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Filer:	Silvia Palma-Rojas
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Summary and Recommendations from the Staff Workshop on Next Generation Wind Energy Technologies and their Environmental Implications

California Energy Commission (CEC) staff held a workshop titled "Next Generation Wind Energy Technologies and their Environmental Implications" on October 25, 2018. The objective of the meeting was to obtain feedback and responses from experts in the energy industry, utilities, operators, stakeholders and academia regarding the future challenges of wind energy and its environmental impact in California.

The workshop was organized into three main parts:

- **Expert Presentation:** US DOE Wind Energy Technology Office Programs Overview
- **Panel Discussion**: Research Needs and Opportunities for Next-Generation Wind Energy
- **Panel Presentations**: Risks to Sensitive Species and Habitats from Offshore Wind Energy

For more details, please refer to the link: https://www.energy.ca.gov/research/notices/#10252018

1. Expert Presentation: US DOE Wind Energy Technology Office Programs Overview

Michael Derby, Program Manager for Wind Technology of the U.S. Department of Energy's Wind Energy Technologies Office (DOE WETO), provided an overview of WETO research areas and highlighted some current projects addressing the challenges to increase the performance and reliability of next-generation wind technologies.

Major Takeaways

- The U.S. Department of Energy's Wind Energy Technologies Office (DOE WETO) programs focus beyond the development and risks of wind energy technology, the program includes also wildlife, human-use conflicts, grid integration, and cost analysis. DOE believes that research and development programs are key to drive the cost of wind energy down, make wind energy more cost-competitive with conventional resources, and increase deployment of wind energy projects in the country.
- DOE's strategy to increase wind energy generation centers on tall wind, wind plant optimization, offshore wind, and distributed wind energy.
- The Tall Wind Technology Development Program works, primarily, on the design and development of taller towers, bigger blades, drivetrains and lightweight generators.
- The program sees the need for innovation to facilitate transportation and/or develop on-site manufacturing approaches that make larger and taller wind technologies more cost effective. For instance, DOE has been looking at tall towers since 2002, observing that taller towers must increase the thickness of the steel in the tower, making the technology no cost effective.
- Through the Big Adaptive Rotor Initiative, DOE is researching bigger rotor sizes that allow capturing more energy and increasing capacity factor of a turbine. DOE's target for rotor specific power is 150 watts per square meter. The lowest available today is 200 watts per square meter.

Low specific power rotor and tall towers (>140-meter) could unlock wind energy developments in California, where wind energy is not economical today.

- The DOE Atmosphere to Electrons (A2e) Initiative focuses on wind plant design improvements, such as real-time monitoring, advanced turbine technology, plant-wide flow control, and reliable forecast and dispatch.
- The program funds projects that help understand the field and flows to optimize the power plant design, forecast the power production per plant and predict ramps events.
- The National Offshore Wind Strategy provides funds to offshore wind projects to make this energy resource accessible and cost-competitive in the U.S. DOE believes that offshore wind represents a significant opportunity for the U.S. since it has steadier resources and tends to provide a wind profile that matches the load distribution. Therefore, DOE is interested in leveraging the European success and knowledge on offshore wind, but focuses on those challenges that are unique to the United States.
- DOE launched the Offshore Wind R&D Consortium having the New York State Energy Research and Development Authority (NYSERDA) as the implementing agent. The initiative is concentrated in three main areas: 1) Offshore Wind Plant Technology Advancement, 2) Resource and Site Characterization, and 3) Installation, O&M and Supply Chain Technology Solution. The Offshore Wind Plant Technology Advancement area studies how to accelerate floating foundations required for deep waters, which is an essential research for potential development in California.
- DOE's efforts on wind advanced technology demonstration is funding a R&D project focused on floating foundations, which uses a concrete semisubmersible foundation.
- The A2e program is also working on offshore wind plant optimization. According to DOE, the optimization is critical for offshore wind power plants because their turbines are usually installed in a very tight matrix, as a strategy to reduce cost. Hence, the wake effect of those turbines is a bigger concern than that of land-based turbines.
- Another DOE's Current Offshore Wind Effort is the development of new technologies for monitoring wind-wildlife interactions in the offshore wind space, and information aggregation and dissemination through domestic and international collaborative partnerships.
- DOE also funds improved forecasting and integration for small wind turbines in rural systems and has worked with the Federal Aviation Administration (FAA) and military to study turbine impact on radar systems.

