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Policy Perspective: Externalities of Developing Floating Offshore Wind Turbines

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Abstract

Offshore wind industry is a growing renewable energy source that has barriers for implementation like many other energy sources. It is key to identify both positive and negative externalities associated to implement well thought out policy. Policymakers must use a future oriented frame of mind to execute lasting successful policies that will impact the future direction of the offshore wind industry. Floating offshore wind technology is a growing tool for the expansion of the industry with its own new and varying effects. As more information and technological advancement comes there will be greater understanding of the externalities that come with the implementation of this new technology. This policy perspective paper will discuss the known externalities associated to direct future policy creation.

Keywords: Offshore wind, Floating Wind Turbines, Energy Transition, Externalities, Renewables

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Introduction

The offshore wind industry has the potential to become a leading industry in the United States as a force to combat global greenhouse emissions, rivaling that of solar, nuclear, hydroelectric and geothermal. President Biden's Administration proposes a goal of reaching 30 gigawatts (GW) of offshore wind by the year 2030 and 100 GW by the year 2100 (White House, Office of the Press Secretary, 2021). This objective is a key part of Biden's ambitious goal of reaching a net zero emissions future in the United States. Offshore wind is a growing industry with one current project operating off the coast of Block Island, Rhode Island, while many more under construction, in the permitting, leasing or planning phases. Many of the current proposed or planned commercial offshore wind turbine developments are along the east coast of the United States. This is due to the currently available commercial wind turbine technology and the specifications needed for these offshore wind turbines to be installed. The offshore wind industry is going to have to hurdle significant challenges and expand its planned development or it will hinder the successful completion of Biden's goal by 2030 and 2100.

There are many barriers to the implementation of offshore wind turbines due to technological specific specifications, but there are also factors that development of wind turbines have faced. These include pushback from environmentalists, fishermen and coastal residents who feel as though the development of offshore wind farms negative externalities out way the overall benefit that they would have to society. Some of these negative externalities include the destruction to species, impact in fishermen's livelihood or the fact that they are an eyesore. While these barriers may not seem insurmountable when implementing offshore wind projects, in fact that they have been in the past. These lead to the demise of the Cape Wind offshore project back in 2015. Throughout this paper the policy perspective on the future construction of floating offshore wind turbines will be constructed through the analysis of the externalities associated with this future technology. This analysis will make use of the topic of externalities found in Ethan Bueno de Mesquita's "*Political Economy for Public Policy*." This paper will first describe the background behind floating offshore wind turbines, then the negative and positive externalities associated with the new technology and concluding with a recommendation for future policy implementation of floating offshore wind technology.

Background

Offshore wind is a great source of renewable energy for the United States and has seen success in countries around the globe. There is a need for a larger number of commercial offshore wind sites along the United States, but there is a problem. Current offshore wind turbines that are listed in development plans along the United States and throughout the globe are predominantly known as fixed wind turbine structures. Fixed offshore wind turbines have foundations such as gravity base, monopile, tripod and jacket foundations, which need to be installed in water depths of less than 50 meters(m) (Wu et. al., 2019). A water depth that is greater than 50 m results in an economically infeasible model because the cost to construct a turbine of that size is not worth the amount of resource that can be exploited. Wind speed is also a critical factor for the location of fixed turbines. According to the U.S Energy Information Administration (EIA), the optimal wind speed for a small wind turbine is approximately 9 miles per hour (mph) or 4 meters per second (m/s) while utility scale wind turbine's optimal wind speed is 13 mph or 5.8 m/s (EIA, 2021).

Floating offshore wind turbines are a relatively new technology that has not seen large commercial development within the United States. In fact, the first floating offshore wind array consists of five turbines off the coast of Scotland (Hockenos, 2020). There are also projects being constructed in other locations of Europe and Japan at a much greater size. This new and evolving technology has primarily three different setups which include buoyant substructures known as: Spar, Semi-Submersible, and Tension Leg Platform. All these installations use mooring lines that are connected to the substructure and can be attached to the sea floor with a depth of up to 1000m (Jiang, 2021). This increase in depth creates a greater potential for future offshore wind energy that can be harnessed that we will explore below.

Question & Hypothesis

The question being asked is: Will the positive externalities of future implementation of commercially sized offshore floating wind turbine technologies outweigh the negative externalities, thereby demonstrating the importance for this technology in the future growth of the offshore wind industry? I hypothesize that the use of offshore wind turbines will advance the wind industry's future growth through limiting the barriers of "Not in my backyard" arguments (NIMBY), opposition of environmentalists and fishermen, and allowing the United States to harness potential economic development and reduce cost of electricity.

