Advancing Clean Energy:

Cost and Policy Options Analysis for Statewide Offshore Wind Procurements

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Honors Degree in Major with Distinction

May 23, 2022

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ACKNOWLEDGMENTS

I would like to thank my thesis advisor and research mentor, Dr. Willett Kempton, for his support and advice throughout this process, as well as his role as lead author on the Delaware SIOW procurement report. I've worked with Dr. Kempton since Spring 2020, and the vast majority of my understanding offshore wind policy comes from his depth of knowledge. I would also like to thank Kris Ohleth, Director of the Special Initiative on Offshore Wind (SIOW) and Amy Bosteels for their work as authors on the Delaware report and dedication to offshore wind research. I was co-author on the SIOW report and draw on it extensively in chapters 2, 3 and 4 of this thesis.

Other critical contributors include Dr. Cristina Archer, second reader, and Dr. Monique Head, third reader, both of whom sat on my defense committee and provided critical feedback. Dr. Head also administered two mid-semester progress reports which helped with my defense presentation and content organization. Lastly, I would like to thank all stakeholders that are engaged by the wind power conversation, namely Delaware's environmentally-engaged policymakers and groups who allowed me to participate in their sessions: the League of Women Voters, Interfaith Power and Light, and People for Offshore Wind Energy Resources. This research wouldn't have been possible without their contributions.

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ABSTRACT

This thesis describes the process in which a non-profit group provides expert guidance to a state government for an offshore wind procurement, which I recently participated in. It then details the initial reactions to that process from officials, local media, and engaged members of the public. Such examples of expert guidance have been published by the Special Initiative on Offshore Wind (SIOW) for the state of New York, the Commonwealth of Massachusetts, and, as described here, the state of Delaware. Discussion is mostly focused on wind procurement potential for Delaware, following recent publication of the SIOW cost analysis report for this state. Chapters 2, 3 and 4 of this thesis paraphrase data and context from the Delaware SIOW report, which was written by myself and three other authors. The remaining sections are my analysis of the reactions to the report.

This thesis begins with context about the offshore wind industry in Delaware and in nearby states. It also includes an explanation of an offshore wind procurement process. Then, the literature review considers existing research on the national and state wind power markets, external benefits of wind power, and pricing systems that a state may choose for a wind power solicitation. The methodology section introduces the two primary topics for further discussion: cost analysis and state options presented by the SIOW report, and stakeholder feedback and reactions to the report itself. In-depth results are then provided in these subject areas. The calculated price point estimate for a Delaware offshore wind farm of 800 MW is $71.48/MWh, which is within the range of recent Delmarva wholesale electricity purchases. If human health and environmental factors are considered, the price of wind power is half that of Delmarva's recent purchase price. Options for Delaware to consider in a procurement are then provided, ranging from cost-saving metrics to job-creating initiatives. Several stakeholder meetings and media releases are also analyzed between publication of the SIOW report and May 13th, 2022. Initial data from these sources suggested that the offshore wind conversation has restarted in Delaware due to the SIOW report, but that state leaders are still reluctant to take action.

Finally, the discussion expands to the impact of the 2016 Massachusetts SIOW report, and how this illustrates the effectiveness of pre-procurement analysis. With growing international demand for offshore wind power, this thesis concludes that pre-procurement cost analyses and guidance on the procurement process enables successful offshore wind solicitations.

Chapter 1

INTRODUCTION

Wind power costs have decreased rapidly in recent years (Lazard 2020). This trend is coupled with a rising urgency for clean energy solutions as climate change continues to pose a global threat. Further, fuel-based energy sources have become less reliable in the present geopolitical realm. Now more than ever, many government bodies with coastal authority are considering offshore wind project procurements. This notion has great potential to strengthen the resilience of the grid, combat climate threats, and improve general health and quality of life. However, new wind power projects must be approached with caution; several past examples have shown that large wind projects offshore will fail if projects are not properly planned and financed.

In 2021, Delaware state environmental policy leaders asked the Special Initiative on Offshore Wind (SIOW) to produce an informative, non-biased, analytical study regarding cost analysis and state options for a potential wind power procurement. The terms of the report's delivery were outlined by a Memorandum of Understanding (MOU) between the SIOW and the Delaware Department of Environmental Control (DNREC), the latter being the agency tasked with reviewing the report prior to public release. This report was submitted to the state by the SIOW in early 2022 and serves as a case study for state pre-procurement planning. Because I was second author on the Delaware SIOW report, items that I contributed to such as context, data analysis, and outcomes will be referred to as "our" work frequently in this thesis. I also refrained from referring to this thesis as a "report," so as to avoid confusion between the two documents. The writing of the Delaware SIOW report parallels similar analyses completed for the Commonwealth of Massachusetts and the state of New York, published in 2015 and 2016 (respectively), also by the SIOW.

The series of three SIOW reports provided policymakers with projections of wind power costs for their state, in comparison to the greater energy market. They also offered states a menu of options to consider for their procurement legislation. The SIOW reports delivered necessary information for states to make economic and policy decisions regarding wind power procurements and have played a decisive role in the success of procurements in New York and Massachusetts. Now, with the recent Delaware report, there is substantial data available for decisionmakers to weigh the value of such pre-procurement writeups.

This thesis aims to document the process of providing this type of data to a state, as well as the first set of public, government, and media reactions to that data. From prior results, given that neither New York or Massachusetts had carried out offshore wind procurements at scale, this appears to be a successful process. In NY and MA, the report apparently helped to reduce consumer cost of energy and maximize the success of an offshore wind power project. While this thesis is most closely tied to the research, writing, and feedback processes involved for the Delaware SIOW analysis, the research process outlined here could be applied to other U.S. coastal states that may harness offshore wind power. In the weeks after the Delaware report was released by the SIOW, several analysts, policy makers, and other stakeholders shared their relevant perspectives and opinions. This feedback and the greater conversation that it spurred was documented as a part of this thesis research.

In summary, this thesis captures the content of and reasoning behind the 2022 SIOW report as well as the report's initial impact in Delaware. It concluded that any legislature considering an OSW procurement bill should commission an LCOE and policy analysis like that completed in the states of New York, Massachusetts, and most recently Delaware.

Electricity Pricing Language and Context

When speaking of electricity prices, it is critical to understand and differentiate between units of power and of energy. The capacity of a power generator relates to the maximum amount of power that that source could produce and is usually expressed in terms of megawatts (MW) or kilowatts (kW), which are $1/1000^{th}$ of a MW. The energy produced over time is expressed in megawatt-hours (MWh) or kilowatt-hours (kWh). If a 1000 MW windfarm were to be working at 100% capacity for a full hour, it would produce 1000 MWh of electric energy over that period of time. The capacity factor (CF) relates capacity to production, therefore knowledge of the capacity factor for a wind farm is important for calculating energy production. The average offshore wind farm CF is closer to 40%, so that 1000 MW project would produce roughly 400 MW of electric power on average, or 400 MWh of energy over an average hour.

During a wind energy procurement, the developer estimates the amount of energy that a wind farm will produce over a year, based on the capacity factor and the project capacity. This is called annual energy production (AEP). The final cost of energy calculation sums all the diverse project costs in dollars, including interest, risks, and ongoing maintenance with consideration of the time value of money. That sum of costs is then divided by the AEP, with units of MWh, to yield an energy price in $/MWh. This energy price is used to compare between projects. $/MWh is typically used to describe wholesale electricity prices, while the much smaller unit of $/kWh is suitable for retail electricity costs.

Electricity prices can further be compared across energy resources if they are "levelized," which means that changes in energy prices are adjusted for over the course of a project's lifetime. This way, a single price can represent that source of energy, despite fuel cost fluctuations, price escalators, changes in the energy market, etc. The resulting levelized price of any energy source is referred to as the levelized cost of energy (LCOE). The other way to describe a renewable energy price, which is predictable in advance since it has no fuel price fluctuations, is to give the "first year energy price" and the "annual inflation rate," both of which are set at the beginning of the project.

When wind power is generated, there are several steps it must go through before it can power lights in ratepayer's homes. First, the turbines spin to turn a generator in the hub of the turbine, which produces electricity, then this electricity is transmitted through a cable that extends from the turbine to an offshore substation, where the voltage is stepped up to transmission voltage and transmitted via a new cable to shore. This cable, buried just underneath the sea floor, runs from the substation to the cable landing point, where it now must be routed underneath the beach. It continues until reaching a point of interconnection (POI) at an onshore substation, where it connects to the regional transmission grid. From other locations in the grid, the power in cables is stepped down in voltage and distributed in smaller wires until it eventually reaches ratepayer's homes, offices, and industries.

Delaware's Wind History

Although Delaware is the only Northeast coastal state between Virginia and Massachusetts without an active offshore wind procurement process as of early 2022, its history is deeply intertwined with the industry. Delaware, in fact, awarded the first offshore wind power purchase agreement (PPA) in 2008 for the NRG Bluewater Wind project. The company was granted authority to build as much as 600 MW of offshore wind generating capacity. 200 MW of this was purchased by Delmarva Power and Light, Delaware's sole publicly regulated utility (Offshore Wind Hub 2019). State leaders were excited to launch the nation's commercial wind power in Delaware; unfortunately, it proved difficult to build at the price agreed to, and the project's lease area was sold to Orsted's Deepwater Wind in 2011 (Offshore Wind Hub 2019). Their initial bid was to sell power at $0.14/kWh, but in hindsight NRG likely would've needed a $0.17 or $0.18/kWh price for the project to be financially sufficient. Today, these prices are much higher than what can be expected for wind power.

After the Bluewater Wind project failed, there was little talk of offshore wind in the state for several years. The conversation was restarted with the Offshore Wind Working Group, established by Governor John Carney in 2017. Working group members included industry leaders, policymakers, and members of the public. Initiation of the working group began after the state of Maryland approved 2 offshore wind projects, one of which was planned on Bluewater Wind's re-sold lease area. According to a 2018 report from the group, Maryland developers at this time had interest in extending the project to sell energy to Delaware (Burcat et al. 2018). The working group concluded in their report that "Delaware should not move on the immediate procurement of offshore wind energy from a project already approved by another state" (Burcat et al. 2018). They concluded overall that the cost of power from offshore wind was too high at that time.

This report brought any state policy consideration of offshore wind to a halt, and the legislature has seemed hesitant to revisit the topic since. With Delaware's tumultuous past regarding the offshore wind industry, there may be more future political obstacles to a procurement initiation than other states have experienced. With the new SIOW report, legislators now have access to updated cost estimates that represent the current wind energy market. These numbers have the potential to spark a new offshore wind conversation in Delaware and address the state's concerns that renewable energy will never be affordable or worth investment.

Present Northeast U.S. Wind Market

Even though the state of Delaware's political dialogue has minimally discussed wind power since Bluewater Wind's downturn, in other east coast states the industry has progressed rapidly. The Delaware SIOW report stated that 14,000 MW or 14 GW of offshore wind projects have been awarded on the East Coast, with the expected industry spending through 2035 estimated to be $109 billion. The report also indicated that the American Wind Energy Association (AWEA) anticipates that 45,000 to 83,000 jobs will be created by the offshore wind industry between now and 2035. Table 1 below is taken from the Delaware SIOW report. It lists the U.S. offshore wind projects that have successfully completed power procurements, all of which are on the East Coast and are at varying stages of development.

Table 1 US Offshore Wind Purchase Agreements.

