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Comments on the CEC Draft Research Concept on Advance to Next-Generation Offshore Wind Energy Technology

I strongly support the CEC draft research concept Advance to Next-Generation Offshore Wind Energy Technology. My comments are mainly related to "What type of innovation is needed in design and material science that support the improvement of substructure and foundation components?"

- When an advanced manufacturing method is introduced for offshore structural components, ranging from modular construction and rapid assembly to onsite additive manufacturing, the materials must be modified and optimized to accommodate the specific manufacturing method and processes. For example, a material that works for prefabricated modular construction will not work for additive manufacturing, and vice versa. The manufacturing process would also dictate changes in structural designs. Therefore, research is needed on how to best improve and optimize the material designs, and the structural designs, in order to improve the capability and efficiency of advanced manufacturing methods for cost and performance considerations. Research is also needed to test the material performance at both materials and structural scales.
- It is important to understand the materials and structural performance in the marine environment, when different types of mechanical and environmental loadings are considered. The materials and structure's load carrying capacity, damage pattern, deterioration and degradation, and long-term durability need to be tested.
- Corrosion is a major issue for steel structures. Corrosion is also a concern for concrete structures reinforced by steel rebars or post-tensioning rods. Research is needed on corrosion-resistant materials for substructure and foundation components to ensure safety, prolong service life, and minimize life cycle maintenance costs and environmental impacts.
- Stronger and tougher materials are needed for offshore wind structures. For example, a concrete that can have strength triple that of normal concrete and damage resistance 10X normal concrete, would lead to less material use in structural design, lighter structures for easier lifting and installation, and can last longer and have much less maintenance requirements to reduce costs.
- Advanced manufacturing methods must be coupled with testing the performance of the structural components made by this manufacturing approach. They cannot be separated. Connections can be important "weaker links" that need to be tested. The manufactured structural components need to be experimentally studied and validated at the reduced laboratory scale to gain confidence before any field implementation and demonstration.
- The field performance of offshore turbine structures need to be monitored long term. Such performance includes cracking, damage, deformation, degradation and deterioration. Considering the difficulty and costs of installing structural health monitoring systems in the offshore environment, novel self-sensing structural materials can offer an innovative approach for long-term, in-situ monitoring with more reliable

data, without the need of installing and maintaining expensive sensors, and can significantly reduce costs and labors.
- Life cycle assessment is needed to compare and evaluate the impacts of different materials (conventional vs. new) and manufacturing technologies.
- While this is a rapidly emerging area with lots of exciting new technologies being developed, it becomes crucial to educate and train the next-generation workforce so they're well prepared to enter this industry. Applied university research can be a great vehicle for this mission to bring much broader impacts to the industry as well as the general public.