Analysis

Offshore wind potential has not been fully harnessed without the use of floating offshore wind turbines. As stated above, in the EIA there are certain water depths and wind speeds that inhibit the future installation of fixed offshore wind turbines. Currently, the offshore wind industry is missing out on wind power potential in the Pacific and other waters that are deeper than 50 meters. A study on Wind Energy Resource Assessment done by the National Renewable Energy Laboratory (NREL) can give one a good understanding of the potential of offshore wind energy as shown in the figure below.

Figure 1: Gross potential resource area showing excluded water depths of more than 1,000 m in dark blue. NREL used turbine hub heights of 100m, the capacity array was 3 MW/Km^2, energy production potential of 6MW turbine power curve, excluded areas with a depth greater than 1000m and excluded wind speeds less than 7 m/s (Musial et. al., 2016)

Figure 1 illustrates the potential for offshore wind resources through depicting the depth and distance from shore. NREL states that the gross offshore resource capacity for the United States is 10,800 GW and technically feasible is 2,059 GW according to this study (Musial et. al., 2016). Technically feasible area demonstrates the GW that would be able to be harnessed by current, non-floating wind turbine technology due to a water depth that is acceptable for their installation. The gross offshore resource capacity for the United States uses depths of greater than 60 m, a boundary of up to 200 nautical miles (nm), 3 MW/Km^2, gross capacity factor from open wind and the losses from that capacity factor through wakes, electrical, availability, etc. Thus, there is a huge renewable energy potential that can be harnessed with the future development of offshore floating wind technology on a commercial scale. Renewable energy production using wind can be signified by the International Renewable Energy Agency (IRENA) calculator which back in 2018 stated that there was, "275,834 GW hours resulting in the avoidance of 213.8 million tonnes of Carbon dioxide emissions from fossil fuels," (IRENA, 2021). As the production and implementation of renewables become greater, this avoidance of emissions will continue to grow which in turn mitigates the devastating effects of climate change.

There is great potential for future offshore wind development, but what is the economic cost and future forecast of offshore floating turbines that would make this newly evolving technology economically feasible in comparison to fixed offshore wind turbines? I will be identifying how the Levelized cost of energy (LCOE) and Levelized avoided cost of energy (LACE) play a factor in the future forecast of economic feasibility of offshore floating wind turbines. LCOE is the total cost of generating a unit of electricity and is commonly expressed in dollars per megawatt hour (MWh) and factors in variations due to energy production (e.g., average wind speeds, etc.) and capital expenditures (e.g., varying sea states, distance from shore, water depth, soil and substructure sustainability, etc.) (Musial et. al., 2016). The LACE is known as levelized avoided cost of energy and is a metric used to capture the system value of generation electricity. The metric is used to approximate the electric system value of a generational technology over its expected lifetime and commonly expressed in dollars per MWh (Musial et. al., 2016). In short, LCOE refers to estimates of revenue required to build and operate floating offshore wind turbines over a certain period of time where cost can be recovered, while LACE refers to the revenue that can be generated during that period.

Using LCOE and LACE we can determine the net value in dollars per megawatt hours by subtracting LACE from LCOE. This will help determine future forecasts for the economic feasibility of offshore floating wind turbines. If LACE cost is high, the LCOE is bound to decrease due to the expansion of new commercial developments of offshore wind lowering the cost of dollars per megawatt hour. Once the LACE becomes higher value then LCOE a floating offshore wind turbine site is economically feasible. As illustrated in the figure 2 below, one can distinguish (net value >0) the economic feasibility for some wind sites are valued. This trend will continue through the year 2030 and the future creating an advantage for the use of floating offshore wind turbines.

Observers have been recorded to see offshore wind turbine facilities from up to 44 km (27 miles) (Sullivan et. al., 2017). According to the figure below the optimal distance for a suggested sight based off LCOE and LACE is approximately 72 km which is much farther than the observable distance of offshore wind turbines. The site has a water depth of 221 m and 72 km from site to cable landfall. Its LACE of $103/MWh (green star) compares to an LCOE of $92/MWh (blue star) by 2027 (Musial et. al., 2016). Since its LACE is above its LCOE this site will be economically feasible by 2027.

