Floating Offshore Wind 101 Webinar Q & A

Cost and Economics:

Questions	Answers
Can you comment on the recent report which characterizes offshore wind in the US as too expensive? Is the industry positioned to counter that assertion?	Without being aware of which report is being referenced, recent cost declines in Europe which have been verified by NREL's analysis of the revenue generated from negotiated power purchase agreements for the first few U.S. offshore wind projects suggest that: 1. Offshore wind is no more expensive in the U.S. than in Europe 2. Offshore wind may soon be competitive in many electric markets, especially in the Northeast 3. Offshore wind may be able to provide additional benefits to the utility system – especially in constrained energy markets
For US utility-scale projects starting construction in the mid-2020s and later without the benefit of federal tax credits, what are the most likely financing schemes? Is PPA single owner the most likely, absent the past tax benefits for flip structures?	For early commercial-scale floating wind projects (e.g., in the mid-2020s), we expect project finance arrangements similar to today's financing of fixed-bottom wind projects in the U.S. The benefits of the fading tax credits will have to be compensated through other means (e.g., lower costs or technology-specific, state mandated PPA or OREC structures, possibly in combination with public financing institutions) to make projects bankable. Green Giraffe has recently summarized considerations for floating wind financing in a presentation, which could be helpful: https://green-giraffe.eu/sites/green-giraffe.eu/files/190611_2019_green_giraffe_fow_seminar.pdf
What is the projected cost per KWH to users?	This depends on the project specifics, location, and the expected commercial operation date (COD). In terms of Levelized Cost of Energy (LCOE) we estimate $5,355/kW (CapEx), $137/kW-year (OpEx), and $132/MWh for a commercial-scale floating offshore wind farm at a "typical" site along the Pacific Coast https://www.nrel.gov/docs/fy20osti/74598.pdf By 2030 (COD), we estimated the LCOE to decline to levels of approx. $60-80/MWh which is 6-8 ¢/kWh. See e.g., https://www.nrel.gov/docs/fy20osti/74597.pdf
Does the pricing (and pricing drops) include the US regulatory requirements for constructing such arrays?	Yes – the economic analysis accounts for the regulatory timelines and requirements. Of course, there is a lot of speculation here because no project has been built yet in Federal waters.
Adjustable strike price is the total price of the project? What is the capacity factor of these projects?	The adjusted strike price is the price the developer has negotiated to sell the electricity of the project for the life cycle of the project. Capacity factors for offshore wind projects have ranged from 40% to 55%. The Equinor 30-MW floating project has reported capacity factors over 50%.
Is floating generally more expensive than non-floating to construct and operate?	Currently floating is more expensive but we believe that these higher costs are mostly due to the nascent stage of the technology development rather than an inherent cost premium that must be incurred. As floating technology matures, costs will come down to the same range as fixed-bottom offshore wind systems.
What influences total project size for a utility scale project? Is it based on the size of the lease? Is it more cost effective to build an 800 MW vs. 400 MW project?	Larger project sizes are more economical. This is because the apparatus and supply chain logistics for a larger project are approximately the same as for a smaller project, but more megawatts of capacity can be installed. Yes, 800 MW projects appear to be more cost effective, in general.