Project	Capacity (MW)	State	Net CF (%)	Year 1 (COD)	Year 1 Price ($/MWh)	Price Escal. Rate (%/year)	PPA or OREC Tenure (years)	PPA Price, Levelized Real 2021$ ($/MWh)
Revolution	400	RI	46.6%	2024	98.43	0	20	$79.3
	304	CT	46.6%	2024	99.5	0	20	$80.2
South Fork	90	NY	46.6%	2023	160	2%	20	$153.8
	40	NY	46.6%	2023	86	2%	20	$82.7
Sunrise Wind	880	NY	44.0%	2024	110.37	0.0%	25	$86.1
Empire Wind	816	NY	43.0%	2024	99.08	2.0%	25	$93.4
Empire Wind 2	1260	NY	43%	2026	107.5	0	25	$83.9
Beacon Wind	1230	NY	49%	2028	118	0	25	$92.0
Atlantic Shores	1509.6	NJ	44%	2028	86.62	2.50%	20	$78.7
Ocean Wind I	1104	NJ	44%	2024	98.1	2%	20	$92.4
Ocean Wind II	1148	NJ	44%	2029	84.03	2%	20	$71.7
Skipjack 1	120	MD	43.3%	2022	$166.0	1.5%	20	$155.7
Skipjack 2	846	MD	44.2%	2026	$86.3	3.0%	20	$85.6
US Wind 1	248	MD	42.1%	2022	$166.0	1.0%	20	$155.0
US Wind 2	808.5	MD	35.5%	2026	$71.5	2.0%	20	$64.7
Vineyard Wind	400	MA	49%	2023	74	2.50%	20	$75.6
	400	MA	49%	2023	65	2.50%	20	$66.4
Mayflower Wind	804	MA	49.0%	2025	70.26	0	20	$55.7

Table 1 provides a great deal of information about the quantity of offshore wind projects that have successfully contracted for power and what states they're concentrated in. The project capacity, capacity factor, first expected year of operation, year 1 energy price, price escalator rate, project lifespan, and levelized price are also provided.

The prices vary quite a lot, with some patterns in price observable in Table 1. Note that the cheapest PPA contracted prices in 2021 dollars have later commercial operation dates (CODs) and that more expensive wind power projects will power-on sooner. This suggests that the cost of wind energy on the east coast is declining and that later procurements may have even cheaper costs of energy, if the trend continues.

A 2021 Delaware Public Service Commission (PSC) presentation by Liberty Group helps to contextualize the state and regional energy market. The Liberty Group presentation included crucial data regarding Delmarva's recent electricity purchases. Since Delmarva is Delaware's largest utility company, research into their recent electricity costs provides a good benchmark to compare to projected wind energy prices for the state. Liberty Group (2021) reports that wholesale power bought by Delmarva between 2015 and 2021 ranged from \$53 to \$82/MWh.

This electricity is mostly from conventional resources, a significant percentage of which would be replaced with offshore wind power if the state were to procure a commercially viable project of at least 800 MW capacity (further details given in results section). Delmarva's purchases are comparable to the wholesale electricity prices listed in the rightmost column of Table 1. Eight of the projects reported here are contracted to sell power within Delmarva's recent purchase price range, with power-on dates ranging from 2023 to 2029. The data suggests that commercial-scale offshore wind power on the East Coast, in states as close to Delaware as Maryland and New Jersey, can be sold as cheaply as electricity from conventional resources. This cost comparison is critical to understanding the maturity of the wind industry in the U.S. and the economic competitiveness of an offshore wind procurement for the state of Delaware.

Procurement bill to PPA: Steps of a Power Solicitation

Since the SIOW reports were written to as a guide to a potential procurement that could follow the report, their content is only fully understood within the context of procurement activities. For the sake of clarity, these procurement events will be numbered chronologically in the explanation below. A report like those commissioned by New York, Massachusetts and Delaware can be considered an optional "step 0" before the procurement is officially initiated.

The relevant steps are as follows:

1. <u>A procurement bill is written by the state legislature and passed</u>.

This bill will assign a particular state agency with the responsibility of overseeing the newly initiated procurement process.[1] Past examples show that the procurement bill can include guidance for what the state legislature would like the developer to provide, i.e., whether the project should prioritize a lower cost of electricity or local job creation. Since there is no template for what this bill may look like, it is up to the state to provide as much or as little guidance for what they'd like the final project to look like. To give an example, Massachusetts HB4568 provided a deadline for proposal submission, the total capacity of wind power to be procured, notice of the Renewable Energy Credit (REC) system by which the procurement would operate within and objectives

[1] In Delaware, the agency may be the Delaware Department of Natural Resources and Environmental Control (DNREC) or the Public Service Commission (PSC). The scopes of both agencies – environmental and electricity concerns, respectively – each overlap with offshore wind. In the Massachusetts procurement for Vineyard Wind I their chosen agency was the Department of Energy Resources, which is analogous to DNREC for Delaware. Note that VW I is a project currently under construction and that resulted from the process prompted by the 2016 SIOW report. Also note that the above-mentioned REC system will be explained further in later sections.

for the winning project.[2] The state of Delaware may add more or less regulation than HB4568, with tradeoffs in either regard: if the legislation is more detailed, state representatives and senators would have a greater say in later procurement steps, however this comes with the added risk of giving too much red tape to the developer that could increase the cost of electricity. The SIOW reports, especially that written for Delaware, aimed to educate state policymakers so that legislation could be written carefully and to the benefit of all stakeholders.

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[2] HB4568 outlines the following requirements for proposals, to be integrated into MA Department of Public Utilities regulations: it must provide reliable electricity, help to reduce spikes in electricity prices typically seen in the winter; be cost effective for ratepayers throughout the term of the contract, mitigate transmission costs, demonstrate project viability within a reasonable timeframe, allow for potential pairing with energy storage systems, mitigate environmental impacts, and foster economic development and employment in the state. They also add that "the Department of Energy Resources shall give preference to proposals that demonstrate a benefit to low-income ratepayers in the commonwealth, without adding cost to the project" (Massachusetts House of Representatives, 2016).

2. The responsible state agency writes and publishes a Request for Proposals (RFP).

   This RFP is addressed to offshore wind developers with WEAs nearby the state at hand. It can, like in the case of Massachusetts, be written in conjunction by the state agency and publicly regulated utility companies that will eventually buy wind power. The document typically interprets and elaborates on any terms and conditions for the procurement that may be set out by the state legislature in their bill. The Massachusetts RFP for VW I (2019) identified an evaluation team for reviewing proposals and the stages of their review, compared statute within the procurement law to the RFP, listed components for bidders to include in their proposal, and specified preferences of the evaluation team for proposals. Over the course of 90 pages, this document provided a lengthy but thorough set of instructions for developers to shape their responses.

3. Interested developers design and submit a proposal (bid) for a given electricity price from a specified project.

   Once the RFP is public, developers can form a response, typically in the form of a several-hundred page package with marketing prompts, site design layouts, and cost of energy (based on their private estimates for every part of the project). This large report is the developer's proposal. It serves to convince the evaluation team that this company can follow through with the construction and operation of a wind farm due to their comprehensive project design, financing and experienced team. The developer also wants to prove that their project design is better than any other competitor, taking heed to the preferences outlined by the state legislature and evaluation team. They will highlight any job creation in the area, speak to why their particular transmission cable landing route is best, and even promise large sums of money to locally important efforts (i.e. marine mammal research or to better a state's coastal municipality). These are all meant to impress the evaluation team and tip the balance in favor of one developer or another, along with the proof that this is all feasible. This proposal is intertwined with the developer's bid price, which is simply the wholesale price that they plan to sell electricity for. Of course, if this price is low, it is a selling point in the proposal. Calculations for that price are explained transparently in the proposal, however the value of the bid price has independent worth and is the most important outcome of this step in the process.

4. After the deadline for bidders (developers) to submit, the state reviews all bids received and picks a winner.

A single procurement process may yield several bids that have to be reviewed by the evaluation team. While it may be time-intensive to review multiple proposals, we pointed out in the SIOW report that this is in the best interest of the state, since increased market competition can help lower electricity bids. Given the conditions of the legislation and the RFP, along with the developer's demonstration of their competency, ability to deliver a project, adherence to the state's wishes, and bid price, the team picks the best developer and awards them with the project.

5. <u>A Power Purchase Agreement (PPA) is written and signed by the seller of electricity (the developer) and a utility company (the buyer).</u>

   The PPA is the final step of the procurement, as it signifies the decision being made for who is contracting to buy and sell power. Both parties agree to the developer-specified bid price and to the amount of time that energy will be sold (typically around 20 years), along with any price escalators or other financial conditions that may exist for the project.

These steps, while generally stated here, are quite intricate processes that take several years to fully complete. These, along with several federal requirements, must be satisfied before construction of the wind farm can begin.

Stakeholders in a Delaware Wind Power Procurement

In any procurement process, many entities are considered stakeholders beyond those buying and selling power in a PPA. A primary stakeholder, and one that we underscored in the Delaware SIOW report, is the ratepayer of electricity that is sold by the utility company. Their funds are what allows the utility company and the developer to make a profit, and it's their lights that the wind power will keep on. The final cost of wind energy has a direct economic impact on this group. Since ratepayers of a large public utility company may comprise many people in a state, their satisfaction with a potential project can be translated back the seat of power and influence the state legislature's decisions in a procurement. As insinuated previously, the state government is also a major stakeholder due to the legislature's role in writing and passing procurement bill, the state agency and governor's office that oversee the procurement process, and the agency that mediates the final PPA. And of course, potential developers and utility companies are active commercial stakeholders throughout this process.

Another key stakeholder is the regional transmission operator (RTO). The RTO (sometimes referred to as an ISO, or independent system operator) is a company that manages the "grid." It has to evaluate whether added power can be passed through the transmission system from the developer to the utility company. The developer is responsible for transporting the electricity that they generate up to a point of interconnection (POI), usually an onshore substation managed by the RTO. The RTO runs large cables from this substation to the utility companies for further distribution. All sources of energy plug into the grid and have their electricity sold after interconnection, with the exception being "off-the-grid" sources such as distributed solar power from rooftop photovoltaic panels. RTOs in the U.S. tend to be large organizations that oversee power distribution for several million people each. The RTO that operates in Delaware, for example, is PJM, which also manages power for the rest of the Mid-Atlantic region.

Slightly less obvious but still viable stakeholders include beach communities and the tourism industry. Since power must find its way to the POI, transmission cables must pass under or overhead the beach and be routed inland, under or overhead. Therefore, the potential disruption to coastal municipalities during project construction constitutes these communities as stakeholders. Furthermore, while many want wind turbines to be invisible onshore, many areas with instituted wind projects have recognized an increase in tourism after a project's construction. While turbines may still be undetectable to the naked eye from a state's beaches, an offshore wind visitor center with a display showing wind speed and power produced, and with telescopes or binoculars could be a draw for those who want to see clean energy in progress. A state's tourism industry could benefit as a result.

In a procurement, the federal government is very involved, specifically the Bureau of Ocean and Energy Management (BOEM). While federal processes are largely out of the scope of the SIOW reports to state governments, it is still important to note the involvement of BOEM in auctioning ocean space to developers as Wind Energy Areas (WEAs) and in reviewing the developer's Site Assessment Plan (SAP) and Construction and Operations Plan (COP) for approval. The developer must work to appease state leaders as well as federal administrators before their project can be picked.

The commercial fishing industry is a stakeholder due to their use of vast swaths of offshore space. The introduction of wind turbines threatens that autonomy. This has caused many fishing interest groups to initially oppose the adoption of offshore wind. There are several factors that must be ironed out for the two groups to coexist; researchers must also determine whether wind farms are fishable based on safety factors and threats of damage to the wind power project. Since commercial fishing is such a large and economically viable industry, this stakeholder is significant in many states. However there is no commercial fishing industry in Delaware, and fishing concerns are primarily handed by the Federal permitting and Federal agencies.

Finally, conservation groups express concern over wind power turbine placement and environmental impact. Many have previously opposed wind power due to the worry that the flight paths of bats or migratory birds may be intercepted by turbines, hurting species populations. Other apprehensions stem from the impacts of turbine foundations and buried transmission cables on ocean floor ecosystems. While these are valid concerns, recent studies have found that operating onshore wind turbines kill approximately 1.5 birds annually, which pales in comparison to the rates of house cats, cars, full-window skyscrapers, etc. (LWV 2022). Researchers have also discovered that some marine ecosystems can thrive around turbine foundations. These findings, combined with the role of wind power in combatting much graver environmental risks – namely, climate change – has led many conservation groups to favor large offshore wind power projects.