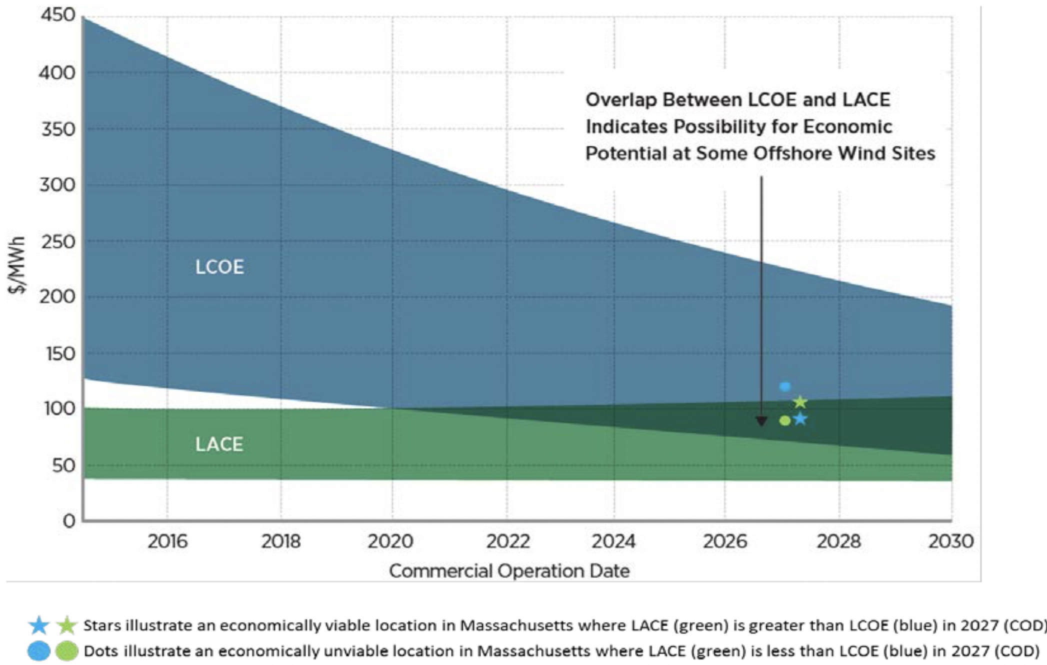

Figure 2: Comparison of LCOE and LACE estimates from 2015 to 2030 (Musial et. al., 2016)

Floating offshore wind turbines are currently cost prohibitive due to their new technology creating high costs to construct. Looking at the figure below, the future cost reduction scenario for floating and fixed turbines shows the future forecast for their ranges of LCOE through the year 2030. The lower range of LCOE estimates among all U.S. offshore wind sites indicates a decline from $130/MWh in 2015 to $95/MWh in 2022, to $80/MWh in 2027, and $60/MWh in 2030. The upper range of LCOE estimates among U.S. offshore wind sites shows a decline from $450/MWh in 2015 to approximately $300/MWh in 2022, $220/MWh in 2027, and $190/MWh in 2030. These reference scenarios represent averages for and not any specific Bureau of Ocean Energy Management (BLM) lease area or site (Musial et. al., 2016). One can identify that the LCOE for floating technology is significantly higher in 2015, but is expected to converge with fixed bottom over time. In fact, it looks to have a lower LCOE by the year 2030 and will continue to become lower throughout time. The reason for these lower LCOE at sites is due to strong wind resources resulting in net capacity factors between 40% and 60%, proximity to onshore grid interconnection, shore-based port facilities, and other relevant locations.

Another large proponent for the opposition of offshore wind developments are fishermen. In a case study done in Scotland and Germany we can analyze the results in the figure below. The main concern for fisherman's opposition of the offshore wind industry is the limited data on the safety risks, data availability regarding effects on marine organisms and ineffective communication creating a large divide. Below is a representation of the surface of an ever-evolving discussion between the fishing industry and offshore wind industry. In figure 4 there have been a list of factors identified by three major stakeholders of the offshore wind industry; the offshore wind developers, the government and the fishing industry, according to the study. In both case studies it was identified that there were several drivers and barriers to implementation of offshore wind turbines developments. The results illustrated that the positive effects outweighed the negative effects by 18 (positive) to 7 (negative). These barriers and drivers illustrated both negative and positive effects. Some included: noise impacts, indirect cost to consumers, artificial reefs, benefits to local economy, etc. It can be identified that the positive effects outweigh the negative effects in this figure due to the number of factors identified in the study, but it is important to understand that this is data at the beginning. The fishing industry does not feel as though there is adequate data that can solidify a decision or discussion for the future coexisting off offshore wind developments.

