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Topic: Offshore wind and mineral symbiotic harvesting

Offshore Platforms for Harvesting Renewable Energy and Minerals from Seawater

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This paper studies how offshore oil & gas platforms could be used for supporting renewable energy and seawater mineral extraction systems. In the Gulf of Mexico there are thousands of platforms and we consider location, age, type of platform, depth of water, ownership, and plans for continued use or decommissioning. The platforms are then assessed for ability to support wind turbines, wave energy, and/or machines for extracting minerals from seawater [1,2]. Once categorized in terms of the overall structure and water depth, modular design for renewable energy and mineral harvesting systems can be created.

Offshore wind energy systems are estimated to cost 2-3X onshore costs, as they have the added costs of mooring, and undersea transmission, and use 6-9X as much steel as onshore wind turbines. However, their capacity factor can be higher and they can be closer to coastal population centers where the power is needed, thus potentially having a competitive levelized cost of energy (LCOE). To date we have studied how offshore wind turbine structures could be used to also support wave energy harvesting and seawater uranium extraction machines to help lower costs. Even further cost reductions might be achieved if decommissioned oil and gas offshore platforms could be utilized. In addition, active oil and gas offshore platforms could also serve as mounting structures for wave energy harvesting.

The US Bureau of Safety and Environmental Enforcement estimated as of Sept. 2012, there were about 2,996 platforms in the Gulf of Mexico [3]. Assuming each could be retrofitted to harvest 5 MW of renewable power, a potential 15 GW could be harvested. Given platform size, we estimate they could also support uranium harvesting equivalent to power generation on the order of 50-100 GW. Vanadium is collected as a by-product of uranium harvesting and is needed for vanadium redox energy storage batteries. Platforms in water deeper than 100m could also be used to support machines for harvesting of cobalt [4].

It would be unlikely that a large wind turbine could be attached to an active platform. However, wave energy converters (WECs) could be attached to offshore platforms. Figure 1 shows concepts considered for WECs that show promise for extracting power using a Wells turbine. These could be attached to the platform legs. Figure 2 shows performance estimates [5].

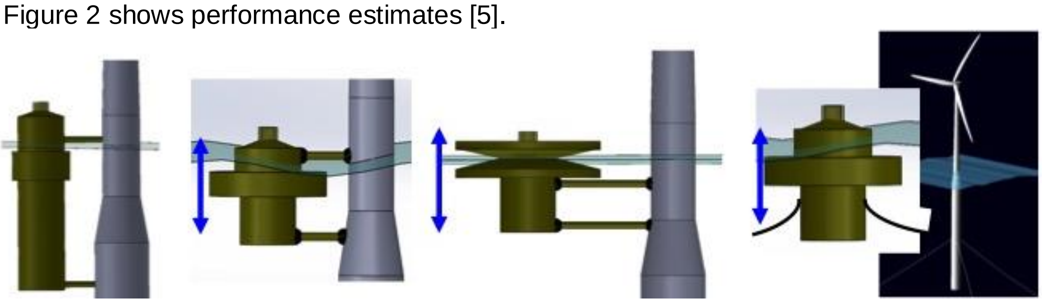

Figure 1 Concepts for wave energy converters for attaching to offshore platform legs or wind turbine structures: 1) rigidly connected, 2) hinged, 3) hinged WEC with nonlinear hydrostatic stiffness, 4) moored separate structures.

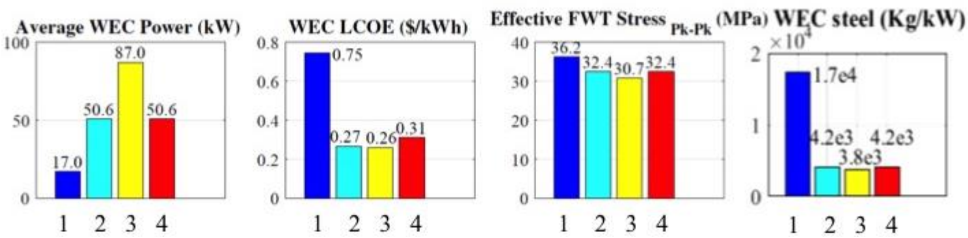

Figure 2 Operating properties for wave energy converters of Figure 1.

Perhaps even more important than renewable energy harvesting is harvesting of rare and valuable minerals that are dissolved in seawater, for example, uranium for nuclear power plants, and cobalt and vanadium for batteries. In particular, the expanded use of nuclear power has the potential to significantly reduce carbon dioxide emissions from power generation: One gram of U^{235} can produce as much energy as burning 1.5 million grams of coal [6]. However, at the current consumption rate, global conventional reserves of terrestrial uranium (approximately 7.6 million tonnes) could be depleted in a little over a century [7]. As these reserves decrease, uranium is expected to come from lower quality sites leading to higher extraction costs and greater environmental impacts. Fortunately, the ocean contains approximately 4.5 billion tonnes of uranium, present as uranyl ions in concentrations of approximately 3 ppb [8, 9]. A sustainable way to harvest uranium from seawater will provide a source of nuclear fuel for generations to come. It will also give all countries with ocean access a stable supply of uranium, thereby eliminating the need to store spent fuel for potential reprocessing, and helping to address nuclear proliferation issues.

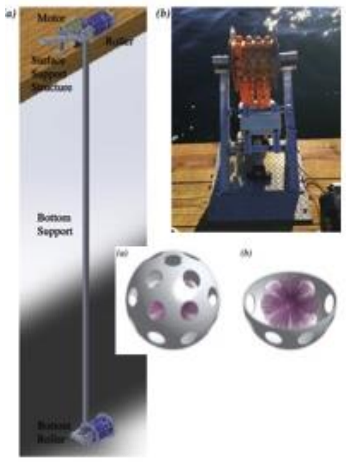

Figure 3 Outer protective sphere encapsulating a soft, inner mineral adsorbent: Solid model of a mineral absorption system and the 1/10 scale system tested at the ocean.

Polymers used to adsorb minerals from seawater require irradiation to induce grating of ligands such as amidoxime which provide mineral affinity. However, this irradiation process embrittles the materials [10]. Figure 3 shows how we have been able to decouple mechanical and chemical functional requirements for mineral adsorption from seawater through the use of a tough, outer protective sphere encapsulating a soft, inner adsorbent [11]. The outer sphere features holes to allow adequate seawater flow to the adsorbent interior. Figure 4 shows the model of the shell enclosure and a 1/10 physical scale system prototype of a uranium harvesting system tested at the Massachusetts Maritime Academy [12].

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