This is far from an exhaustive list, however it provides an idea of major stakeholders that are considering pre-procurement reports and providing the state with feedback before and during the process.

Report Writing and Feedback Process

A great deal of this contextual information was used to introduce the original Delaware SIOW report. Since the report details the Delaware wind market, cost estimates for wind power, and state procurement policy options, it was important to cover electricity language, the surrounding wind market, and the steps of a procurement. We structured the Delaware report to include more than just a comparison of wholesale Delmarva electricity purchases and the wind power cost projection, taking into consideration the many factors that will eventually determine that price. A single power projection is given, however each state option is condensed to a single price that electricity will be raised or lowered by, so that the economic impact of building a factory, utilizing the federal investment tax credit, or installing a meteorological buoy offshore may be quantified. This is the first report or publication giving the cost impact for procured electricity of different actions or policies by the state.

In the following sections, relevant literature in the field is reviewed, then the methodology for findings in the 2022 SIOW report is discussed. All final cost estimates from the SIOW report and any report reactions are included in the results section, based on the methodology identified. The discussion section then concludes by considering the data from the Delaware SIOW report and feedback in the greater context of pre-procurement processes at the state level.

Chapter 2

LITERATURE REVIEW

As discussed in the introduction, the SIOW report written for the Delaware state legislature, titled “Options for an Offshore Wind procurement for Delaware,” provides the basis for this thesis. Therefore, our SIOW report is the primary literature source for review. We aimed to provide Delaware policymakers with a nonpartisan analysis of the market price of electricity in comparison with the projected price of electricity from an offshore wind farm off the coast of the state. Varying conditions under which a wind project could be procured, designed, and operated are provided by the report, with estimates for the impact on electricity price from each possibility. These options are meant to provide the state with a neutral judgement of the feasibility of an offshore wind farm given Delaware’s electricity market, and to inform policymakers of the potential priorities and strategies that a wind procurement can have. As mentioned before, this thesis draws on the research, text and projected results from the recent SIOW report. It gives further observations about stakeholder feedback and advances larger discussion of the significance of such a report in the wind power state procurement process.

McClellan et al. (2015) provided an earlier SIOW report, written for the state of New York. That study parallels the 2022 report written for Delaware; it serves as a pre-procurement analysis used to advise the state, requested by NYSERDA, and in the

New York case, also nominally co-authored by NYSERDA. The New York report considers the impact of world-wide cost reductions on expected wind power prices for New York, as well as the effect of learning curves in the U.S. market. McClellan et al. (2015) provided LCOE cost estimates for four 600 MW projects, all using 5 MW or 8 MW turbines. Final estimates for the theoretical projects and subsequent 600 MW projects, all with expected financial close between 2020 and 2023, were greater than $200/MWh (or $0.20/kWh) for every case. Our estimates can be compared to the final contract values for the state of New York. Table 1 reports 6 successfully contracted offshore wind projects in New York, with PPA prices ranging from $82.7 to $153.8/MWh and project capacities ranging from 40 to 1260 MW. The earliest COD for the New York projects is 2023, and the latest is projected for 2028. Our cost estimates were very conservative in this case, as the maximum real price was far below the McClellan et al. (2015) projections.

Like the 2015 New York report, Kempton et al. (2016) provide another case study for SIOW report impact in the commonwealth of Massachusetts. This report assumes the total build-out of 2000 MW of wind power capacity, deployed between 2020 and 2030 for Massachusetts in three segments: 400 MW, 800 MW, and finally 800 MW. LCOE prices for these tranches, including transmission costs, are $162/MWh, $128/MWh, and $108/MWh, respectively. These prices show a large drop in expected energy costs within just a year, however are still much higher than what we would expect for Delaware in 2022. For comparison, the three Massachusetts projects that have successfully contracted for power in Table 1 are 400 MW, 400 MW, and 800 MW. They are priced at $75.6/MWh, $66.4/MW, and $55.7/MWh with power-on dates projected for 2023, 2023, and 2025, respectively.

Project energy prices have dropped in recent years for several reasons. Turbine sizes are now much larger (12 MW is a commercially viable turbine size, with 15 MW turbines expected soon), and projects are estimates to be larger (around 800-1200 MW in total capacity). A larger economy of scale, better turbine technology, U.S. supply chain and infrastructure improvements, and several other factors have led to a much more competitive wind energy price estimate for Delaware in 2022 than for New York and Massachusetts in 2015 and 2016, one that is closer to the actual contracted prices for the two states. That said, estimates for New York and Massachusetts were, at the time, convincing to those state's decision-makers. The states both launched procurement processes, and eventually reached contract power prices below the more conservative estimates in the SIOW report that initiated financial interest. Their political leaders said they wanted to meet CO2 reduction goals and create a local industry that would subsequently have lower energy prices. By contrast, the 2018 Delaware Working Group emphasized only price in their decision for inaction.

U.S. Wind Power Market and Price Trends

Future energy costs can be estimated in part by reviewing available data on current trends. The Lazard 2020 report, for example, compares the LCOE of conventional and renewable energy technologies, highlighting several key parameters. The authors graphically compare unsubsidized prices, along with prices sensitive to federal tax credits, fuel costs, and carbon pricing. The study generally finds that the projected range of wind energy costs is comparable to and, in many cases, lower than that of conventional sources. The Lazard study further compares the price of electricity from different energy sources through time, showing the downward trend of wind energy costs between 2009 and 2020. We used the Lazard study to reference the drop in the cost of electricity from wind power over the last several years.

An AWEA report provides background information and statistics regarding the state of offshore wind in the U.S. as of March 2020. It is used in the SIOW report to describe the projected number of jobs that will come to the U.S. due to the growing offshore wind industry: an estimated 45,000 to 83,000 by 2030. The report further comments on the projected capacity of operational offshore wind by 2030, an impressive 20-30 GW.

A 2020 Energy Information Agency (EIA) report further describes the projected additions to electric generating capacity for the upcoming year in America, stating that wind and solar power contribute 76% of these expected additions. The futures of wind, solar photovoltaics (PV), natural gas, coal, and nuclear energy are estimated for 2020.

These findings are used in the SIOW report to illustrate the growing economic, environmental, and technological potential of offshore wind power generation. Expectations for wind energy encourage consideration of wind power in Delaware, giving reason for the SIOW report analysis.

In another example, Beiter et al. (2021b) project wind power costs for the foreseeable future and discuss the several factors that would affect that power cost. Their report continues to advise wind developers on how to maximize their economic value as the cost of wind power decreases and value of wind power rises. Factors considered include “siting, project scale, turbine size, operational synergies, commodity prices, advancements in turbine technologies, enhanced management of the wind resource, and novel control technologies.” The authors conclude that the offshore wind industry can expect significant cost reductions within the next decade. Beiter et al. (2021b) even state that the price of wind power is expected to drop by half within the next 30 years, a phenomenal prediction. This suggests that wind procurements are now much more viable for east coast states, as costs continue to trend downward.

Beiter et al. (2020a) work to measure the potential impact of offshore wind on the greater electricity system. Most relevant to the SIOW report, Beiter et al. (2020a) explain the fall of wholesale electricity cost as the capacity of an offshore wind project rises, in line with the concept of economies of scale.

In “2019 Cost of Wind Energy Review,” Stehly et al. (2020) provide LCOE estimates for onshore, offshore, commercial, and distributed wind projects for the United States from 2019. The SIOW report used Stehly et al.’s 2020 research to explain project financing differences for fuel-based energy and renewables. Since fuel prices fluctuate frequently and can be difficult to predict, this factor drives overall energy cost for conventional sources. Renewables don’t have to account for a large fluctuating fuel price, therefore most required funds are upfront capital costs. The Operations and Maintenance (O&M) costs for a wind project are ongoing like fuel costs, but unlike the fuel of oil refineries or coal plants, O&M cost is very predictable. Knowledge of the cost distribution for a wind project, combined with expert analysis of cost trends and future estimates, can help to inform an upcoming procurement process within a state.

Delaware Wind Power Market and Resource

For a Delaware state procurement, national trends and energy use insight are only useful within the context of Delaware’s energy profile. The EIA 2021 report provided total power sales in 2020 for Delaware, or 11,129,051 MWh. This data was used in the SIOW report to estimate the average yearly MW load of the state of Delaware of 1,270 MW_a. Based on this load, a wind farm with an 800 MW capacity and assumed capacity factor (CF) of 44% would supply 28% of the electricity demanded by that average load. A 1200 MW wind farm with the same CF would supply 42% of the entire Delaware load. This speaks to the high volume of Delaware's electricity that a single wind farm could provide, and therefore to the significance of a potential state procurement. The power supplied by a 1200 MW project also fulfills the 2027 and 2035 RPS legislation requirements singlehandedly. If completed, the current challenge of securing RECs in the state, as described further in a later section of the literature review, would be resolved.

Further, Kempton et al. (2007) developed a method for assessing the offshore wind potential in a particular area that can be applied here. Their calculations suggest that 2.4 GW total capacity of offshore wind for the state of Delaware, with some additional solar energy, could provide all of Delaware's electricity in the future. This could be done with three 800 MW projects or two 1200 MW projects. This data about Delaware resources, combined with our knowledge of newer technology, shows that we can feasibly harness wind power for the state and cover a significant portion of Delaware's electricity demand. This, coupled with information regarding state and regional energy market factors, provides insight into the economic feasibility of offshore wind power.

Given the Delaware resource and market background, cost trends and projections from literature, and our cost calculations as displayed in the SIOW report, we were able to determine an energy price estimate for a Delaware offshore wind procurement. The last three sources discussed above speak to the final price determination that will be discussed in the results of this report. Note that EIA (2021), Kempton et al. (2007), and Liberty Group (2021) are critical references for the price calculation methodology and state energy market considerations moving forward. These offer important information that shape the model for wind costs in Delaware.

While not directly related to the wind developer's project cost, it is also worth considering the distribution of electricity after the point of interconnection is reached by transmission cables, as well as the market conditions surrounding this system. Bernstein and Kern (2021) represent the work of a critical stakeholder in the success of a wind power project: the regional transmission operator. As mentioned in the introduction, the RTO serving Delaware PJM, which serves the greater Mid-Atlantic area. The role of the RTO and their preparedness to accept energy from a large, new source is crucial for energy to be properly transferred from the project site to utility companies. Therefore, the RTO's review of cooperation with state agencies and consideration of offshore wind public policy and transmission solutions is important to determining the viability of a Delaware project. If PJM is engaged in this process and is laying early groundwork for transmission upgrades, there will be future expected hurdles and setbacks to establishment of an operating wind farm. Most relevant to the SIOW report, the Bernstein and Kern (2021) review further provides a cost estimate for necessary transmission grid updates. Assuming a 1200 MW wind power project connecting at the Indian River substation, the authors claim that PJM would need to invest $53 million in transmission between this POI and the next transmission nodes. This price estimate should be considered alongside other projections for the greater context of a wind power project; however, it should be noted that $53 million is on a much smaller magnitude than the larger project cost of two to three billion dollars. This amount would later be paid by ratepayers, as the developer sells energy to the utility company.

Quantified Health and Environmental Benefits of Wind Power

While the economic feasibility of wind power is a relatively new phenomenon, other benefits of harnessing this clean resource have existed since the technology's onset. Buonocore et al. (2016) attempt to quantify the health and climate benefits of clean energy use for Mid-Atlantic communities with respect to local considerations. The 2016 report concludes that offshore wind power in the region could have $54-120 worth of health and climate benefits per MWh. Variability within this range is modeled with regards to the state receiving power, years of operation, capacity of the wind farm, and grid complexities. The SIOW report cites Buonocore et al.'s 2016 conclusion that New Jersey could expect $41 of health savings for every MWh of wind energy produced, using this assumption for further cost calculations.

