that Hawaiian Electric's system is designed to withstand the loss of 180MW per load, but there is an effort to reduce this to 135MW to improve reliability as more inverter-based generation comes online. Therefore, it is important that any offshore wind facility is designed in way such that no single component could result in a loss of more than 135MW.

  Matt asked if the preference would be to have a single export cable brought onshore then split to different substations, or to have multiple export cables. Colton stated that the previous study focused on one export cable connecting to the Koʻolau substation and a second cable connecting to Iwilei. In addition, the study evaluated the option of connecting two lines at each location. Matt asked whether the previous study was publicly available; a participant responded that the study is publicly available and was authored by Dave Corbus (NREL).
- Scott referenced ongoing efforts to enhance overall resilience. He reiterated that there is not any utility-scale energy generation on the east side of the island, so interconnection of an offshore wind facility could increase resilience of the overall electrical system. He also referenced ongoing discussions related to energy justice, which are focused on ensuring that energy generation is distributed around the island such that communities with existing fossil fuel power plants do not continue to be unfairly burdened.

Matt noted the preference for interconnection on the south and east sides of island (as opposed to a power plant on the west side). He also referenced a comment from a participant that adding generation to the west side of the island would increase congestion of the transmission system (presumably due to the number of power plants in this area). He asked, if an offshore wind project were to be located south or west of O'ahu, whether it would be realistic from a grid resilience and energy justice perspective to run a longer export cable to Honolulu or the east side (as opposed to a shorter connection to a power plant on the west side).

- A meeting participant referenced the need to limit losses to less than 135MW per load to improve reliability, noting that this would require at least three export cables for a 400MW project. He referenced Campbell Industrial Park as a good example, noting that this area has approximately 400MW of generation with three lines (located along two separate routes). In the case of an offshore wind facility, this could mean running two lines to Iwilei and an additional line(s) to another location; however this approach would increase the total cost of the project. Matt agreed that this would significantly increase costs; however, he emphasized that the purpose of the study is to objectively report the potential costs so it is best for the model assumptions to reflect the grid requirements. He also noted that it is possible to run a sensitivity analysis based on the number of cables, as well as to qualitatively explore other trade-offs (e.g., increased confidence for project developers). Scott noted that it may be possible for the discussion to also reference grid upgrades that would be needed for the different options.
- Colton emphasized that the model involves a finite scope based on a set of assumptions; however, this will not necessarily encompass the entire range of possibilities. He also reminded the group that regardless of which interconnection point(s) are assumed, the cost will not include upgrades or expansion of land-based infrastructure needed for interconnection. These costs will still need to be determined, but may be considered in a limited fashion as part of the IGP process. The goal should be to use develop a reasonable assumption regarding the number of interconnection points to facilitate NREL's study, then to link the results with the IGP process.
- A participant emphasized the value of this study as an early stage analysis, and expressed support for evaluating all three study areas, each with specific interconnection point(s). The study should not rule out any of the fairly limited options in order to provide comparative value and offer the most flexibility. Matt stated that it is well within the scope of the study to customize the interconnection point(s) for each study area. He noted that based on the modeling approach, the results will not substantially differ between interconnection points that are close to one another (e.g., two different substations on the east side of the island). Rather, it is more important to focus on refining assumptions that involve major bifurcations in the point of interconnection (e.g., Ko'olau substation versus Iwilei) to make sure they are reasonable, while also considering grid resiliency and energy justice issues.
- Scott recalled that the PSIP contemplated approximately $200M in grid upgrade costs for offshore wind, and asked Colton if this estimate is still valid across the range of locations being considered. Colton stated that he thinks as long as a reasonably consistent assumption is used, it shouldn't matter as the focus of the NREL study is on the relative pricing difference. The cost of the land-based infrastructure will be significant, and will likely differ by location and capacity. Estimated costs can be incorporated into the IGP process, based on assumptions about the interconnection point. He emphasized that resource planning typically does not identify specific site(s), but includes rough cost estimates based on project sizing and timing.

Supply Chain

Matt explained that the model generally assumes that the project components, particularly the platform and floating substructure, would be obtained from a U.S. supply chain. However, Hawai'i is in a unique position as it is proximate to manufacturing hubs in both the U.S. and Southeast Asia. Demonstration projects and full commercial scale pipeline development is occurring in areas such as Japan, China and particularly South Korea. He explained that it may be possible to reduce project costs by sourcing components from Southeast Asia. He then described a floating offshore wind project that is currently being installed off Scotland. For this project, the platforms are being built in Spain then barged to the Netherlands, where the turbines are mounted on the platforms; the assembled components are then wet-towed to Scotland. This indicates that it is not unrealistic to assume that assembled components can be wet-towed through relatively unprotected waters. As such, he stated it may be worth considering whether a Southeast Asian supply chain could reasonably be used for an offshore wind project in Hawai'i (e.g., platforms built in South Korea then barged to a port on O'ahu for assembly).