Are fixed turbines in water deeper than 60 meters structurally unsound, or is it too expensive in terms of the amount of steel to install a structure at greater depths?	The oil and gas industry installed fixed-bottom substructures in water depths much greater than 60 meters, therefore fixed-bottom support structures are quite feasible from a structural standpoint, but they would likely be jacket-type substructures. The assumption of a 60-meter depth transition to floating substructures is based on economics. This assumption has not been fully proven yet in transitional depths (60-90meters) but most floating designs intend to go much deeper regardless of the transition depth between fixed-bottom and floating.
The cost per KWH quoted needs to be broken down. How much of the initial costs will be put on users and how much will be paid for by developers, other sources such as grants and incentives?	The cost of an offshore wind plant is financed by the developer who recovers those costs from revenue obtained by selling electricity generated by the turbines and by other policy incentives provided at the state level. The capital cost per kWh is roughly broken down among turbine (20%) balance of system, including soft costs (50%), and O&M (30%) See e.g. https://www.nrel.gov/docs/fy20osti/74598.pdf
How much do the longer transmission distances factor into higher costs for floating OSW?	Longer transmission in the water has a cost impact but it is incremental and based on the length of the export cables. Once the project connects to land, there may be additional costs to bring the power to load – these costs will vary depending on the viability of the grid connection point.
When the presenter says, in water deeper than 60m, floating technology is 'superior', what criteria is that based on? Economics only?	Yes – it's based-on economics. A fixed bottom turbine will get very expensive in deeper water due to non-linear power law scaling of support structure costs with water depth. In contrast, floating systems cost is relatively insensitive to water depth.
These arrays will be displacing current economic activity, how will this be taken into consideration?	Several recent economic impact studies estimate significant jobs and economic activity from offshore wind's component supply chain, installation and operation activities. These studies have focused on the gross economic impacts supported by wind plant development and not net impacts to the entire economy. Further research will address other potential economic effects on areas, such tourism, fishing, and other maritime industries. Sustaining all aspects of the blue economy is important as the offshore wind industry develops and many of the new offshore wind jobs require similar skills as the traditional economy.
We have seen some pilot projects in Scotland, Norway, France, Spain and the US with floating wind turbines. Where do you consider the boost of the technology commercially will arise?	It is very difficult to predict where the first commercial project will be but there is large-scale commercial activity in Asia, Europe, and the United States.

Environmental, Siting & Marine Wildlife:

Questions	Answers
How will impacts to ESA listed species be addressed?	Impacts to protected species will be addressed through ESA section 7 consultations and through MMPA incidental take authorizations. The protection of ESA-listed marine species falls under the jurisdiction of the National Oceanic and Atmospheric Administration, https://www.fisheries.noaa.gov/topic/endangered-species-conservation#overview. NOAA also is charged with the protection of marine mammals under the Marine Mammal Protection Act, https://www.fisheries.noaa.gov/topic/marine-mammal-protection. Section 7 of the ESA requires federal agencies to ensure that actions they authorize, fund, or carry out do not jeopardize the existence of species listed under the ESA. The MMPA requires that an incidental take authorization be obtained for the unintentional "take" of marine mammals incidental to otherwise lawful activities.