2. Panel Discussion: Research Needs and Opportunities for Next-Generation Wind Energy

Experts in wind energy discussed six prepared questions on wind energy technologies and identified key challenges and opportunities associated with the design, manufacturing, and deployment of next-generation wind energy technologies, and real-time monitoring systems for land-based and offshore wind energy projects. Wind-components manufacturers located in California are specialized on resins and coating, generation seals and connectors, power transmission, hydraulics, switches and control systems, converters, and construction equipment[1]. Staff believes that alongside the experience of the wind-component manufacturers and wind energy experts, and its pioneering role in the wind energy sector, California has the expertise to lead the Nation to the development of next-generation wind energy technologies. The driving motivation behind next-generation wind technology is that larger wind

[1] Public Comment received from American Wind Energy Association – California on November 7, 2018.

turbines have a larger energy output per unit rotor area due to increased mean wind velocity with height. This development will bring innovative materials science and designs for on-site manufacturing or hybrid approaches that might assist increase the cost competitiveness of wind energy generation, reduce the logistics challenges for larger and taller wind technology, and help unlock wind's potential across the additional 64,000 square kilometers in California. This next-generation wind technology has the potential to lead also the development of advanced real-time monitoring systems for proactive operation and maintenance approaches that work in synergy with environmental applications for land-based and offshore wind projects.

Moderator: Prof. C.P. van Dam, University of California, Davis

Panelists: Jason Cotrell, RCAM Technologies

Kevin Smith, DNV GL

Mo Li, University of California, Irvine

Walter Musial, National Renewable Energy Laboratory

Question 1*: According to the Market Report 2017, there are neither new nor existing wind turbine manufacturing facilities located in California. How critical is this, and are there opportunities for advanced manufacturing technology in California? How can the evolution in next generation wind energy technologies support the advancement of manufacturing in the state?*

There are a few wind turbine-manufacturing facilities in the Western regions of the Unites States, having only two manufacturers producing blades, one producing turbines, and one manufacturing towers, all located in Colorado. The remaining few manufacturing facilities distributed in the region center their production on other type of components. This is a large missed opportunity because every gigawatt of wind turbine is worth a billion dollars of capital investments. Therefore, California does not have the manufacturing capacity for the new five-megawatt class turbines (currently manufactured by GE and installed overseas), which has 78-meter-long blades in two pieces, a 160-meter-tall concrete tower, and 100 trucks of concrete for the foundation. Another important fact is that despite wind turbine prices have decreased over time, California installed only 50 megawatts of new turbines in 2017, which translate to 25 or less modern wind turbines. On the other hand, Texas installed 2,300 megawatts in 2017.

Currently, next-generation wind turbines are expensive machines. For instance, the new 5-megawatt turbine tower alone costs more than one-and-a-half million dollars and there is manufacturing only overseas. Hence, there is a need to make next-generation wind technology more cost effective and overcome their economic, technical, and logistics challenges to be able to exploit the benefits of high winds and unlock wind resource areas where wind energy is not economical today. According to NREL, a 140-meter tall turbine could increase deployable land with sufficient capacity factor by a factor of twenty times in California. In order to reduce costs, some companies are looking to provide concrete printing solutions for tall wind towers.

The next generation of blades is 115 meters long. California has the opportunity to start a manufacturing industry for super-size blades that could serve the land-based and offshore wind market in the Western region, since moving or transporting large-scale turbines across the Western United State is costly and inefficient, particularly in mountainous regions like Colorado.