NREL plans to review the existing literature and to reach out to industry contacts to better understand the cost benefits and a potential scaling factor for the capital cost of a substructure build outside a U.S. supply chain. The modeling results could be presented as a sensitivity analysis of the potential cost impact of sourcing from an alternate supply chain. Based on preliminary information, it is somewhat speculative whether a Southeast Asian supply chain would make sense for a project in Hawai'i, so NREL doesn't want to commit to this as the best approach to building a project in Hawai'i. However, given the potential cost savings, the study will seek to at least provide information regarding the potential impact of a Southeast Asian supply chain with regards to cost, logistics and other related considerations.

Matt then sought input from the participants regarding the supply chain. In particular, he asked about the importance of local content to the viability of offshore wind in Hawai'i, as compared to lower cost supply chains. He noted that offshore wind development on the east coast is heavily driven by local content. He noted that there are complexities for Hawai'i, as a Southeast Asian supply chain would involve sourcing a significant amount of fabrication to another country; however, it may not even be possible to build these components in Hawai'i due to space constraints. Questions and comments included the following:

- Scott stated that he doesn't think the Jones Act is a major concern, but noted that it should always be considered when discussing supply logistics. He recommended that NREL review the requirements of the Jones Act, noting that anything that doesn't comply would need to be struck from the study. Matt responded that if a Southeast Asian supply chain is used, it is assumed a foreign vessel would deliver components from an overseas port to Honolulu, but would not be used for the installation. The assembled substructure would be towed out to the project site with a U.S.-flagged tugboat or similar. This arrangement is expected to comply with the Jones Act. Issues with the Jones Act would arise if a foreign-flagged vessel is used to transport components back and forth between the local port and the project site.
- Scott asked for clarification as to what is meant by "local content," noting the presentation referred to workforce training, investment, and manufacturing. He explained that Hawai'i doesn't have a substantial manufacturing industry (at least the type of industrial manufacturing needed for offshore wind). Matt explained that local manufacturing is the most significant component; other examples include job creation (both construction and service operators). He asked whether it is even realistic to even assemble a substructure on O'ahu, or if it would need to be built offsite and towed to O'ahu. If not realistic, then the follow-up question is whether there is a preference for the substructure to be built on the U.S. mainland versus Southeast Asia.

- A participant expressed that it is vitally important to build as much local capacity as possible into any offshore wind project. Although some of the required activities may not be currently conducted in Hawai'i, there is still a substantial period of time to conduct training and build capacity before any project would be implemented. Matt provided examples of different types of capacity building that has occurred on the mainland, including community college training programs and university degrees to develop a pipeline of workers, and expanded manufacturing capability. He asked if these types of interest and involvement are envisioned for Hawai'i. The participant stated that COVID has underscored the need for a more diversified economy in Hawai'i, such that the full range of opportunities should be considered. Scott confirmed that workforce development is a high priority for the state. He also reiterated that manufacturing opportunities are limited (due to the cost of importing raw materials), but indicated there would be support for any types of jobs that can be based in Hawai'i with adequate training programs.

  Matt noted that this issue is also tied to the questions about the ports, as building local capacity for fabrication and manufacturing of project components would also depend on having adequate space and investment in the port infrastructure. He noted that this would be addressed as part of the consultation with HDOT Harbors Division.

- Scott noted that it would help to better understand the types of jobs that could be created to support construction. Matt responded that the exact type and number of workers needed for construction is not well understood as a commercial-scale floating offshore wind project has yet to be built. Based on demonstration projects, construction of a single turbine has required a couple dozen workers approximately 3-6 months to complete. These include manufacturing jobs (e.g., welding, steel rolling, painting, electrical work), as well as crane and vehicle operators. He emphasized that there are still many unknowns regarding the requirements to commercialize floating offshore wind technology.

- Colton noted that this is not a question of all or nothing, and the reality is that construction of an offshore wind project would likely involve some degree of local content. For now, the focus is on providing a reasonable assumption for the study. He emphasized that the study provides value just by raising awareness of the relationship between offshore wind and local employment, helping to explore the benefits, as well as documenting the rationale of decisions made for the study. Other meeting participants noted that the study will play a vital role in helping people to understand the various dynamics.

Hurricane Upgrades

Matt explained that because Hawai'i has previously been affected by hurricanes, it may be prudent for the model to assume a hurricane-class turbine design (i.e., a more robust turbine that can withstand loads associated with high winds and storm surge). This design approach may not necessarily be justified based on the frequency of storms, but is an option that can be considered. He emphasized that the study does not include a detailed design effort or a detailed risk assessment of hurricane frequency or magnitude.