The 2021 EPA article employs another method of measuring the monetized health benefits associated with the use of energy efficient systems and renewable energy. There, the EPA estimates that the value of health benefits range from $31 to $69 for every MWh produced from offshore wind in the greater Mid-Atlantic region. These numbers agree with the $44/MWh projection from Buonocore et al. (2016), which established credibility for both methods in the accepted literature. The SIOW report used the more precise Buonocore et al. (2016) estimate for further cost calculations but cross-referenced with those values produced by the EPA.

The 2021 White House report provides sound estimates for the social cost of carbon, applicable to the SIOW report in demonstrating the benefits and offsets associated with wind power production. This source differs from the EPA article and Buonocore et al.'s 2016 report in that this data was used for SIOW price calculations. The White House estimates the carbon cost of electricity as $40/MWh, which, if added to the market price of conventional energy resources, shows the significance of external expenses for this type of power generation. With the social and health costs of conventional energy sources considered, wind is a much cheaper option, however it should be noted that wind prices are still on par with the greater energy market if these externalities are ignored. They illustrate benefits of wind power, however are not necessary to consider the current economic value of wind power. The results of this thesis section includes more detail on the impact of health and environmental cost considerations to the overall cost of wind power.

While an operating wind farm would overwhelmingly reduce the carbon footprint of Delaware, it is worth considering the expected greenhouse gas emissions of the involved manufacturing and construction processes. In a 2016 study, Bonou et al.

quantified the expected carbon outputs for production of an offshore wind farm. They determined that an offshore wind farm produces 11 g of CO2-equivalent for every kWh of power produced; for reference, their paper cites that coal produces 990 g CO2-eq/kWh and that natural gas produces 530 g CO2-eq/kWh. With the carbon offsets associated with wind power, an offshore farm makes up for this output within its first year of operation; for comparison, the typical lifespan of an offshore farm is 20-30 years, as is evident by the "PPA or OREC Tenure" column of Table 1. We used these calculations to compare the carbon cost of wind to that of conventional sources. Based on our estimations in the SIOW report, wind has 1% of the carbon cost of fossil fuel power, further demonstrating the environmental benefits of this energy source.

The use of ORECs and PPAs to Account for Wind Power Purchases

Beiter et al. (2020b) provide a summary of successful methods that have been used previously by state governments for choosing the path of the procurement process. At the time of this publication, two "procurement instruments" had been used by states, each employing a competitive bidding process. Beiter et al. (2020b) report that east coast states thus far have either opted for a power purchase agreement (PPA) or an offshore wind renewable energy credit (OREC) system. The PPA is a long-term contract between the winning bidder – the developer that is generating and selling energy – and the utility company that is buying power. By 2020, Massachusetts, Rhode Island, and Connecticut had all used PPAs for wind energy power solicitations.

Alternatively, the OREC method operates similarly to the general renewable energy credit (REC) system that many states have incorporated into renewable portfolio standards (RPS) policies, by which a “credit” that represents one MWh of clean energy is bought and sold. The REC system requires energy industry entities to generate or buy a certain number of RECs per clean energy standards that are set by the state. The OREC system is a way of managing these credits but is specific to wind power. Both ORECs and RECs exist to create an incentive for the generation of clean energy, as producers of conventional energy resources are forced to pay an extra cost that renewable developers don’t have. New Jersey, Maryland, and New York have all opted for this system.

In the SIOW report, we discuss the benefits and drawbacks of the PPA and OREC options, eventually suggesting that a procurement via PPA is more suitable for the state of Delaware for several reasons. For instance, the OREC and REC systems, as mentioned before, are based on the need for a renewable energy incentive; now that wind power is cost competitive with conventional energy sources, the need for this incentive has dwindled, making the basis of this system less effective. Additionally, the state of Delaware already uses RECs within its RPS policy and can reach its clean energy policy goals by awarding RECs for the energy generated by an offshore wind project. The creation of ORECs would mean that the wind project wouldn’t benefit the state in this regard, unless new and updated policy were to involve ORECs in the RPS requirements. The use of a PPA can also aid in a developer’s project financing and risk reduction as it is a long-term contract with a creditworthy utility. Finally, the PPA sets the cost of electricity in a legal contract before project construction and operations begin, making the price of the project more transparent to all stakeholders. While ORECs have been used successfully by several states, the SIOW holds that a PPA is likely the best option for Delaware to choose, if state policymakers decide to initiate a procurement process.

Harris (2015) discussed proposed options for the advancement of "large-scale renewables" in New York state, including offshore wind power. Most relevant to the SIOW report, Harris provided evidence that the PPA method for contracting power leads to lower power prices than other methods. We suggested that the state use a PPA for the power purchase contract after finding that this method is the most common way for utilities to purchase wind power, and that this results in a lower ratepayer cost, all according to Harris's findings.

The MD PSC press release details Maryland's 2021 decision to execute their offshore wind electricity procurement with an OREC system. The Maryland Skipjack project is an example of an approved offshore wind project that chose to employ ORECs, therefore giving reason for the SIOW report to present a description of ORECs to the state and for the state to consider the benefits of the OREC system. That said, we cited the advantages of PPA over ORECs (per above), suggesting instead that Delaware employ a PPA method.

Sources of Government Authority; Federal and Local Considerations

The 2022 SIOW report and this thesis both have a state-authority focus, however acknowledgement of the role of federal and municipal action can help to contextualize the requirements for a successful offshore wind project. The ELI report provides a detailed description of local, state, and federal regulations and authority that may be relevant to a Delaware offshore wind procurement. This report was prepared in 2011, when it seemed very likely that Bluewater Wind would construct the first offshore wind farm in the U.S. for Delaware. While this project didn't go as planned, the in-depth evaluation of stakeholders and policies provides a checklist of authorities and interests that could still be relevant today.

Vann (2021) summarized several factors of offshore wind policy and pre-project planning that extend beyond state authority. Vann first discussed ocean jurisdiction: states have authority over ocean activity between 0 and 3nm off of the coast, and the federal government has authority from 3 to 200 nm (ELI 2011). This means that offshore wind power projects are typically constructed in federal waters and have transmission cables in both federal and state waters. The Coastal Zone Management Act, a federal act with state compliance requirements, illustrates a complex deal between the federal and state governments regarding offshore activities in potential wind power project areas. Vann (2021) continues to discuss federal permitting under the Energy Policy Act (EPAct) and National Environmental Policy Act (NEPA).

While these jurisdictions and federal acts have a great impact on the project planning process, they are out of the scope of the SIOW report. Vann's report is given as a reference to contextualize state activity and to point out the role of the federal government in this process. Of federal engagement, BOEM is the most relevant organization with respect to the SIOW report. Their wind energy area (WEA) leasing process directly affects state procurement activity.

Recent New Jersey legislation answered a common question posed to Mid-Atlantic states regarding transmission cable laying authority (New Jersey Senate, 2021). In most past cases, developers had to work with municipal authorities in order to determine the beach landing and layout of transmission cable on land, before the point of interconnection was reached. Coastal communities that intersected with cable routing had to agree to the plans before the developer could move forward. This gave power to local communities that were more likely to experience disruptions from project construction, however, it also could slow the project significantly and create another hurdle for the developer; typically, any obstacle to energy generation puts a higher price on electricity for the ratepayer. In this 2021 legislation, the state of New Jersey transferred this authority from municipal governments to the state, considering it part of the greater procurement process that the state is responsible for executing. This legislation is in favor of the developer and of an expedited project timeline; while its benefits and drawbacks can be debated, it has monetary benefits for the ratepayer, therefore is noted in the SIOW report for consideration by the Delaware legislature.

With context from surrounding literature in mind, the next section presents methods for which the SIOW report performed a wind power cost analysis. It also reviews methods that were followed for measuring initial reactions to the SIOW report.

Chapter 3

Methodology

Gathering data for this thesis required both price estimation techniques and a feedback collection process. Pricing methodology as described here parallels the methods used in the SIOW Delaware report, while the feedback methodology was developed after the report was written and followed available stakeholder meetings and media releases. Again, this thesis was developed in tandem with the SIOW report, so its methods overlap significantly with the methods for that piece.

SIOW Report Commissioning and Timeline

SIOW writers received authority to produce our 2022 report for Delaware from the Delaware Department of Natural Resources and Environmental Control (DNREC) and the state general assembly. Note that DNREC representatives and policymakers asked for, but did not commission, the report. We cite in the "Objectives" section of the SIOW report that DNREC's Secretary, as well as the chairs and co-chairs of the Senate and House Environment and Energy Committees, encouraged the SIOW report with various correspondence. Interest from state leaders for expert advice provided reason for us to produce the paper for Delaware.

Our 2022 report was released by the SIOW on February 27, 2022. The paper was then subjected to DNREC review and was released for public viewing on April 7, 2022. The most up-to-date version of the paper as of April 2022 includes corrections from March 6 and April 8. Initial feedback on the paper began with general report information (any cost estimates redacted) that was presented after SIOW release. Any media coverage or cost calculation-informed report feedback was provided on or after April 7, 2022. Because some of the report's content was discussed in meetings before official release, any stakeholder reactions are categorized as pre-DNREC release or post-DNREC release in the results section below.

Methods of Offshore Wind Pricing Estimation in SIOW Report

The SIOW report for Delaware discussed three distinct methods for estimating a cost of offshore wind energy from a near-future project. Each method pulled from different data sources, and the benefits and drawbacks of each method are touched on.

First, we examined a method that the report calls "Electricity Prices from Prior U.S. Projects (Method 1)." This process relied entirely on data from previously contracted offshore wind projects on the East Coast, all of which are summarized in Table 1. Method 1 used this data to glean industry trends and estimate potential future project costs. Because the last column of Table 1 shows levelized PPA prices in 2021 dollars, they are comparable and therefore can provide some industry insight. We noted that the lowest PPA prices are for Massachusetts, then considered how the state was able to get such a low cost of energy. We explained that the Massachusetts state legislature prioritized a low cost of energy in their procurement process, and that more expensive projects in the table were generally contracted earlier and/or had more job-creating requirements that may have raised the energy price. Our discussion of varying final contract prices also reviews changes in technology and in developer's cost calculations and risk estimations, the latter of which is indistinct to public reviewers but certainly not a uniform process. We cited Method 1 as a rudimentary way to get an understanding of the surrounding wind power market. However, we note that it is not reliable if making a definitive projection for the state of Delaware. To do this, more local data would be needed, such as nearby offshore wind speeds and on the state's energy policy portfolio.

The second method, "Electricity Price Predicted by Survey of Experts (Method 2)," instead employs a process that was developed by Wiser et al. in a 2021 paper. These authors provide a method of estimating future wind costs that is distinct from methods relying on data trends from recent project costs. Here, Wiser et al. employed expert elicitation to predict cost reduction in wind power between 2020 and 2050, basing estimates off of the 2020 market. They stated that the price of wind power is expected to decline by 37-49% over this 30 year period. Their data is based on a survey sent to several experts, and their compiled results show high, low, and median estimates for the change in LCOE relative to 2019 prices. We presented this information in the

SIOW report as “Method 2” of determining general wind price in the near future, stating that this was a better approach than the backwards-looking estimates based on past projects that Method 1 relied on. We chose to base further estimates in the report off the 21% drop in OSW electricity prices that predicted by the median expert response in Wiser’s report between 2020 and 2025. This time frame is most relevant to a potential Delaware procurement. For a visualization of Wiser et al.’s relevant results, see Figure 1 below.