Offshore wind provides a significant resource and the interest in that technology has increased in the last three years. The Bureau of Ocean Energy Management has announced three call areas in California, a first step towards offshore leasing areas. Developers estimate that the commercialization of offshore wind technology in California would be around 2025/2026. Europe is ahead in offshore wind deployment, with over 16,000 MW of shallow deployment in the North Sea, which operating conditions differ from Atlantic-based wind farms. California will require leveraging the European knowledge base and adapting it to Pacific Coast conditions.

Present-day infrastructure investments will need to anticipate how wind power technology will evolve over the next few decades. Experts have identified the need of advancing in design and manufacturing techniques of technologies like floating platforms. Ports and infrastructure may need proactive upgrades to support offshore wind deployment. There is a need also of validates higher-resolution geospatial data in order to anticipate variable energy generation profiles to model the effects on ramp rates, duck curve, and seasonal flux.

Question 2*: What are the research needs to enable on-site manufacturing or hybrid solutions for wind energy technologies? What are the main on-site manufacturing challenges in California and what is needed to address those challenges?*

Next-generation blades and towers are areas that on-site manufacturing really has the potential to contribute to the competitiveness of wind energy generation. On-site manufacturing approaches for wind towers have already existing parallel techniques in materials science and technology (e.g. 3D concrete printing and concrete batch) that with effort and research can help advance the readiness of the technology for wind energy projects. On the other hand, there is not parallel solutions for blades since they are unique objects and structures with incredibly lightweight for their size and internal complexity. Experts are still discussing about whether the blades can be efficient, cost-competitive with a blade manufactured on site versus a blade manufactured off-site and transported to the project. Innovative on-site manufacturing approaches for blades (e.g. using additive manufacturing or printing or injection techniques) must consider some key parameters, such as the sandwich composite, the strength and stiffness of the outer shells, the resins, the core materials and structure, quality control process, among other.

Therefore, the on-site manufacturing approaches need R&D efforts in materials science, equipment, construction machinery, and quality control standards to be able to have a production rates and cost competitive with the current technologies. At the same time, logistics and transportation still play an important role in next-generation technologies, where their structure can innovate to adapt its services to larger wind technologies. Both on-site manufacturing approaches and transportation can compete and complement each other.

Beside the R&D efforts in manufacturing and technology development, a California-specific analysis is also valuable for helping decision makers and local jurisdictions understand the opportunities and challenges of deploying next-generation technologies, especially because California has specific characteristics, in terms of geography and deployment barriers. Additionally, California site-specific analyses are appropriate for turbine manufacturing solutions too. For example, tall towers are ideal for some offshore areas due to the large and positive wind shears. However, some onshore areas of California have negative wind shear profiles or negative wind shear during parts of the day.

Question 3*: What are the research needs (e.g. in the area of materials science) to make the next-generation of wind energy technologies, such as super-sized blades and concrete or hybrid wind towers, feasible?*

The future research on materials science for wind turbine structures might focus on high performance, stiffness, durability, and damage tolerance, as well as newer material innovations to accommodate advanced manufacturing methods and lower environmental impacts. For on-site manufacturing techniques or modular construction, researchers need to pay attention in material design and additive manufacturing. For instance, the design of 3D concrete printing for wind towers is very different from a conventional concrete for construction applications. While in applications, where you have a form and sufficient curing time, 3D printing application use a robot that handles the concrete without enough time for curing.

Experts confirm that longer and slender blades are an effective design to make blades spins faster and to facilitate their transportation, but the challenge is to understand how to control blade loading. Other research need for blades relates to material science, which needs innovative materials with high in stiffness and low weight, such as fibrous materials. Because its properties in terms of field reparability, experts consider thermoplastics as an interesting material to work with in on-site manufacturing applications, having as only limitation the stiffness quality. However, research groups from California laboratories and universities have the expertise to develop resins, fibrous thermoplastics, and thermosets that are high in fatigue and stiffness, but one of the major challenges is to lower the cost of strong fibers for the wind industry.

According to experts, materials used for advanced wind manufacturing methods need to achieve the following major goals: suitable for on-site manufacturing, higher performance, and lower environmental impacts. For example, currently manufacturers use carbon fiber reinforced plastic or glass fiber reinforced plastics to build blades. The research question is to understand how those materials can be improved to achieve those major goals.