NREL plans to consult with climatologists at NOAA to better understand hurricane risk, as well as with turbine manufacturers to evaluate if a hurricane-class turbine design is justified. If so, a cost premium (e.g., a multiplier) would be assigned to the turbine cost based on industry information and a high-level analysis. This assumption could have a significant impact on LCOE, as the turbines make up nearly 20 percent of the overall cost. Matt emphasized that the intent is not to provide a definitive assessment of hurricane risk, but rather to make the relevant information available and account for the costs as needed.

Matt then sought input from the participants regarding the extent to which other infrastructure projects (e.g., harbors, buildings, ports, etc.) have been designed for hurricane resiliency and whether there is a local perception that hurricanes are a significant risk. Questions and comments included the following:

- Scott commented that the map of previous hurricanes included in the slide deck does not show Hurricane Douglas, which was a Category 4 hurricane that came within one mile of Honolulu in 2020. In addition, several years prior, there were five active storms within a short period of time. Collectively, these recent storms further demonstrate the risk of hurricanes in Hawai'i. He also discussed the potential damage that can be caused by a hurricane, particularly to airport and harbor facilities, which in turn disrupts the logistics chain for the entire state.
- Scott asked the extent to which climate change will be factored into the model. The analysis of climate change in Hawai'i indicates that the ocean water will get warmer, trade winds will decline, and hurricanes will occur more frequently. Matt responded that the wind resource data is a hindcast dataset, and isn't used to project wind resources into the future; the model is inherently limited in that it does not consider climate change. The approach currently used in the industry is to overdesign certain components to account for changing conditions; however, there are no consistent design standards or best practices. Overall, this has resulted in more expensive and less efficient projects over the short term.
- Henry that stated that an issue that has been raised by the community is that the safety manuals are not publicly available; specific concerns include the potential impacts of a turbine losing a blade. Matt asked what aspects are considered to be a risk (e.g., environmental impacts, floating debris, impacts to marine vessels, washing ashore, or other). Henry responded that all aspects are concerning. Matt stated that a potential tradeoff of a higher cost premium for a hurricane-class turbine design could be increased community confidence that these impacts may be avoided.
- A participant commented that sea level rise should also be considered as part of the planning process, particularly the extent to which it may affect the cable landings. Scott indicated that since the model doesn't specifically address sea level rise, it may be prudent to apply a cost factor (with a description of the uncertainties covered by the cost factor included in the report). He suggested that it would also be good to assume the use of hurricane-class turbines, as he thinks that this type of major infrastructure should account for the possibility of hurricane.

  Colton agreed and noted that various industries are working toward more resilient systems, especially for long-lived assets. He also explained that another reason that hurricane-class turbines should be used is that loss of generation from an offshore wind facility (which could provide as much as 20-30% of energy production for O'ahu) would significantly complicate hurricane recovery. Matt underscored this point by noting that it could take a significant amount of time to get the necessary vessels to bring an offshore wind project back online after a hurricane due to logistical complexities.
- A participant asked if the turbines need to be brought to port for repair. Matt said that this question is not entirely settled within the industry, but the working theory is that it is potentially cheaper to bring a turbine back to port using a tugboat or small local vessel for a major repair (e.g., changing out a gear box, generator, or blade). The advantage of this approach is that wind turbines installation vessels would not be needed, as these are quite expensive and are not readily available. Standard maintenance and minor repairs (e.g., resetting breakers, blade repair, etc.) could likely be performed at sea.

- A participant asked if the costs include decommissioning at the end of a project's useful life. Matt confirmed that decommissioning is included in the overall cost. He explained that the model does not include a detailed cost breakdown, but includes decommissioning as a percentage of capital expenditure.

Matt asked for any additional feedback regarding aspects of the market in Hawai'i that would significantly impact the cost of floating offshore wind, or any other topics of interest that were not previously covered. He also invited participants to follow up with him directly prior to February 5, 2021. No additional comments were provided at that time.

Scott concluded the meeting by stating HSEO was appreciative of the opportunity to work with NREL to obtain updated resource information and cost modeling results for consideration as part of the ongoing discussion of floating offshore wind in Hawai'i. He stated that HSEO will continue to work with NREL, and encouraged stakeholders to reach out directly to NREL or HSEO with any additional comments.