Do mooring lines or cables suffer from biofueling? If yes, then what are the maintenance actions and frequency to maintain the integrity of the lines/cables?	Assuming the question was intended to be about biofouling. We do not have much data on this due to lack of experience overall, but the industry does anticipate that biofouling (the growth of organic plants and animals on the submerged structural elements) will be a routine maintenance issue. There are several methods for both inspection and mitigation that have been proposed including robotic techniques. Better information will be available when more industry experience is acquired.
Are there any known differences in the requirements of the Environmental Impact Assessments between anchored vs. floating wind projects? Particularly in relation to marine life.	Environmental Impact Assessment requirements in federal waters fall under the authority of the Bureau of Ocean Energy Management. Survey guidelines which are available here: https://www.boem.gov/renewable-energy/survey-guidelines-renewable-energy-development Currently posted guidelines are agnostic towards foundation type.
What are some environmental challenges associated with floating offshore wind turbines? Do any overlap with fixed bottom?	There is considerable overlap in environmental challenges between fixed and floating systems at a high level. However, the context changes considerably between the benthic habitat, species composition, and biomass on the continental shelf versus the continental slope, where water is much deeper. How these ecosystems respond to different stressors is expected to be different. Furthermore, the disturbance during construction and the installed infrastructure among substructure types varies as well. While seabirds and bats fly offshore, they don't all use the same space. So similar with changing context under the surface, we may also see different species composition above the surface based on distance from shore.
Can hybrid floating wind turbines operate in water shallower than 60m? There is growing interest in quiet foundations that don't require pile driving, which can have significant impacts on marine wildlife.	It is possible to design a floating wind turbine that can operate in less than 60-m of water but there are challenges with short mooring lines in shallow water.
Will the cables mooring the turbines affect Whales?	The mooring lines that secure the floating platforms to the seabed extend through the entire water column. They are very large in diameter and are made from chain or synthetic rope. They are under relatively large axial forces so unlike fishing lines or smaller diameter rope lines it would be very difficult for marine life to become entangled. Where concern remains is around secondary entanglement where marine debris (such as fishing gear) may become entangled in the line which may pose an entanglement risk to wildlife. However, this is a topic that deserves further research to better understand the likelihood and magnitude of risk.
How does marine life deal with fixed and floating platforms? Do they all use sonar to maneuver around the underwater portion of these structures?	Different marine species utilize different strategies for navigating their environment. They would utilize these same strategies for maneuvering around any underwater obstruction.
Structures further offshore may also have more impacts on marine wildlife. How should this be considered in selecting site locations?	When evaluating site options, one should consider the differences in benthic habitat and species composition for each site. However, there is currently a paucity of information to support an assessment of relative impacts to marine ecosystems on the shelf versus slope.
Did the proof of concept and pre-commercial projects include data collection on observed impacts to marine environmental and wildlife at locations? Any idea of how floating platforms differ in impacts on local ecosystems from fixed platforms?	We believe these early projects in Europe and Japan did consider impacts to wildlife, but data are not always publicly available. There has not been sufficient research to compare impacts between floating and other substructure types. The benthic habitat and species composition at a given site may be more or less sensitive to the introduction of a particular substructure and associated construction activities which also need to be accounted for.
What about monitoring these floating wind projects for impacts on wildlife – marine mammals, sea turtles, birds, bats. How are these projects measuring impacts in order to calculate cumulative impacts, activate adaptive management if needed, etc?	Floating wind projects will be required to comply with the same requirements for preconstruction and post construction monitoring as other offshore wind energy projects. Practically, in order to monitor offshore, technological solutions are needed that can withstand the harsh marine environment and operate reliably in remote locations. The U.S. Department of Energy is investing in research and development to augment the suite of options available for robust and practical monitoring regimes. Such technological solutions