The same research question comes to advanced manufacturing for tower and foundation. For example, blades are going larger and towers are going taller. Therefore, taller towers must increase the thickness of the steel, making the technology no cost effective. To make a taller tower cost-effective and meet the major goals, it is important to understand if high-performance concrete with reinforcement can replace the conventional steel towers or to identify if it is suitable to use fiber reinforced concrete in on-site manufacturing. In terms of foundation, the sector needs to identify how improve its performance reducing cracking or how use additive manufacturing using 3D printing concrete for foundation.

The development of offshore substructures is likely to apply on-site manufacturing techniques. Currently, the fabrication of most substructures uses steel and material sciences research is needed since steel is strongly subject to corrosion. Therefore, from a long-term operation and maintenance perspective, materials used to build offshore substructures are an ongoing concern. Several researches have been focused on concrete substructures.

In addition, automation of manufacturing processes is transforming construction, and robot manufacturing and robotics programming are opportunities for California industry. Automation can take advantage of low cost materials. Robotic concrete tower production will require concrete mix specialists and further research. Experts pointed out that automation and material science need to talk to each other and work together.

Question 4*: How the environmental life cycle aspects of the new composite materials and technology innovations are being evaluated in the design and development of next-generation land-based and offshore wind technology?*

Despite Wind turbines produce energy with virtually no emissions, there are environmental impacts associated with their manufacture, installation, and end of life. For instance, first-generation wind turbines are reaching their end of the life and most of the waste goes to landfills. Life cycle assessment (LCA) is a method to assess the environmental impacts of a product from raw material extraction through material production, manufacturing, transportation, operations and maintenance. For a typical installed 45.2-meter and 1.5 megawatts glass fiber reinforced plastic (GFRP) blade, the carbon footprint is 42.1 metric tons and the total energy consumption is 795 gigajoules (GJ), with manufacturing and raw material extraction processes leading the highest carbon footprint and energy consumption. Literature shows that the energy consumption and carbon dioxide emissions of carbon fiber reinforced plastic (CFRP) blades are much higher than GFRP blades.

Next-generation wind turbines with larger blades and taller towers need to include a life cycle perspective in the design stage to improve the environmental performance of wind energy technologies, and facilitate the recycling strategies and waste management at their end of life. For example, 90 percent of iron is recycled, 100 percent of concrete go to landfill, 100 percent of fiberglass go to landfill, and about half of aluminum is recycled. Currently, there are a few possible recycling methods for fiber-reinforced plastics identified in the literature and life cycle performance can vary for onshore and offshore applications.

It is very important to evaluate how new materials, designs, foundation techniques, and manufacturing approaches are going to affect the life cycle environmental impacts of wind turbine tower structures.

Question 5*: What is the current technology (e.g. use of drones and robots) for maintenance and monitoring of wind energy farms? Are there any further developments needed, and are any of the currently available or applicable for use in any future offshore wind farms? What are the research needs to encourage proactive maintenance while reducing operational and maintenance costs and help future offshore wind projects have a competitive levelized cost of energy?*

Real time monitoring is extremely important to improve the safety, minimize downtime, provide reliable power generation, and lower maintenance and logistics costs, especially for offshore wind applications. There are a variety of methods for monitoring and inspection techniques, such as visual inspection, video scopes and flying remote visual inspection devices, vibration analysis, point-based strain measurements, and acoustic emission method:

1. Projects use visual inspection of the surface to see if there is any damage, flaw, or delamination. The visual inspection in offshore applications and remote areas is difficult, especially, considering safety issues. New developments include video scopes and flying remote visual inspection devices, such as drones are considered critical in the first stage of inspection in offshore projects.
2. The vibration analysis compares the mode shape between the reference and inspection stage to identify any difference. This approach requires the deployment of many sensors and computational analysis. It focuses more on the global behavior, but does not really focus on the local damage and it is affected by the environmental change such as weather, which can change the modal behavior.
3. Point-based strain measurements like the strain gauges attached to the surface or optical fiber sensors can detect local deformations. If the damage is located further away from the sensor or deeper in the material, the sensor is not capable to capture it and provide that information. For example, to monitor concrete cracking in wind towers or foundation would be very difficult to collect information using only strain sensors. Both vibration analysis and point-based strain measurements need the installation of many high-cost sensors to get more distributed information.
4. The acoustic emission method is suitable for blade and steel tower monitoring. Despite the accuracy of the testing increases with the proximity of the test to the damage source, data contamination can occur due to noise and secondary sources. Contamination is more severe for concrete due to its heterogeneous structure and the analysis of its data is one of the major challenges in the research field.
5. Ultrasonic testing requires energy-intensive instrumentation and the environmental conditions can influence the test quality, especially for concrete structures like foundation and towers.
6. Radiographic inspection is sensitive to cracks and voids. However, it does not evaluate structural performance and is labor-intensive to conduct.
7. Thermal imaging methods have lower resolution, are labor intensive, and not appropriate for early fault detection because the temperature changes more slowly in the early stages of failure.

There is a need to develop reliable, low-cost, continued, and distributed damage sensing approaches, with one possible strategy of integrating monitoring system into the wind turbine system. Another research opportunity is to develop artificial intelligence tools that help to advance in proactive monitoring system that provides a holistic picture of the turbine condition, where all the discrete signals go to the turbine controller. Data collected in the controller might be used for an integrated assessment that supports the decision making process in the power plant. In addition, researchers have found that many types of health monitoring need the contribution of turbine manufacturers to be able to understand the technology reference and identify deviations from the normal state. Experts pointed out that it is difficult for the wind turbine owners to have access to big data and consider that the lack of big data availability is the Achilles heel of the industry today.

Question 6*: What environmental and technological research is needed for future development and implementation of offshore wind energy in California?*

Research areas should include:

1) Studies on local port upgrades, logistics for high sea state crew transfer, deep-water mooring systems, and the value of integrating offshore wind to the grid.
2) A statewide coastal grid study for power distribution optimization.
3) Development of proactive monitoring system using drones and remote sensors for inspections in offshore environments.
4) Consider concrete 3D printing applications in offshore environments. Concrete is simpler and more cost effective than steel, which can bring scalability issues. In addition, the on-site manufacturing of concrete towers or hybrid towers create more local jobs compared to transporting large steel structures.

3. Public Comments and Questions

Q1: Is 3-D printing onsite for offshore application possible? Could resin be printed?

A1: 3D printing process for additive manufacturing of large structures using polymers is a research topic that is being explored. In addition, there is the option to print molds and fill them with concrete. For instance, Oak Ridge National Lab researched the use of molds for wind turbine blades; therefore, new research can focus on applications for towers and offshore foundations. For offshore wind projects, any on-site manufacturing process that can be performed onshore will be easier and more economical than performing at sea.

Q2: What is the best approach for evaluating California wind resources for the future market?

A2: There is a need to determine areas with high shear value. California is unique and the shear values vary from region to region and throughout the day.

Q3: Is there a good map of existing wind generation diurnal patterns in different locations in California?

A3: There is but not good enough. There is a need to have more information generated on hourly site-specific resource.

4. Panel Presentation: Risks to Sensitive Species and Habitats from Offshore Wind Energy

Speakers from a federal (Bureau of Ocean Energy Management, BOEM) and state agency (Ocean Protection Council, OPC) and the private sector (H.T. Harvey & Associates) provided an overview of the state of the science of environmental research into the potential environmental impacts of offshore wind energy projects on California's Outer Continental Shelf (OCS). The OCS is a new ecosystem for offshore wind, so the potential risks to species and habitats has not been well-studied. The presentations collectively covered what is known, what research is underway, and what needs to be learned through future research. They also clarified what types of research each agency funds.