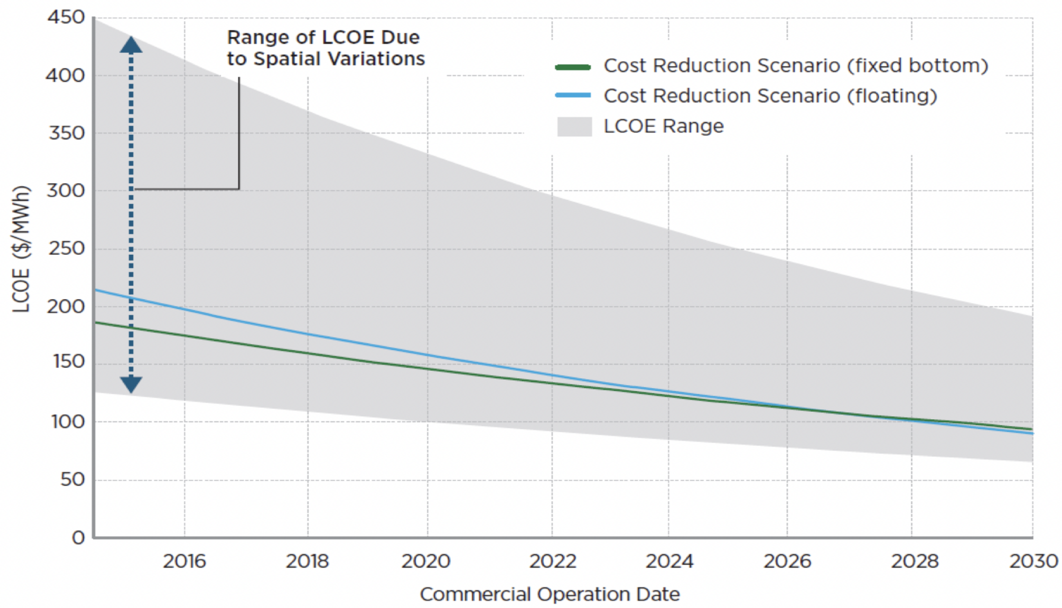

Figure 3: Levelized cost of electricity for potential offshore wind projects from 2015 to 2030 over technical resource area (Musial et. al., 2016)

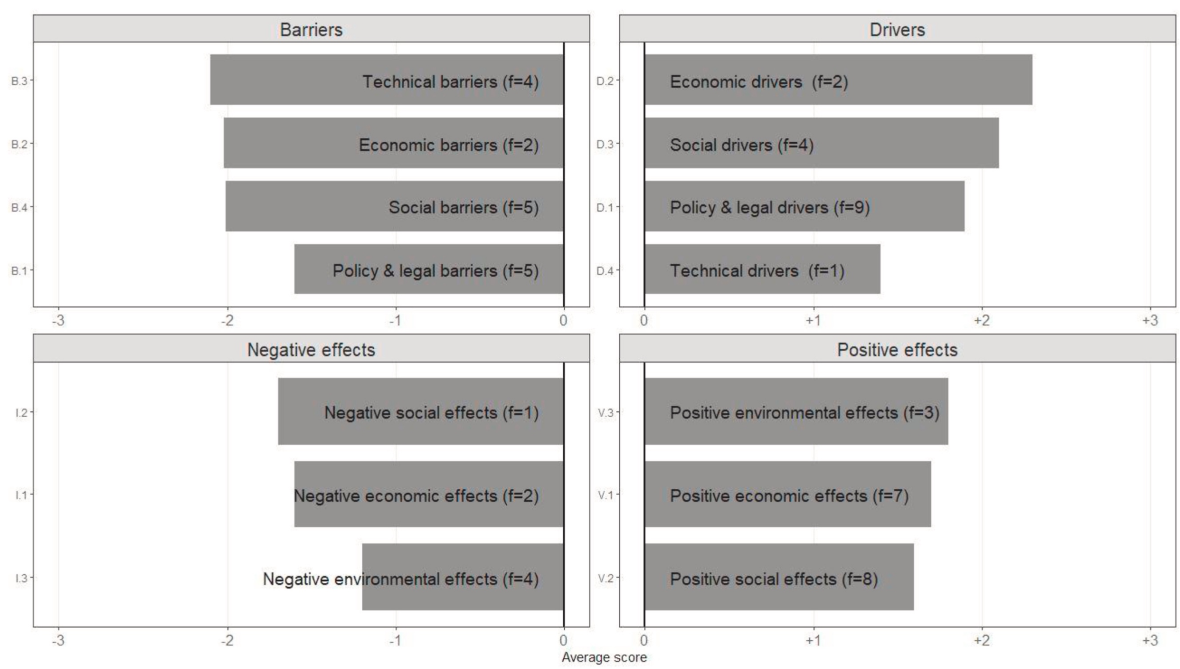

Figure 4: Identification of positive and negative effects of offshore wind in fishing industry (Schupp, 2020)

Discussion

There are several positive and negative externalities associated with the policy implementation of floating offshore wind turbine technology as highlighted in the above analysis. These positive externalities consist of reduction of electricity cost for consumers, countering the NIMBY arguments, while some negative externalities include impact of fishing industry and the environmental destruction. The discussion for implementation of floating offshore wind is a complicated issue with evolving developments.