	will support data collection to assess the source and magnitude of impact for a given project and may inform adaptive management practices or cumulative impact assessments. See this webinar for an introduction to some of these research projects: https://www.nationalwind.org/new-research-on-wildlife-monitoring-at-offshore-wind-facilities-supported-by-the-u-s-department-of-energy/
Can you please describe what testing, if any, has been done to determine potential impacts to birds from potential blade strikes, and to cetaceans from potential collisions with underwater cables or other subsurface structures associated with these arrays? Thanks	While collisions are a concern for volant species offshore, studies to date suggest that impacts from avoidance is also of concern. BOEM Pacific summarized the state of the knowledge well in this recent webinar: https://www.boem.gov/sites/default/files/documents//West-Coast-Science-Exchange-20200108.pdf
How do you address endangered and/or protected species?	The protection of threatened and endangered species falls under the jurisdiction of the National Oceanic and Atmospheric Administration. NOAA also is charged with the protection of marine mammals under the Marine Mammal Protection Act. Impacts to protected species will be addressed through consultation with NOAA and adherence to their policies and guidelines. Where applicable, developers or owner operators may be required to apply for take permits. For more information you may want to review these websites: https://www.fisheries.noaa.gov/topic/marine-mammal-protection https://www.fisheries.noaa.gov/topic/endangered-species-conservation#overview
Does floating offshore wind have a smaller impact on benthic habitats?	When evaluating site options, one should consider the differences in benthic habitat and species composition for each site. There is currently a paucity of information, however, to support an assessment of relative impacts to marine ecosystems on the shelf versus slope.
What are their effects on seabirds?	Impacts to seabirds from offshore wind include collision and avoidance. See this webinar from BOEM Pacific for a more detailed summary on the state of the knowledge: https://www.boem.gov/sites/default/files/documents//West-Coast-Science-Exchange-20200108.pdf
Are there any entanglement risks associated with floating wind turbines (ie whales and other marine mammals)?	Whale entanglement with mooring lines is not expected to be a problem for floating turbines because the lines are big, heavy and tight. Where concern remains is around secondary entanglement where marine debris may become entangled in the line which may pose an entanglement risk to wildlife. However, this is a topic that deserves further research to better understand the likelihood and magnitude of risk.
Is one of the challenges with floating windfarms, in terms of conflicts with other users such as DOD/shipping/fishing, that the array cables are in the water column preventing transit (in contract, fixed bottom turbines have their cables buried in the seafloor)? Has the industry evolved to try to address this issue?	We do not anticipate that floating turbines will have a large impact on transit as the spacing between turbines will be over 1 mile and the cable depths will be much deeper than the drafts of surface vessels. Of course, this becomes more of an issue during foul weather when visibility is lower. Other techniques may be implemented to provide additional navigational safety such as lighting. Fishing activities that involve bottom trawling will likely be impacted within the wind array.
Do you have any insights regarding floating wind with respect to marine spatial planning? In particular, the mooring and cabling infrastructure and its impacts on DOD (Navy) training waters. Have there been serious discussions to date in the US?	There have been many serious discussions about this subject, but the discussions are not always in the public domain. Competing uses will need to be carefully considered. We cannot speak to the needs or concerns of the Department of Defense; however, we can say that spacing between turbines will typically be over 1 mile and the mooring lines and cables will be much deeper than the drafts of any surface vessels.
Fishing:	
Are floating offshore wind turbines less challenging for commercial fishermen and other commercial vessels to navigate around than fixed bottom turbine farms of the same size?	From a navigation standpoint, floating wind turbines would be about the same as fixed bottom turbines.

What is the protocol for commercial fishing around these floating turbines? The fixed turbines are working closely with fishermen so that both entities can use the ocean resources together. With the tethering cables, it seems all commercial fishing will be displaced.	Mooring lines would be a significant challenge for large scale commercial fishing inside a floating wind farm, but it is premature to assume that all commercial fishing would be excluded. This issue has not yet been fully addressed but should be a topic for further research and discussion.
With 8 rotor diameters spacing, would smaller vessels (say commercial fishermen) be able to safely navigate the array?	8-diameter spacing will set the turbine spacing at 1 mile or more. This distance would allow safe passage for most smaller vessels.
Fisheries have led to increased turbine spacing for fixed bottom in the northeast. Has there been any feedback on spacing for floating turbines due to mooring configurations?	Due to the nascent state of the industry, this issue has not been addressed yet.
What is the offset of fishery jobs and the importance of fish for nutrition?	There is no evidence that offshore wind plants hurt fish populations and many believe that they can be beneficial to fish by providing artificial reefs and feeding grounds The offshore wind industry is working closely with the fishing industry to minimize the economic impact on fisheries. The large-scale deployment of offshore wind would not occupy a major fraction of the ocean so fishing would continue normally in most ocean areas. Nevertheless, there is a lot of discussion about how fishing could continue within the wind plants as well. Ideally the fishing community and the wind industry will work together to create more jobs. For more information you can contact the Responsible Offshore Development Alliance (RODA). https://rodafisheries.org/
At what depth will inter-array cables be mid-water instead of the bottom? These mid-water cables essentially exclude all fishing activity inside the array.	The depth of the array cables and the method of placement within the array are all variables of the floating array design. The degree to which fishing activity is disrupted is dependent on the type of fishing under investigation. The offshore wind industry would seek to minimize fishing impacts if possible but some impacts might be project specific and would need to be mitigated by the developer.
How come you never mentioned the opportunity and economic cost to commercial and recreational fishermen? What are they? How mitigated?	Competing use issues of which there are many were not in the scope of my presentation due to time constraints. These issues deserve a lot of attention and should be the subject of future webinars. For more information you might contact the Responsible Offshore Development Alliance. https://rodafisheries.org/