Panelists: Jeremy Potter, Bureau of Ocean Energy Management

Marine Environmental Research to Support the Transition to Renewable Energy: Review of the Science and Remaining Information Needs

Scott Terrill, H. T. Harvey & Associates

Avian considerations and offshore wind in the California Current

Chris Potter, Ocean Protection Council

Improving Access to Information for Marine Renewable Energy Siting, Planning, and Regulator Processes

Questions:

1. Are there topics where EPIC could add significant value and not unnecessarily duplicate research being done by others? What output/product would be most beneficial to inform the intended policy, regulatory mechanism, or program? What are the topic(s) and what research would be needed to have a measurable impact?

2. What are the specific barriers or knowledge/data gaps that need to be addressed? How significant are the risks if the gaps are not filled? Are the barriers from knowledge gaps primarily due to:
    a. Lack of environmental observation data?
    b. Need for improved risk assessment methods?
    c. Need for improved environmental monitoring and surveying technologies?
    d. Other?

What Is Known?

Market interest and planning for offshore wind in California is focused on the OCS, which is far deeper than conventional offshore wind development in Europe and the U. S. East Coast. Experts expect wind turbines to be deployed here on floating platforms that are only beginning to be deployed elsewhere. The technology to be deployed, therefore, will be novel so that the potential environmental impacts are likely to be different. BOEM has just announced three call areas for public comment—Humboldt, Morro Bay, and Diablo Canyon—as precursors to wind lease areas. These call areas are relatively far off the coast. The remoteness and adverse atmospheric and oceanic conditions in such areas makes environmental data collection and monitoring extremely challenging and expensive.

The OCS ecosystem and its species are different from areas with existing offshore wind, thereby limiting the value of lessons learned elsewhere. For example, migratory terrestrial birds tend not to migrate off the West Coast because of the orientation of California relative to flyways so collision risk for these birds is probably not a major issue for California compared to the East Coast. Therefore, the risk to migratory species is considered low. Upwelling in the California Current produces biodiversity hotspots for birds and marine life – one of the highest abundances and diversities of seabirds on the planet. Birds whose flight behavior could potentially put them at greater risk of collision with turbines are those that perform a dynamic soaring maneuver in strong winds, such as albatrosses, shearwaters, and petrels. Some bird types are at higher risk for collisions due to flight behavior, natural history elements and conservation status. Pelicans, for example are highly vulnerable because they are not very maneuverable.

What Research Is Underway or Planned?

BOEM is currently conducting several broad scale assessments and inventories in the OCS. They are continuing a project of seafloor mapping with assessment of fishes and essential fish habitat. BOEM is part of a large consortium monitoring the rocky intertidal zone along the West Coast since 1992. The agency also recently completed the first comprehensive evaluation of marine bird vulnerability in the Pacific in terms of displacement and collision risk. BOEM is considering a Pacific Seabird Monitoring Network suitable for monitoring the effects of offshore energy on a suite of indicator species, but it had not been funded at the time of the workshop.

Thirty years of spatial data on the distributions and flight height of seabirds off the California coast were used in the BOEM-funded study of their vulnerability to collision and displacement. These data could be used to create 3D models of bird behavior in risk modeling. These models will be challenged by lack of information about how these birds will respond to the presence of turbines. Nevertheless, risk models could initially model soaring behavior relative to turbine rotor-swept area under different wind conditions.

On the day of the staff workshop, OPC approved two Proposition 84 grants for three marine renewable energy research projects. The "North Coast Offshore Wind Feasibility Analysis" project for the Humboldt Call Area includes modules for environmental impacts from the wind turbines and from the associated infrastructure. The "California Offshore Wind: Workforce and Grid Integration Analysis" study will estimate effects on employment, grid integration, and renewable energy goals. The third study, "Wave Energy Conversion in California under the present and future Climate and economic feasibility analysis of different technologies," will provide the first statewide assessment of the technological and economic feasibility of wave energy deployment in California. It will also provide the public and private sectors with state-of-the-art tools and data for other analyses and research, including the assessment of ecological and coastal effects of a specific wave farm siting. OPC expects to continue funding new environmental research studies associated with offshore wind.