Mesquita (2016) defines situations with externalities as, "situations in which one person's actions directly affect another person's welfare," according to his book; "*Political Economy for Public Policy*," (Mesquita, 2016, p. 100). Mesquita's idea of collective action correlates directly to the future success of the implementation of the offshore wind industry. The probability a goal is achieved is a function of the amount of people that participate as Mesquita states. The incremental benefit needs to be greater or equal to the incremental cost. If everyone participated there would be a social surplus of thousands more GW of renewable energy leading to mitigation of an extraordinary amount of greenhouse gas emissions resulting in a larger utility pie. Therefore, a policy intervention such as implementation of floating offshore wind technology would have everyone participating, which in turn would be a Pareto improvement. A Pareto Improvement can be defined by Mesquita as "a policy change that is unambiguously in the public interest" (Mesquita, 2016, p. 76). This will be supported by further assessments made throughout the paper.

In the past Mesquita has found that many people didn't participate because their expected costs didn't outweigh their expected benefits. An example of this for the offshore wind industry is the demise of the Cape Wind project in 2015. A new development of offshore wind was shut down because citizens believed that the expected cost of having to see the offshore wind turbines outweighed the potential to create GW of renewable energy for consumption. The future policy implementation of floating offshore wind will successfully address this previous argument that was so detrimental to the Cape Wind project of 2015 because optimal location for offshore wind is farther away than the human eye's capability to see.

The policy implementation of the floating offshore wind technology and the creation of renewable energy, a clean source of energy aimed at mitigating the devastating effects of climate change, reduce the greenhouse gas emissions that would otherwise be emitted by an alternative source of energy. This falls under Mesquita's idea of the ubiquity of incentives that lead to the under-provision of public goods. Public goods in this case are both non-excludable and non-rival, both defining characteristics of public goods. Everyone has access to positive externalities of renewable energies effects of the mitigation of carbon emissions without diminishing the supply of leftover goods.

The second-best policy is a way to describe the implementation of floating offshore wind technology. As Mesquita states, "it is policy that maximizes the utilitarian social welfare, taking into consideration all the various effects of the policy." (Mesquita, 2016, p. 126) While some of the negative externalities include ecological destruction and impact to the fishing industry, these policies are dominated by other effects. These effects include future reduction of electricity cost, mitigation of devastating effects of climate change and squandering of NIMBY argument. These policies dominate the second-best policy discussion.

Conclusion

This policy perspective is a preliminary discussion of the full scope of the implementation of commercial floating offshore wind turbines. Further research analysis will need to be conducted as more literature becomes available to comprehend the full scope of the externalities present. This paper was only able to discuss a select few that would help the reader best understand the future direction of the subject matter.

The question I had identified and looked to answer was: Will the positive externalities of future implementation of commercially sized offshore floating wind turbine technologies outweigh the negative externalities, thereby demonstrating the importance for this technology in the future growth of the offshore wind industry? Part of my hypothesis was correct in identifying that the policy implementation of floating offshore wind technology would lead to reduced cost of electricity, reducing arguments of NIMBYs and lead to economic development. There are still issues concerning environmental destruction and pushback from fishermen that will continue to be studied and analyzed as technology continues to advance.

The future implementation of floating offshore wind technology has many positive externalities which have been discussed above. These positive externalities identify that this future policy implementation will be better understood through the second-best policy lens. There will be various effects of this policy that will continue to be created in the future, but the overall development of positive externalities this future policy implements outweighs the negative externalities. Just as the offshore wind industry started with fixed turbines, future policy implementation and policy will continue to mitigate the negative externalities associated with the growing wind industry. Therefore, it is my assessment that the future of the offshore wind industry is heavily reliant on the technological advancement of turbines. Future research should explore the challenges and policy needed to be implemented to successfully and efficiently transmit this growing renewable technology to the national grid to promote greater energy security and independence. This in culmination with future research and data on impact on marine life would help policymakers break significant barriers in the future implementation of floating offshore wind technology.

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