Configuration, Design, Sizing & Installation:

Questions	Answers
Why only 3 blades?	Over the years wind turbines have been designed with any number of blades, but through experience three-bladed rotors are optimum. Increasing the number of blades increases the design complexity and cost but does not improve the energy yield. Two-bladed rotors also can work but they are dynamically more challenging.
Is anyone pursuing turbine technology other than 3-blade upwind? Also, does the size of the underwater structure vary with the size, weight and rotor diameter of the turbine?	There may be a few that are looking at two bladed turbines. Some may also be pursuing vertical axis machines. The size and weight of the components above the water directly affect the size and weight of the underwater structure.
Are helical turbines an option offshore, both fixed or floating?	Not currently. Helical turbines exist at smaller scales and have been demonstrated for marine current applications. They have not been demonstrated at the MW scale for commercial utility wind. The most significant technical challenges are that they are very difficult to scale up to utility scale without incurring large weight (and hence cost) penalties, and they are less efficient at capturing the wind.
Can you please verify the technology filter (slide 11) for water depth LESS than 1000 feet, correct?	The technology filter for the resource was to eliminate all area with depths greater than 1000 meters. (not feet)

What will the entire footprint of these facilities be including the mooring apparatus?	It depends on water depth, mooring type, and mooring design. Catenary moorings have a footprint (measured by the anchor circle radius) that is proportional to the water depth. The mooring lines are at least 4 time longer than the water depth. In a tension leg platform, the mooring lines are taut and relatively vertical, so the footprint is much smaller.
In the Catenary Mooring Line figure, what is the anchor radius as a factor of water depth? Does this impact turbine spacing?	The figure is conceptual and is not intended to represent a specific design. The anchor radius is at least as great as water depth but likely greater. This dimension is generally independent from the spacing of the turbines. However, new concepts for shared moorings and shared anchors may influence future mooring system designs to also consider turbine spacing.
Can you provide information about the mooring scope required for the different types of platforms (based on water depth)?	Spar and Semisubmersible substructure platforms typically use catenary moorings which sag along their length such that the anchor line forces are mostly horizontal. Tension Leg Platforms (TLP) have vertical mooring line forces that are an order-of-magnitude larger. Therefore, TLPs do not use drag embedment anchors but use pile type anchors that can take large upward forces.
How many anchor lines are used?	A minimum of three mooring lines are required to stabilize the floating substructures. Design standards for oil and gas require some redundancy in the design so this number may be doubled. The exact requirements are still being debated under U.S. and International standards development committees.
Are anchor lines under tension? How much tension?	Yes – the anchor lines are under tension and these tensile forces provide stability to the system. In catenary moored systems, the tension is created by the weight of the mooring lines themselves, which are typically made of heavy steel chain.
How are the anchors embedded/installed? (slide 19)	The drag embedment anchors are installed using vessels that pull on them from the surface. As the anchor is dragged along the bottom, it is designed to penetrate the seabed. The harder it is pulled the deeper it penetrates.
At what depth will inter-array cables be mid-water instead of the bottom? These mid-water cables essentially exclude all fishing activity inside the array.	The depth of the array cables and the method of placement within the array are all variables of the floating array design. The degree to which fishing activity is disrupted is dependent on the type of fishing under investigation. The offshore wind industry would seek to minimize fishing impacts if possible but some impacts might be project specific and would need to be mitigated by the developer.
What is the water depth range expected and is there any expectation that floating will be used in water depths less than 60 meters?	The expected water depth range is 60 to 1000 meters. Shallow water floating systems below 60 meters could be possible but fixed bottom substructures become more competitive as the depths get shallower, and there are additional technical challenges with shallow water moorings due to shorter lines.
In developing turbines larger in size, what is the limiting factor, or on what basis do we decide if the turbine size is applicable?	Larger turbines mean fewer turbines are needed per project. Fewer turbines mean fewer array cables and connections, lower maintenance, more energy (because the towers are taller), fewer support structures, etc. The greatest challenges in upscaling turbines are in maintaining high reliability composite blades that are longer and carry more load, drivetrains that operate at increasingly slower shaft speeds, and maybe most important, the port and supply chain infrastructure that manufactures, assembles, installs, and maintains these mammoth structures.
Is there a turbine size limitation for floating offshore wind in terms of the amount of mass required to offset the turbine weight?	Mass below the waterline must be added as ballast in most cases to offset the weight to the turbine and more importantly the horizontal thrust loads due to the wind. The mass below the water line is generally not a large cost penalty because it is typically obtained through low cost materials such as sea water, concrete, or iron ore.
As a university interested in getting involved in advancing floating wind, are you aware of key areas that might be ripe for work in academia? Such as mooring systems, environmental impacts, or other topics?	Offshore wind is a rapidly growing field and training the engineers, technicians, biologists, scientists of the future is a high priority for the industry. The key fields of possible study include resource assessment and characterization, wind plant control and optimization, wind technology innovation and modeling, advanced manufacturing and materials, grid systems integration and hybrid systems development with