Comments submitted following the meeting included the following:

- A participant asked if the cost of disaster recovery is captured as part of the operations and maintenance cost or if this is instead addressed through insurance. He noted that at one time, a wind developer indicated an insurance requirement to keep a crane onsite for repairs in order to minimize disruption of revenue. Matt responded that disaster recovery is not included in the operations and maintenance cost, and to the best of his knowledge is addressed through insurance. However, it is not known whether this would extend to cover port infrastructure repairs in the case of a disaster.
- The participant also stated that port repairs would require that the port facility and necessary infrastructure is available. This might not be feasible unless there is an ongoing use for the facility and infrastructure that keeps the business afloat. The participant noted that the Navy might have the ability to assist, but their facilities are almost always occupied by vessels and tended by either government workers or a private contractor. The participant asked if there are data regarding how long it would take to restore to service following a hurricane. Matt stated that he is not aware of any data regarding post-disaster recovery, mostly because the bulk of offshore wind has been installed in northern Europe and has not been subject to hurricane-type conditions. He stated that he does not know of any offshore wind project that has been taken offline for an extended period of time due to hurricane damage, and noted that this is an issue that needs to be further investigated for Hawai'i.

ACTION ITEMS

- NREL to send meeting notes to participants; feedback and comments due to NREL by February 5, 2021
- HSEO to connect NREL with HDOT Harbors Division staff (Derek Chow) to discuss the existing port infrastructure and potential use for future offshore wind projects
- NREL to follow up with Hawaiian Electric to further discuss existing power plants and substations that may be used for interconnection

REFERENCE DOCUMENTS

- List of Attendees
- Meeting Presentation

LIST OF ATTENDEES

Name	Affiliation
Alex de Roode	County of Maui
Amanda Yano	Hawaiian Electric
Audrey Newman	Sustainable Molokaʻi
Billy Wooton	Hawaiʻi State Energy Office
Brian Lam	Hawaiian Electric
Cameron Black	Hawaiʻi State Energy Office
Chris Lau	Hawaiian Electric
Chris Yunker	Hawaiʻi State Energy Office
Christopher Kinoshita	Hawaiian Electric
Clarice Schafer	Public Utilities Commission
Colton Ching	Hawaiian Electric
Dale Murdock	Dale Murdock Consulting LLC
Darcy Endo-Omoto	Hawaiian Electric
David Parsons	Public Utilities Commission
Dean Nishina	State of Hawaiʻi Department of Commerce and Consumer Affairs, Division of Consumer Advocacy
Derek Stenclik	Telos Energy, Inc.
Donalyn Dela Cruz	Strategies 360
Douglas Boren	U.S. Bureau of Ocean Energy Management
Douglas Codiga	Schlack Ito
Earlynne Maile	Hawaiian Electric
Gerald Sumida	Carlsmith Ball LLP
Gil Riviere	Hawaiʻi State Legislature
Gina Yi	Public Utilities Commission
Grace Relf	Public Utilities Commission
Henry Curtis	Life of the Land
Hermann Kugeler	Makai Ocean Engineering, Inc.
Hugh Baker	HDBaker & Company Hawaiʻi LLC
Jacqui Hoover	Hawaiʻi Island Economic Development Board / Hawaiʻi Leeward Planning
Jay Griffin	Public Utilities Commission
Josh Steiner	Salt River Project
Keith Yamanaka	U.S. Army Garrison Hawaiʻi
Ken Aramaki	Hawaiian Electric
Kirsten Baumgart Turner	Hawaiʻi State Energy Office
Kurt Tsue	Hawaiian Electric
Kylie Cruz	Earthjustice / Blue Planet Foundation

Name	Affiliation
Lisa Hiraoka	State of Hawai'i Department of Commerce and Consumer Affairs, Division of Consumer Advocacy
Marc Asano	Hawaiian Electric
Marcey Chang	State of Hawai'i Department of Commerce and Consumer Affairs, Division of Consumer Advocacy
Maria Tome	Hawai'i State Energy Office
Matt Shields	National Renewable Energy Laboratory
Michael Laurienti	National Renewable Energy Laboratory
Michael Schwing	Hawai'i State Energy Office
Mike Wallerstein	Public Utilities Commission
Necy Sumait	U.S. Bureau of Ocean Energy Management
Noelani Kalipi	Progression Energy
Parker McWilliams	U.S. Bureau of Ocean Energy Management
Patrick Duffy	National Renewable Energy Laboratory
Pete Polonsky	Public Utilities Commission
Rene Kamita	State of Hawai'i Department of Commerce and Consumer Affairs, Division of Consumer Advocacy
Richard Argall	Makai Ocean Engineering, Inc.
Rick Rocheleau	Hawai'i Natural Energy Institute / University of Hawai'i
Rocky Mould	City and County of Honolulu
Sara Guiltinan	U.S. Bureau of Ocean Energy Management
Scott Glenn	Hawai'i State Energy Office
Steven Rymsha	Sunrun
Terry Surles	University of Hawai'i
Tiffany Byrne	National Renewable Energy Laboratory
Walt Musial	National Renewable Energy Laboratory
Will Rolston	Energy Island
Wren Wescoatt	Progression Energy