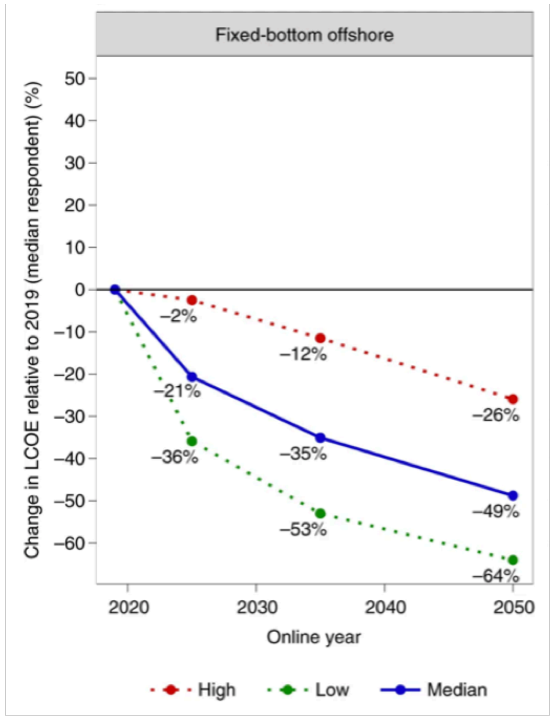

Figure 1 Expert Elicitation Cost Estimates from Wiser et al. (2021) used for Method 2 of the Delaware SIOW Report.[3]

[3] The SIOW report further notes that Wiser et al. conducted a similar poll of experts in 2015, and their lowest cost estimate aligned most accurately with real contracted wind prices between 2015 and 2020. To be conservative, the SIOW referenced the median cost estimate trendline, in order to avoid underestimating the cost of energy for Delaware.

Finally, we reviewed "Calculating Electricity Price from Component Costs (Method 3)." This method was most specific to Delaware, therefore the resulting energy prices from Method 3 were used as a comparison benchmark by the SIOW. This required price estimates of physical and non-physical component parts, all of which were loaded into a wind power model. The National Renewable Energy Laboratory (NREL) provides a public domain tool for estimating wind energy cost called CREST, which was used here. CREST is simpler than a developer's cost calculation software but uses a similar process and can provide similar estimates. As we emphasized, the CREST model considers project costs as well as a developer's project financing and risk premiums when calculating the expected price of energy. The calculated results from the CREST model are discussed in the next section.

We used a theoretical "Base Project" with several assumed parameters for the CREST model. Inputs matched what could be expected for a near-future wind farm that supplies power to Delaware. Primary cost estimates in the SIOW report stem from the Base Project, with the following assumptions for this project: a power capacity of 800 MW, a distance from the POI of 70 km, AC cables, a water depth of 32 m, and project coordinates of 38.623435, -74.3034655. We also assumed a power-on date of December 2027 for the project, a capacity factor (CF) of 44.4%, a state tax rate of 8.5%, and Net Energy Production based on regional wind speeds and expected turbine sizes for a project with COD 2027. The CREST model calculation also assumes no additional RECs will be made to subsidize a wind project. The model further accounts for the cost of developing an O&M port, vessels, and environmental monitoring throughout O&M. Note that these parameters represent educated predictions for a commercial-scale project sited in the Central Atlantic area, but are not necessarily the conditions that the state will face in a near-future procurement.

In summary, Method 1 for estimating wind energy price relies on observing electricity price data from other contracted projects; Method 2 is a forward-looking estimate of future price, based on expert input; Method 3 is the most involved and provides the most accurately documented energy cost estimate for the state of Delaware.

Methods of Gathering Feedback on SIOW Report

As described above, collection of feedback on the 2022 report for Delaware began after February 27th, when the SIOW finished writing the paper. Because this thesis will be released only a few months after this date, long-term impacts of the report cannot be commented on. This includes success of a procurement bill and eventual cost of a Delaware offshore wind power project. That said, the initial reactions of Delaware stakeholders can provide critical data on how a state may receive pre-procurement papers, how the SIOW report may spark a conversation on wind power in the state, and whether state leaders seem more receptive to the idea of an offshore wind project after the report's release. Initial feedback can also be a gauge of public interest for a wind farm, which can largely affect the outcome of a project.

The pre-DNREC feedback resources, collected between February 27th and April 6th of 2022, were all public stakeholder meetings, excluding that labelled "Developer Meeting." These three public meetings were held on ZOOM and were organized independent of this thesis, but provided direct commentary on the report's contents. In each case, Dr. Willett Kempton spoke on the report and gave a lengthy description of the report's context, methods, and general findings, but could not provide final cost estimate values as DNREC was still reviewing the report. Then, meeting attendees could ask questions about his presentation. Their questions and Dr. Kempton's responses were recorded and are summarized in the results section of this thesis.

The pre-DNREC release source labelled "Developer Meeting" was covered by NDA and is therefore discussed at a very high level, however can still offer insight into the general reactions of an important stakeholder for Delaware's potential procurement process.

The post-DNREC feedback resources include both media reports and stakeholder meetings. After the report's initial release, several news articles were published that comment on its findings, which speak to the perceived impact of the Delaware SIOW paper. These articles are summarized and commented on in the results section.

Stakeholder meetings on or after April 7th allowed for much more involved questions, as attendees were able to read the paper before asking about it. Reviewed questions and answers from these sessions were again paraphrased and summarized for analysis in the results section. These meetings included several sessions with an offshore wind advocacy group and follow-up email correspondence. Meetings with state senators and legislators regarding the content of the DE SIOW report are expected soon.

Feedback from these stakeholders is accessible and provides the best available insight regarding initial reactions of those engaged by a potential offshore wind procurement. Therefore, these meetings, media releases, and instances of correspondence are most appropriate to reflect on in the results section.

Chapter 4

Results

The following section reviews state options and cost provisions for a wind power procurement that are identified and summarized by in the 2022 SIOW report. It also shares information gleaned from stakeholder feedback meetings that were held after the report was released by the SIOW, as well as from press releases regarding the report. These results are meant to reflect our findings and significant reactions of affected parties, in order to inform future pre-procurement processes. It is important to note that not all stakeholder groups are represented by the available results, and there could be several other perspectives not accounted for here.

Wind Power Cost Estimates

After applying Methods 1, 2 and 3 to a theoretical Delaware procurement, we produced estimated market prices for electricity generated by offshore wind. The following table summarizes the wind power price ranges that were calculated using each method and can be found in the Delaware SIOW report, using 2021 dollars.

Table 2 Market price of offshore wind electricity, projected using three methods.

Price anticipation method and case	**Price ($/MWh)**
Method 1: Massachusetts contracted wind power prices, where bids were picked primarily for low cost (see the MA projects listed in Table 1)	55.70 - 75.60
Method 1: Maryland contracted wind power prices, including ~800 MW projects, these with economic development costs and lower wind speed (see the MD projects listed in Table 1)	64.70 - 85.60
Method 2: Adjustments to above Maryland contracted wind power price using Wiser et al.'s projected -21% price drop by 2025	44 - 68
Method 3: Delaware Base Project calculation without using Delaware RECs	71.48
Method 3: Delaware Base Project, plus implementation of state cost options (as described further in "State Options and Cost Provisions")	52.31 - 71.48

The price estimates above for offshore wind power based on Methods 1, 2, and 3 can first be compared to the wholesale price of electricity that Delmarva currently pays. As discussed in the literature review, a 2021 Liberty Group presentation stated that between 2015 and 2021, the state's largest utility paid between $53 and $82/MWh for electricity. Every price estimate in Table 2 falls within this range, with the exception of the high estimate for Maryland using Method 1 and the low estimate for the Delaware Base project with options using Method 3. This data heavily suggests that offshore wind power would be cost competitive in Delaware's electricity market, which is a major takeaway from the SIOW report. This further indicates a drastic change in wind costs over the last 4 years since the 2018 working group deemed offshore wind power too expensive.

While comparing all three methods adds value and credibility to these findings, this thesis will primarily reference the point estimate of $71.48/MWh that was calculated using Method 3 and prior to consideration of state cost options. Each individual state option that is discussed in the next section will add or take away from the $71.48/MWh price point.

The analysis summarized by Table 2 strictly considers the cost of wind power as it would appear in a wholesale market. This is without consideration of externalities that, while not reflected in electricity cost on paper, have a real and quantifiable impact on society. As discussed in the literature review, there are several studies that estimate the consequences to human health and the environment that are posed by the continued use of conventional sources of power. Using the 2016 Buonocore et al. report to quantify health costs and the 2021 White House report to estimate environmental costs, the market price range for Delmarva wholesale electricity purchases appears much steeper. Table 3 below presents the current market price in 2021 dollars, to be compared to factored-in externalities. A similar version can be found in the 2022 SIOW report.

Table 3 Conventional wholesale electricity price and externalities comparison

Source for Conventional Electric Supply Cost to Compare	**Added external costs**	**Power cost ($/MWh)**
Delmarva power wholesale purchase price from yearly auctions between 2015 and 2021 (Liberty Group 2021)	0	53 - 82
Delmarva power wholesale purchase price and health cost of power (Buonocore et al. 2016 and EPA 2021)	41	94 - 123
Delmarva power wholesale purchase price and environmental cost of power (White House 2021)	40	93 - 122
Delmarva power wholesale purchase price, health cost of power, and environmental cost of power	81	134 - 163

For a more visual display of the data provided in Tables 2 and 3, Figure 2 below compares the Delmarva wholesale power price to the power price with externalities and to each market price projection developed with the three methods and presented in Table 2. Further note that Table 2 assumes negligible health and carbon costs from wind power construction and operations, as is reviewed in the Bonou et al. (2016) report cited in the literature review. An identical copy of Figure 2 can be found in the SIOW report.

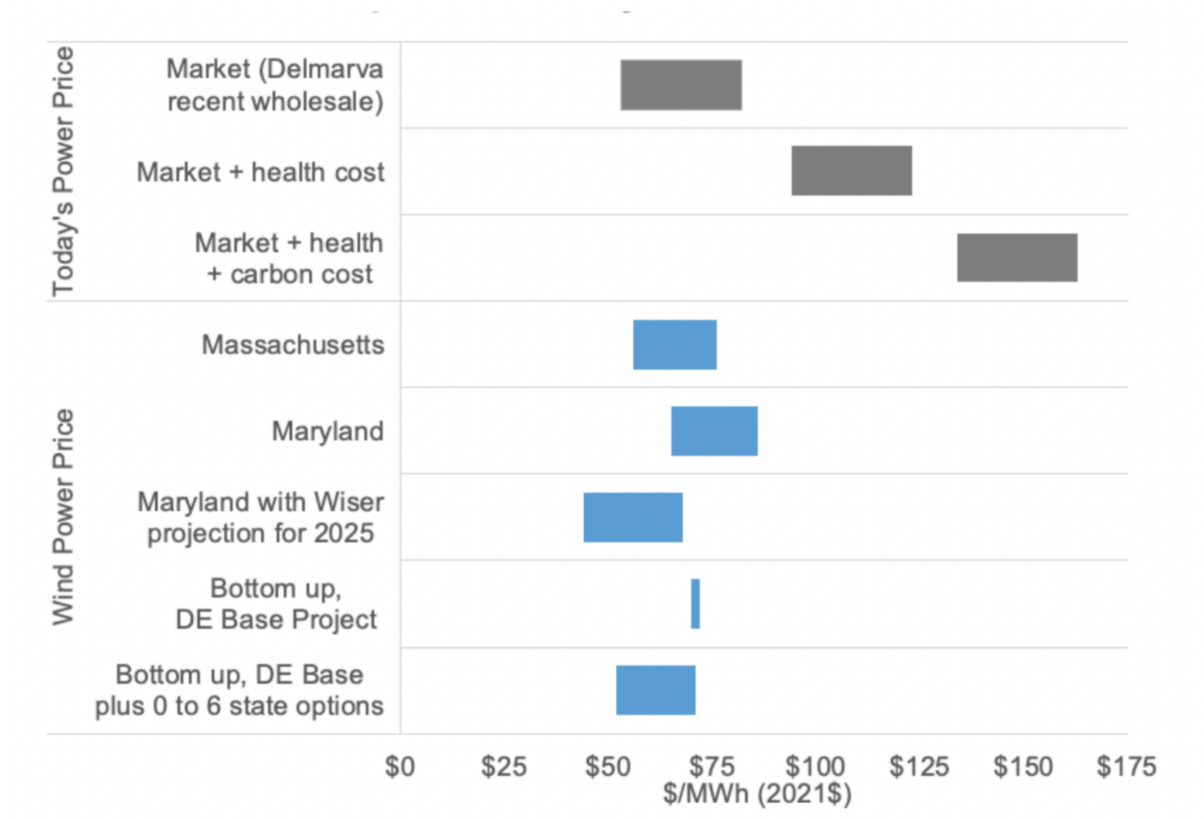

Figure 2 Today's electricity price compared with the price of wind power.