	complementary technologies such as solar, testing and validation, techno-economic analysis, marine environmental science and regulatory policy, and stakeholder relations.
Do you expect that the installation will need to be Jones Act compliant?	Yes. Any structure installed in U.S. waters is considered a US port and will need to be Jones Act compliant. That means that the vessels that install it and deliver its various components will have to be compliant. Generally, this mean US flagged vessels will be used if parts are transferred from a US port to the site where it will operate.
Is floating wind technology "settled" for the floating parts, or are different float designs still competing for dominance?	The technology is still evolving. There may be several technology types that move forward because physical and environmental site requirements may dictate different design optima. Low cost will also drive the technology in various directions to optimize for regional differences.
Statement that Block Island is currently only offshore wind farm in the U.S. Thought there was some offshore wind in Hawaiian Islands?	No there have not been any offshore wind farms in Hawaii.
What does AWH stand for in the US Regulatory Activity slide?	Alpha Wind Hawaii
Has a port study of the US been conducted to show which ports could potentially stage floating turbine quayside construction?	Mott MacDonald conducted a port study for BOEM in 2016 which provides some good information. See link below: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-011.pdf

Electrical and Transmission:

Questions	Answers
Sites further offshore may be better for people (out of sight) but will still need infrastructure to transmit electricity to share. What will be needed to do that and will bringing energy to share be more difficult for locations further offshore?	The farther offshore the project is built the longer the export cable needs to be which does add some cost. In the North Sea, offshore wind projects have economically built over 60 miles from shore. If the project is very far from shore new technology such as high voltage DC current is being used to help reduce transmission losses and save costs. These distances may seem large but are relatively small compared to some land-based transmission distances.
Do wind turbines require any electrical energy during start-up?	The electric grid that the wind plant is connected to must be energized to start. All components of wind power plants such as substation transformers, collector system cables, turbine transformers, and turbine level components such as all auxiliary circuits, controls and actuators, yaw system must be energized using power from the grid in order for each individual wind turbine in the plant to be able to start operation. Once turbine starts spinning under wind flow, it still needs energy to control some if its components such as blade pitch motors to regulate the turbine speed and allow turbine converter to synchronize with grid. Only after that the turbine's main contactor is engaged and the turbine starts producing power. The turbine internal consumption is normally very low compared to rated power of the unit (less than 1-2%) "Black start" capabilities are under development in which wind plants can energize the grid in the event of a blackout.
Do you have a sense of the size of electrical demand that might make floating wind practical? I'm particularly interested in Hawaii, where a 400-500 MW project would be a major portion of the load on the island of Oahu.	Studies done at NREL indicate that an 800 MW offshore plant off Oahu would provide about 40% of the island's electricity. Since Oahu makes up about 80% of Hawaii's electric load, it does not seem practical to consider offshore wind for other Hawaiian Islands at this time. For reference, HECO generated about 6,782 GWh/year in the year the study was done.
Have you done a crosswalk between those areas where floating technology would be best and the current capability on the onshore transmission system to handle the power? I know from other presentations I've seen that considerable	As land-based power plants retire, the East coast has considerable opportunities for offshore wind projects to connect to existing coastal infrastructure with minimal additional land-based upgrades (e.g. Brayton Point in Massachusetts). However, with over 26-GW of offshore wind committed, inevitably we