What Are Key Research Needs and Opportunities?

The EPIC program must realize benefits for ratepayers, so collecting baseline data is typically not within scope. EPIC also funds studies to assess risks and to find solutions to the more severe threats to sensitive species and habitats. EPIC can also fund development and testing of technologies to support the science and to minimize impacts to species. One severe challenge with offshore wind energy in the OCS is that the risks cannot be accurately assessed when there are no working turbines in the water. At this early stage of planning for offshore wind, it is not clear how great the risks will be. None of the speakers or commenters identified a need to develop and evaluate mitigation measures at this time.

Key topics that emerged from the session:

1. Remote monitoring instrumentation. Because of the challenges of monitoring at sea, R&D could continue to refine early stage technologies, such as radars, thermal and visual imagery, acoustic sensors, and accelerometers that might detect blade strikes by seabirds, and combinations of sensors to identify species. Interpreting data to identify bird species is a challenge. Carcass detection is difficult and labor intensive on land, and practically impossible far at sea.
2. Risk assessment of marine mammal entanglement. Although likely to be rare, this remains a public concern. It may be more likely with the interaction of mooring lines, mammals, and derelict fishing nets.
3. Coupled interactions of oceanic and atmospheric models in the presence of large offshore wind facilities. Recent studies have indicated that large wind facilities could potentially have substantial effects on leeward wind speeds and cloud cover. The rich productivity of the California Current is driven by upwelling of onshore winds. Coupling of atmospheric modeling with oceanic models could estimate if offshore wind development at the scale envisioned by the call areas might diminish upwelling and the biological productivity it generates. Alternatively, this modeling could estimate the magnitude of wind development at which the upwelling regime could be altered.
4. Risk assessment of near-shore and onshore issues (e.g., ports/harbors, cabling) associated with offshore wind energy development. Part of the OPC grant for the North Coast Offshore Wind Feasibility Analysis addresses this topic in the Humboldt Call Area.

Coordination of Research

The BOEM environmental science research spans the gamut from collecting data on baseline environmental conditions to assessing risk from offshore energy development and monitoring changes associated with that development. Much of their research program involves synthesizing data needed to make management decisions about offshore energy in federal waters (3-200 miles offshore). BOEM typically does not fund R&D on sensing technologies to support the science. Site-specific assessments will be necessary at the wind farm project level, funded by lessees.

The representatives from BOEM and OPC both expressed a strong desire to coordinate research planning with EPIC team at CEC. The mechanism to achieve that desire remains to be implemented.

5. Written Public Comments

- Dr. Kari Appa submits a design document for an axial flow helical bladed rotor and requests a design review.
- Carla R Gillett submits a design document for a portable hybrid wind turbine and solar power energy system.
- Claire Ann Warshaw asks whether there have been studies of the potential conflicts between effect of lighting on offshore wind facilities and algae (presumably kelp forests). *Kelp forests are a critical ecosystem off the California coast. They thrive in cold, nutrient-dense waters, particularly where there is a rocky and shallow seafloor (5 to 30 meters). Floating platform*

technology will be sited beyond 60 m depth. There should not be any conflict. No one has previously raised this as an issue at the many interagency task force workshops.

- American Wind Energy Associate California comments on the economic potential of utility-scale wind and research needed for electricity transmission.
- Jason Cotrell provides an article that discusses the cost savings of automated concrete construction
- Magellan Wind provides 6 pages of comments on panel discussion, including monitoring and control systems and environmental impacts.
- Mehmet Guler submits a design for a mini hydraulic cycle
- Sri Sritharan provides "A Systematic Evaluation of Wind Harvesting Potential in CA with Tall Towers" paper.
- Donna Tisdale commented on the harmful impacts on public health of infrasound of land-based turbines on nearby residents. *This topic was outside the scope of the workshop, so it will be deferred until future environmental research on land-based wind may be considered.*
- Kevin Wolf provides a document titled "Negative Wind Sheer Documented in the Solano Wind Resource Area Should Be Evaluated by the CEC."