According to Table 3 and Figure 2, when considering both the health and environmental consequences of the conventional power that is currently bought by Delmarva, current power costs to the state range from $134 to $163/MWh. The primary offshore wind power cost estimate of $71.48 is less than half of the range midpoint. This finding was deemed critical to many SIOW readers and was another major report takeaway, as will be discussed further in the report reactions section. Next, state options that are available to Delaware are listed, each with the potential to enhance a state offshore wind power procurement.

State Options and Cost Provisions

We reviewed several options at the disposal of the state government that could make a wind power procurement more favorable, whether the options reduce the cost of wind, boost tourism, create jobs, etc. The following section describes each option identified by the SIOW in their Delaware report and quantifies the change to the total electricity cost that is associated with each option. This section parallels a subsection of Part II in the SIOW report, labelled "State actions to minimize cost." The cost for each option should be considered with reference to the SIOW's final point estimate for a Delaware wind power price of $71.48/MWh, derived from Method 3 and the CREST Model.

State Urges BOEM to Create More Leases near Delaware

One of the first steps that a developer must take to sell power is to secure a lease for ocean space. This is typically done well before the power procurement process begins, as developers with nearby ocean space are the only viable contenders for a power procurement and must be prepared with a secured lease when the RFP process begins. BOEM oversees this leasing process, as discussed in the introduction section. Under the current system, in order to have the chance to sell power to a state the developer secures a Wind Energy Area at auction, years before they could potentially gain revenue from the project and without any assurance that a project will be built there. BOEM recently announced new "Draft Call Areas" in the Central Atlantic area, suggesting that new spaces close to Delaware will be up for auction in the near future. Figure 3 below shows the current layout of Central Atlantic Call Areas and designated WEAs. The image shown is identical to that displayed in the SIOW report.

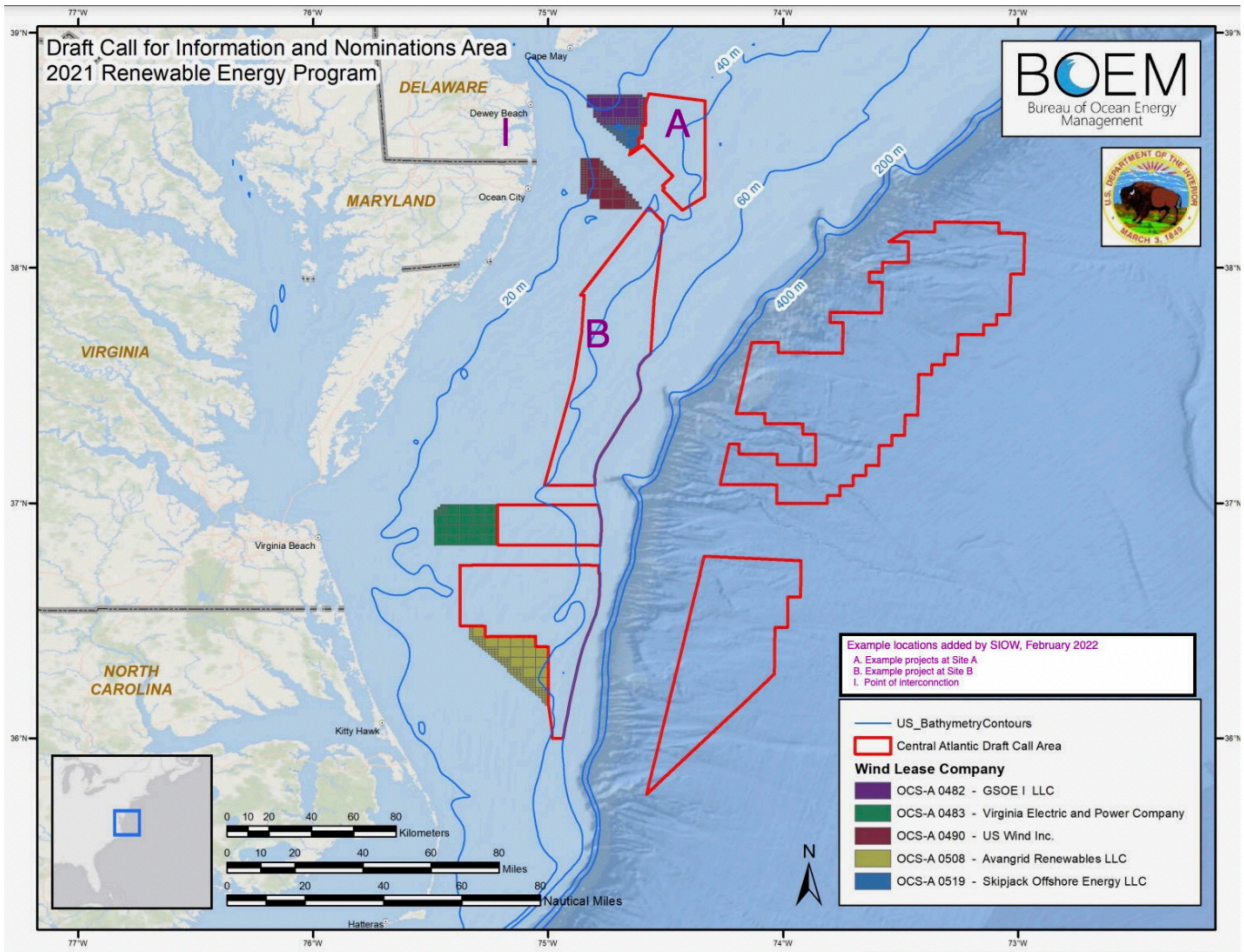

Figure 3 BOEM Central Atlantic Call Areas (red outlines) and existing WEAs (areas with filled-in colors).

Figure 3 further places the POI at Indian River (I), Base Project location that is referenced for Method 3 (A), and another potential site for Delaware offshore wind development (B). Further note that the red outlined areas will not be fully leased and transformed into WEAs, rather public comment and other siting considerations will be used to whittle down these areas until BOEM picks final, auctionable areas.

BOEM's recent expansion of Central Atlantic call areas is indicative of future expected development and could be to the advantage of a Delaware procurement. If Delaware were to send out an RFP today, there would likely only be one viable developer to respond to it, this being Orsted in the OCS-A 0482 lease space (in purple on the map). All other developable areas haven't yet been leased, are set aside for other projects, or are too far from Delaware to provide marketable power. With such little nearby competition, Orsted would expect to have a monopoly in a Delaware procurement and could raise the price of electricity due to their lack of competition. If more developers own WEAs in the Central Atlantic Area before Delaware announces an RFP, the amount of competition in the area will increase and bid prices will likely go down, which is in the interest of the ratepayer. Therefore, we presented Option 1 to the state as asking BOEM to create more lease spaces near Delaware, so that competition is more likely among bidders in the coming years. This can likely be completed by the state during the designated public comment window that BOEM has before finalizing WEAs. The SIOW report further notes that this action costs nothing for the state, but that increased competition would lower the power price an estimated

$3/MWh. This means that, without any other state action, the estimated cost of offshore wind power for Delaware would drop from $71.48/MWh to $68.48/MWh.

State Defines Rules for Siting the Transmission Cable Landing

For many states on the U.S. eastern seaboard, policy surrounding transmission cable landing from offshore projects is under municipal authority. This means that, for a transmission cable that comes to shore and travels to the POI, the affected coastal town is responsible for negotiating terms with a developer. The municipal authority would ultimately approve any construction associated with cable laying and burial.

This is the case in Massachusetts along with several states that have recently procured offshore wind. For the Vineyard Wind I project, the developer (Vineyard Wind) was required to work very closely with the coastal town of Barnstable, MA. Vineyard Wind added some cost-inducing plans to their project proposal that appease Barnstable, most likely in order to gain the approval of the town, such as the construction of a bike path through Barnstable (Vineyard Wind LLC 2017). Vineyard Wind also promised a financial award titled the "Resiliency and Affordability Fund" for "the communities hosting the Vineyard Wind project," including Barnstable (Vineyard Wind LLC 2017). These additions increased the capital cost of the overall wind power project and – even if this cost was minor – raised the price of electricity to the ratepayer. From this example and several others in which coastal towns are granted cable landing authority, it seems that this local power makes the wind power project more costly and less efficient.

One can debate whether coastal towns should or should not retain their authority over cables passing through their boundaries, but if considering only the cost of wind power, this policy isn't favorable. For this reason, the state of New Jersey recently passed legislation that transfers cable landing authority from municipalities to the state, in hopes of encouraging developer interest, lowering developer risk, and lowering the price of offshore wind power (New Jersey Senate 2021). The bill, discussed further in the literature review, provides a development-friendly option that a nearby state has already taken. If Delaware does decide to prioritize a lower cost of electricity and to encourage further wind development, it may consider similar legislation to that passed by New Jersey. According to the SIOW report, it is free to both the state and the developer to transfer cable-landing authority from municipal authorities to the state. It would also knock an estimated $3.40/MWh off the power price. If this were to be the only state action, the SIOW predicts offshore wind power as $68.08/MWh as opposed to $71.48/MWh. Further note that this transfer of authority would shorten the project timeline by an estimated 6 – 18 months, which has added benefits for a developer's project financing, state energy goal achievement, etc.

State Coordinates Electric Transmission Access with Maryland Projects

With offshore wind development booming in the Mid-Atlantic, Delaware may consider interstate transmission cable coordination in order to lower the price of offshore wind electricity. Currently, the state of Maryland has a total of 2022.5 MW of offshore wind planned. While some of these projects are already far along in the planning pipeline, their transmission prices would theoretically drop if Delaware and Maryland had planned ahead for a shared transmission corridor. Such a corridor could connect transmission cables to a single onshore substation, such as Indian River, and would reduce disruption to communities and the environment from multiple cable-laying projects. A shared corridor would also be more cost-effective, as projects would have a single export cable set. The SIOW report concludes that a shared transmission corridor with Maryland, if planned prior to significant project development, would independently reduce the cost of wind power by \$2.30/MWh, or from \$71.48/MWh to \$69.18/MWh. We further estimated that capital expenditures to the developer would drop \$86,000/MW with use of one 3 GW shared DC corridor as opposed to three 1 GW AC cables, each from separate projects.

DNREC Reviews and Provides Early Guidance on Regulatory Process

There are several state environmental policies that could impact offshore wind transmission burial in state waters, cable landing, and cable routing on land. These policies include the Subaqueous Lands Act (SLA), Beach Protection Act (BPA), Coastal Zone Act (CZA), and Delaware Coastal Management Program (DCMP).

Although their provisions can be interpreted as regulations on offshore wind power, these policies largely don't specify how they affect renewable energy projects. The lack of clarity in existing code could increase developer risk and therefore the cost of the project. Therefore, the SIOW suggests that the state via DNREC review these policies and publish guidance for a developer on how to best adhere to them within the context of an offshore wind project. This not only reduces developer inefficiencies but provides a state with the opportunity to specify their interests in coordination with the developer. We estimated that the cost to the state to review these policies and draft guidance is minimal; in turn, this action could lower the price of wind power by $3.40/MWh, or from $71.48/MWh to $68.08/MWh.

State Installs Meteorological Buoy Prior to RFP

Another important factor in project planning and success is access to accurate wind speed data. Sheridan et al. (2012) use a unique method of measuring offshore wind resources via a meteorological buoy. More commonly, wind speeds for an area have been measured using a meteorological tower; these give developers some idea of wind speeds and therefore an estimate of the annual energy production (AEP) of a potential wind farm. However, as wind turbine technology advances and turbines reach higher heights, the meteorological towers aren't tall enough to accurately measure the wind speeds that turbines will be harnessing.