onshore upgrades will be required, and no one is sure who will pay for these upgrades.	can anticipate a future shortage of easy-access grid connection points and additional costs will be incurred to make those transmission upgrades. As you stated it is not yet clear who will pay for these upgrades but these discussions have already begun among states, developers, and utilities. In California where floating wind may deploy, there are significant grid connection challenges especially on the North Coast. These solutions may require a large offshore wind capacity addition (GW scale) to make these investments economical regardless of who pays for them.
How much do the longer transmission distances factor into higher costs for floating OSW?	Longer transmission in the water has a cost impact but it is incremental and based on the length of the export cables. Once the project connects to land, there may be additional costs to bring the power to load – these costs will vary depending on the viability of the grid connection point.
Perhaps a silly question, but do the power cables that draw energy from floating wind turbines float as well?	No – they are heavy and would sink to the bottom. They are connected to the turbines and protected from the dynamic motions of the turbine.

Modeling, Analysis, Controls and Resource Assessment

Questions	Answers
What type of modeling is used for each type of mooring system (spar, floating, tension line) to evaluate the tolerance of these mooring systems to oceanic forces over time and a range of ocean conditions and storm events? Is modeling being required for each project or is a standardized model available and then we take it on faith that the mooring system will be sufficient under X ocean conditions with some error built into the design of the system?	Floating wind turbine systems are designed by considering the entire wind turbine, platform, and mooring assembly together in what is called a fully coupled dynamic analysis. This analysis accounts for thousands of possible load cases to calculate the full system responses. To obtain type certification and project certification, which are necessary for regulatory approval and financing, each design and each project must be fully evaluated. The computer software needed to make these computations is very specialized and models the physics of both the aerodynamic loading and the hydrodynamic loading under all foreseeable conditions as prescribed by International Electrotechnical Commission standards.
In the development of wind farms, how accurate are the data used for the simulation regarding turbine spacing?	The models you may be referring to predict the wake losses from each turbine within the array for a given spacing distance. The model accuracy is very good, and these are the primary tools that are used to make the tradeoff between array cable length and net energy production.
Are there any commercially available software tools used for offshore wind techno-economic analysis?	Not that we know of. The industry is changing so rapidly that it would be difficult to commercialize such a tool.
When will the data be available for the 15 MW NREL Reference Turbine?	The full report on the IEA Wind 15MW Reference Turbine is available here and the design is implemented as input files to various modeling tools which are available on a Github repository here.
Is the surface of ground related to wind resources, meaning, are there less wind resources in hotter areas around the globe?	Winds tend to blow stronger in colder climates, but tropical and subtropical coastal regions have trade winds and often have strong land/sea thermal gradients that can help generate consistent winds at any latitude. Site specific resource assessment is recommended to understand if a site is viable for offshore wind.
Has a floating turbine ever fallen over? How would that be managed?	No. There have been no cases of a floating turbine falling over. Turbine systems are designed to withstand harsh sea conditions using advanced computer simulation codes that ostensibly eliminate this failure mode. The offshore wind design criteria are adapted from 50 years of oil and gas experience and have been continuously upgraded as these industries collectively learn more.