Advancements in measuring techniques have therefore led to the increased use of meteorological buoys. These employ LiDAR technology to accurately read wind speeds several hundred meters above sea level. Sheridan et al. (2012) applied the met buoy method to predict Maryland's offshore wind resource. In their report, they find that this resource could supply 189% of Maryland's currently energy needs alone. This is excluding offshore areas with competing uses. Sheridan et al. show in this study the immense energy burden that offshore wind can carry as the east coast begins to tap into this resource more and more. They also provide credible research that is executed with met buoy use.

In addition to the 2012 Maryland project, meteorological buoys have been deployed off of U.S. coastlines at higher rates in recent years. The Pacific Northwest National Laboratory (PNNL) currently operates a meteorological buoy loaner program, with met buoys currently located off of the coasts of New Jersey and Virginia. The Delaware SIOW report also affirmed that New York state adopted a met buoy per a suggestion by the SIOW. These buoys use LiDAR data to measure wind speeds at a high resolution far above sea level, without using expensive fixed platforms. Correspondence with a point of contact at PNNL provided cost estimates for met buoy deployment and buoy availability within the PNNL loaner program. The PNNL contact also affirmed the credibility of met buoy data, stating that the LiDAR system needs to be validated before deployment, however if approved can be considered a "bankable" source of information.

If the state were to commission, deploy, monitor, recover, and decommission a met buoy, and then analyze the resulting wind data, it would come at a cost to the state of about $1.5 million (PNNL correspondence 2021). Although an investment, access to wind data that is closer to nearby WEAs could drastically reduce the lengthy Site Assessment Plan (SAP) phase that a developer must undergo for federal project approval. The impact on the project's timeline could lower the cost of development by about 20%. The developer would not pay anything if the state were to deploy a met buoy. The SIOW report concluded that the price of offshore wind power would be reduced by $1.10/MWh due to accessible data before the SAP, and by an additional $2.10/MWh with the reduction to the developer's risk. Investment in a met buoy would bring the total estimated cost of wind power from $71.48/MWh to $68.28/MWh.

Right-Sizing the Project

A project of at least 800 MW capacity is currently considered the industry standard for commercial-scale, economically favorable development. This is reflected by our choice to model the Base Project off of an 800 MW capacity wind farm. The SIOW report considers both 800 MW capacity and 1200 MW capacity wind farms for Delaware. These values can be compared to the average load for the entire state of Delaware, which we calculated as 1270 MW_a (or "average" MW) of electricity. This value represents the average amount of electricity used by the state for any given hour in the year. Assuming a capacity factor of 44%, an 800 MW project would supply 352 MW_a, or 28% of the total 1270 MW_a required. A 1200 MW project would supply 528 MW_a, or 42% of it. Further analysis of the 800 MW vs. 1200 MW options shows that the load for a given load would never be exceeded for an 800 MW capacity project, which is ideal as excess power would be wasted in this situation. We determined that a 1200 MW project would occasionally exceed the state's current load; however, predicted electrification of the grid will likely make the load rise and need for offshore wind power increase with it. In our conclusion statement about the two options, we determined that a 1200 MW capacity project would be best for lowering ratepayer bills and cutting down greenhouse gas emissions from conventional energy sources. That said, if excess wind power cannot be routed to an energy storage unit or power-demanding operation, it may make more sense for the state to choose an 800 MW project size. The estimated cost savings for procuring a 1200 MW project instead of an 800 MW project are $3.55/MWh. This means that the total electricity price would be expected to decrease from $71.48/MWh to $67.93/MWh for a 1200 MW capacity project.

State Times Procurement so that Project is Eligible for Federal ITC

One factor with a significant impact on the offshore wind power price is the Federal Investment Tax Credit (ITC). The ITC is a federal subsidy that is currently available to developers until the end of 2025. It can only be applied to projects that are far enough along in the pipeline by the Federal ITC expiration; in order for a project to qualify, the developer must have spent 5% of the total project cost by the December 2025 deadline. This won't happen unless the RFP process is completed, a project is chosen by the state, the PPA is signed, the COP is approved by BOEM, and the developer completes safe harbor investments. The Base Project assumes that a Delaware wind power project meets the deadline for Federal ITC eligibility, however, failure to meet this deadline would significantly impact the cost of power. We reported that a project would lose $614 million in tax credit without the Federal ITC, bringing the price of electricity from $71.48/MWh to $91.9/MWh (or an increase of $20.42/MWh). This is a very significant jump in the power cost, and is a magnitude higher than the financial impact of any other option presented here. For this reason, it is in the interest of both the state and the ratepayer to time a procurement process accordingly.

Table 4 below outlines a potential timeline for a Delaware procurement, assuming that the procurement bill can be passed by the end of the 2022 legislative session. Note that a copy of Table 4 can be found in the Delaware SIOW report. Also note that COP approval, financial close, the beginning of construction, and the COD are all dependent on the length of time between COP submission and approval by BOEM; this timeline assumes that approval would take 1 year, but it very well could be 2 years, pushing these steps back by another year.

Table 4 Potential procurement schedule for Delaware.

Milestone	Completed
General Assembly passes procurement bill	June 2022
BOEM Final lease notice for Central Atlantic “early/mid 2023”	Q1 2023
BOEM lease sale for Central Atlantic “mid-2023”	Q2 2023
Delaware Agencies issue RFP	Q2 2023
Bids due from bidders to evaluators	Q4 2023
Agencies select bid to negotiate contract (developer can start surveys)	Q4 2023
PPA negotiation complete	Q1 2024
Developer submits COP to BOEM	Q4 2024
BOEM approves COP and creates Record of Decision (timing uncertain)	Q4 2025
Developer completes safe harbor investments (to qualify for ITC)	Q4 2025
Developer reaches financial close with investors	Q1 2025
Construction begins	Q2 2026
All construction is complete and full generation begins (COD)	Q4 2027

If the state cannot manage to pass procurement legislation in 2022, it doesn’t necessarily mean that the Federal ITC can’t be met. It would, however, be more difficult to sufficiently advance the project before the Federal ITC expires. For this reason, wind power advocates may consider this time constraint if attempting to provide the lowest possible cost of clean electricity.

Developer Contributes to a Job-Creating Entity

Unlike the previous options presented, all of which are cost-saving metrics that the state can choose, this option and all those following primarily act to create jobs. If the state decided to prioritize cost-saving options, the benefit will be a lower electricity bill for ratepayers; if the state takes more action to create jobs, electricity prices from an offshore wind procurement may be slightly higher, but state residents will enjoy employment opportunities and the wind project may benefit from improved infrastructure. The state can choose to take several actions, some that reduce cost and others that create jobs, but note the increases to price estimates given the options stated below.

In past options, states that have prioritized job creation in the procurement process have communicated this to developers via the RFP, stating that they expect any developer's proposal to dedicate some amount of money to job-creating facilities. We chose $150 million as an approximate value that states could require developers to set aside for this purpose, based on previous procurements that have required a "substantial offshore wind facility." Here, 'offshore wind facility' is used very generally, and the options listed below provide more specific examples of what this facility (or, these facilities) could be. Assuming that the developer were to raise their capital expenditures by $150 million for additional job-creating facilities, the power price would increase by $3.40/MWh, or from $71.48/MWh to $74.88/MWh for the total cost estimate.

Operations and Maintenance Port in Delaware

Given the near-future need for offshore wind farm construction in the Mid-Atlantic region, an expansion of deployment infrastructure will be required to avoid large project delays. One example of needed infrastructure is O&M Ports that could be accessible for a project in Delaware. These, as we described in the SIOW report, are "used to stage routing maintenance and repairs on the offshore wind project" and can serve one or a few projects at a time. Parkison and Kempton (2022) estimate that an O&M port for an 800 MW project would require approximately 5 acres of land space and $15 million of an investment, plus additional spending for vessels. A single O&M port would create about 30 - 60 jobs, these being long-term careers as a project's lifetime can span multiple decades. With the increasing demand for offshore wind in the region, it is likely that larger, regional O&M ports will be more economical and possibly located outside of the state.

The CREST model cost calculation assumed that a developer would build a smaller O&M port in Delaware for a single 800 MW project, as described above. This is factored into the point estimate of $71.48/MWh. If larger, regional options became available, the price of wind power would decrease by a projected $0.60/MWh, bringing the overall cost estimate to $70.88/MWh.

Marshalling Port

Another item limiting infrastructure is available marshalling ports. Currently, there is only one close enough to the state of Delaware for use. As of the SIOW report's publication, three additional marshalling ports have been proposed for the region. If all of these were successfully constructed and operational alongside the existing port, the total regional capacity for wind turbine deployment would be half of that required by upcoming projects. Therefore, the Mid-Atlantic needs more port infrastructure.

House et al. discussed the feasibility of another marshaling port in the Delaware Bay area in their 2020 report. Not only would an in-state port provide needed infrastructure for future wind projects, but it would also create more jobs in the state and would lower the risk to the developer of a local wind farm. We presented the idea of a marshalling port as a state option for consideration in the procurement. This port could be funded by private investment and wouldn't necessarily be a part of the RFP process, therefore the impact on power price isn't calculated in the SIOW report; however, it is important for a potential Delaware marshalling port to be considered by the state legislature in future wind power endeavors.

Like House et al. (2020), Parkison and Kempton (2022) discussed the need for marshaling ports for the near-future success of offshore wind on the east coast, identifying the lack of these ports as a critical “bottleneck” in the advancement of the industry. Parkison and Kempton further claim that the shortage of ports is typically accredited to a lack of suitable locations, however it is more likely because of poor planning by developers in the early stages of marshaling port construction. The overall message of the report agrees with that expressed by House et al.: to further offshore wind in the Mid-Atlantic region, more marshaling port infrastructure is required.

Because the construction of a marshalling port wouldn’t necessarily be tied to the RFP process, the SIOW report didn’t include a cost of electricity impact estimate for this option. We did, however, note that Delaware Bay has a suitable site for a marshalling port and that its construction and O&M would create many jobs.

Workforce Development Center

Another option for a job-creating facility is an offshore wind worker training center. This isn’t necessary infrastructure such as a marshaling port or O&M port, however, could enhance the wind industry in the state of Delaware. Such a workforce development center could provide safety training for offshore wind construction and O&M workers, and could provide support for Delawareans interested in offshore wind for their career path. We added that, according to Maersk Training, one technician per MW installed is in need of training (or, 800 technicians for an 800 MW project). A workforce development center would have about 20 people employed at any given time. Since the developer may contribute funds to a workforce development center, this could impact their final bid price. We assumed that this center would cost $4 million and that a developer would pay half of this cost, while the party operating the center would pay for the other half. A $2 million increase in capital costs would increase the power price by $0.10/MWh, or from $71.48/MWh to $71.58/MWh.

Offshore Wind Visitor Center

The final state option provided in the Delaware SIOW report is the creation of an offshore wind visitor center. This would mainly serve to educate the community and tourists about the operating wind project. It could also provide visitors with a way to physically view the project, maybe through powerful binoculars. A common argument in opposition to wind power cites concern over negative impacts to the tourism industry if wind farms are visible from shore. It would be very hard to see a typical offshore wind project given its distance from shore, so it's unlikely that tourism would fall drastically with the introduction of a wind farm; with the addition of an offshore wind visitor center, tourism may even increase, making this a more marketable option for state policymakers. We estimated that a small visitor center would cost the developer $30,000 in capital expenditures and $15,000 per year for maitenance, excluding land purchase and the cost of worker's salaries. If sponsored by the developer, the effect on the price would be less than $0.01/MWh, and rounds to $0/MWh according to our SIOW report.

Every option listed above is not required for a successful procurement, but could enhance the outcome of one for Delaware. The SIOW report aimed to provide a "menu" of options to the state, allowing the legislature to weigh each option after being provided with a comprehensive list of them. Below, Table 5 provides a summary of the options presented in the SIOW report and their impact on the estimated cost of offshore wind power. Note that negative price values denote a decrease in power cost.

Table 5 Summary of price impacts given state options, relative to Base Project.

	Cost to the state, $	**Cost to the developer, $**	**Change in PPA Price, $/MWh**	**Modification to Price Estimate**
Options for electricity cost reduction				
State urges BOEM to create more leases near Delaware	0	0	-3.00	68.48

State defines rules for siting the transmission cable landing	0	0	-3.40	68.08
State coordinate electric transmission access with Maryland projects	0	-86,000/MW	-2.30	69.18
DNREC reviews and provides early guidance on regulatory process	0	0	-3.40	68.08
State installs meteorological buoy prior to RFP	1,500,000	0	-3.20	68.28
Right Sizing the Project: RFP calls for 1200 MW project rather than 800 MW project	0	-447,000/MW and +9100/MW/yr	-3.55	67.93
State doesn't time procurement so that project is eligible for Federal ITC	0	+614,000,000	+20.42	91.9
Options for job-creating offshore wind facilities				
Developer contributes to a job-creating entity or entities	0	150,000,000	+3.40	74.88
Large, regional O&M Port created near Delaware, as opposed to a smaller in-state port	0	-5,000,000 and -1,000,000/yr	-0.60	70.88
Marshalling port constructed in Delaware	Not calculated			
Workforce Development Center constructed in Delaware	0	+2,000,000	+0.10	71.58
Offshore Wind Visitors Center constructed in Delaware	0	+30,000 and +15,000/yr	~0	71.48

The cost calculations and state options listed above comprised the majority of key findings in the Delaware SIOW report. This thesis continues to discuss stakeholder's initial reactions to the SIOW report. While we sparked a long and complex conversation about offshore wind power, many readers and stakeholders with more wind power expertise primarily reacted to these price estimates.

Stakeholder Reactions and Feedback

After the SIOW initially submitted their 2022 report to DNREC and before the report was publicly released, four stakeholder meetings were held that are accounted for here. Three of these meetings were with various Delaware interest groups that generally support clean energy and environmental policies, and one was with an unnamed wind developer. Because the report was not yet publicly released at the time of these meetings, stakeholders did not have access to the written information or to cost estimates determined by the SIOW. Instead, each group was given approximately a 45-minute content overview with any numerical conclusions redacted.

After the paper was approved for release by DNREC and officially published on April 7, several articles were published about the paper and more informed meetings were held. Five instances of media coverage, including pieces with supporting, opposing, and neutral perspectives, are reviewed here. A series of meetings with one informed interest group are also discussed, along with subsequent feedback and reactions from state senators and representatives. I was in attendance for each meeting, took thorough notes of the presentation and Q&A sessions, and occasionally helped respond to questions in the meeting chat. Note that accessible media coverage and meeting feedback were recorded here between February 21, 2022 (as the paper was being completed by the SIOW and submitted to DNREC) and May 13, 2022. The termination of reactions research came with the deadline for this thesis, not due to a lull in the wind power conversation for Delaware.

Green Drinks Meeting and Feedback

Green Drinks is a networking organization based in Delaware that welcomes anyone with interest in sustainability and the environment. Meetings held by Green Drinks typically host environmental supporters and activists from groups across the state. A Green Drinks meeting was held on February 21, 2022, to discuss the SIOW report for Delaware, making this the first public stakeholder meeting accounted for by this thesis. The meeting began with a presentation that reviewed the SIOW report in detail, delivered by its lead author, Dr. Willett Kempton. His presentation was followed by a question-and-answer session, in which listeners clarified different points with Dr. Kempton and he replied based on his expert knowledge of the paper and SIOW research.

During the question-and-answer session, several representatives of stakeholder groups expressed support for an offshore wind procurement in Delaware, namely those speaking on behalf of the Sierra Club and the developer U.S. Wind. These speakers also stated interest in continuing a wind conversation stemming from the SIOW report. Many questions posed in the Green Drinks meeting were from individuals with less of a foundational understanding of wind energy procurements, policy, and planning, but were eager to know more about the topics covered in the paper. These individuals asked clarifying questions about a number of issues, including the federal ITC, the role of existing RECs in this project, and environmental impacts on marine mammals and from trench digging. They also asked about lessons learned from Bluewater Wind and Block Island Wind Farm projects, the latter of which was the first operational offshore wind farm in the United States. There were some audience questions about electrical transmission and the grid, such as ideal cable landing, potential NIMBY implications, expected load increase due to grid electrification, and the possibility of other states establishing their POI in Indian River, Delaware. During the content presentation, Dr. Kempton mentioned that the existing substation at Indian River could become a multistate interconnection point, which led to detailed audience questions and discussion about the interest of other states collaborating with Delaware on transmission.

Finally, several members of the audience asked questions about the state political process associated with a wind procurement. They were curious about the steps necessary to trigger public involvement, if a procurement bill could be passed by the end of the 2022 legislative session, and what the impacts may be on wind power prices given further delay of a potential procurement.

The Green Drinks meeting was the first event at which immediate reactions of stakeholders could be gathered, even though attendees didn't have access to the report at this time. It was clear, however, that the audience was very engaged with the material, and that the Sierra Club and other organizations had interest in pursuing offshore wind policy. The developer representative from U.S. Wind had several comments that supported Dr. Kempton's points and added credibility to his presentation. It should be noted that the majority of the audience likely had prior interest in renewables; therefore, it was unsurprising that many attendees spoke to their support for wind power and declared their interest in becoming wind energy advocates.

Developer Meeting and Feedback

The SIOW held a meeting with a wind developer on March 11, 2022 about the content of the recently released Delaware report. Since this meeting was covered by a non-disclosure agreement between the SIOW and the developer, they will remain anonymous, and details of the meeting will only be discussed at a high level.

The wind developer representatives, as technical experts with financial interest in the wind power industry, had many advanced questions about the paper and some hesitations with content discussed in the SIOW report. As a developer, they were concerned that certain language in the paper would encourage state action that over-regulated the power procurement process. If points in the paper were to be misinterpreted or incorporated incorrectly into policy, the developer could face unforeseen restrictions that eventually raise the price of energy. They were particularly apprehensive about the suggestion in the SIOW report to establish shared transmission corridors between Delaware and other states, with the worry that shared transmission as a requirement could delay ongoing construction and planning. Overall, developers are a key stakeholder in any wind power procurement as the sellers of power, and are generally very interested in new potential state procurements. That said, their concern over the role of the paper showed their awareness of state policy that could hinder the developer's role and their eager interest in avoiding any misinformed legislation.

League of Women Voters (LWV) Meeting

Another meeting was held with the League of Women Voters (LWV) on March 22, 2022. LWV is a prominent interest group in the state with several members already acting as wind advocates. The meeting followed a similar structure to that of the Green Drinks meeting: Dr. Kempton spoke for about an hour on the content of the SIOW report, then key stakeholders provided their input before opening the floor to more general audience questions.

Sen. Hansen was the first audience speaker. She gave her feedback from the presentation and asked Dr. Kempton a few questions. Sen. Hansen expressed concern over the 2018 Offshore Wind Working Group decision to hold off on a wind procurement, and wanted to know what has changed since then. She asked what grid updates may be needed and how they could be implemented for a possible injection of power from an offshore wind farm, and showed interest in looking to other grid systems that support offshore wind outside of the Delmarva peninsula to inform any necessary changes. As an environmentalist, she was further curious about the potential impacts of an offshore wind farm on marine mammals and birds. She was clearly ready to have access to the paper, as it was still inaccessible to the public (including legislators), being held for release by DNREC. Dr. Kempton answered the questions that she posed by emphasizing the large and recent drop in wind power costs due to the growth of the market in the Northeast U.S. and the currently available federal ITC. He also noted that grid updates will be required for transmission systems, but not for distribution systems, and that this was within the responsibilities of PJM. Senator Hansen mentioned that she has been spending a lot of time with solar rules and utility concern about distribution system upgrades, and noted that focusing only on transmission system upgrades would be easier.

Senator Gay was also present, who spoke after Senator Hansen. She didn't have as detailed of a reply to Dr. Kempton's presentation, however, did express support for an offshore wind power procurement as well as gratitude for the conversation that had just recently been sparked in the state as a result of the SIOW report.

Another critical stakeholder, Chief Coker of the Lenape tribe, also gave his input on a potential Delaware offshore wind procurement. For some context, many indigenous artifacts have been found on the sea floor nearby planned offshore wind sites, as the shallow outer continental shelf (OCS) of the East Coast was once land that first nations people had lived on. Site studies have uncovered some of these artifacts, therefore any comprehensive stakeholder engagement work would recognize the cultural importance of these ocean spaces for indigenous tribes and plan wind development with consideration of their input. In the meeting, Chief Coker discussed the consultations that developers have with tribes regarding cultural artifacts on the OCS. He also described his support for alternative energy projects, this being a critical check for future planning endeavors.

Next, the floor opened for greater audience questions, from several interested parties who were generally less educated about offshore wind. Audience members asked questions regarding the property value effect of offshore wind, whether turbines could be recycled, the distance of offshore wind sites from the coast, the impact of sea level rise on wind farm engineering and design, the consequences of wind speeds not blowing fast enough, how to become a wind advocate, and other industries that use ocean space and may conflict with the wind industry.

Overall, the LWV meeting attendees had varying expertise on wind power. The audience was very supportive of offshore wind in Delaware as a non-partisan interest group.

Interfaith Power and Light (IP&L) Meeting and Feedback

The next chronological meeting was hosted on March 30, 2022 by Interfaith Power and Light (IP&L), an interest group that describes themselves as a religious response to climate change. The meeting began with another 45-minute report content presentation from Dr. Kempton, after which a panel was introduced to discuss their own interests and answer any related questions. The panel added 3 additional speakers, these being environmental conservation representatives from the Audubon Society, Delaware Center for Inland Bays, and a researcher for environmental impacts on human health.

The panel was first asked why they supported offshore wind with regards to its local impacts on bird deaths and inland bays. Each panel member spoke to the overwhelming threat of climate change with respect to their own interests; this was used as a reason to support renewable energy projects that could help mitigate the large impacts of climate change, even if they do have other, much smaller negative environmental impacts.

Then, audience members asked various questions directed at panel members. This was with regards to the current obstacles to wind power in Delaware, the impact of wind development on the horseshoe crab population, concerns about bird migration, the health and climate benefits of offshore wind, the environmental impacts of transmission cables on watersheds and inland bays, and the point of pursuing a wind power procurement after the 2018 offshore wind working group conclusions.

Overall, the IP&L meeting attracted several wind advocates, however it should be noted that there was one attendee from the Caesar Rodney Institute (CRI) who made several comments in the meeting chat in opposition to offshore wind and wind power price. For the most part, however, the IP&L meeting gathered conservation experts whose express interest in offshore wind power eased the minds of environmentally concerned voters. Again, there were varying levels of wind expertise among audience members, but they were generally supportive of a potential procurement and excited about the conversation that the SIOW report had sparked.

Media Coverage

After the SIOW report's release on April 7th, 2022, several news outlets announced the report's publication, findings, and estimated impact. The seven articles and newsletters that are identified here were released by both local Delaware outlets and larger-scale organizations. The following section details each press release, including notes on its credibility, audience, and content.

The first press release regarding the DE SIOW report was published by Delaware News and written by representatives of DNREC, titled "Report Outlines Offshore Wind Opportunities, Challenges for Delaware" (Lavoie and Lee, 2022). The article was published the same day that DNREC released the report for public access, and clearly presents the release of the report from the perspective of DNREC. First, Lavoie and Lee discuss the requests from DNREC Secretary Garvin, the Senate Environment and Energy Committee, and the House Energy Committee for cost analysis and state options report from the SIOW, along with the MOU between the SIOW and DNREC. They include a lengthy discussion of the 2018 Offshore Wind Working Group findings, then a statement from Secretary Garvin that "the [SIOW] report, along with the findings put forward by the Offshore Wind Working Group, are essential pieces that will help ensure we make the right decisions moving forward" (Lavoie and Lee, 2022). The Delaware News article then summarizes key findings of the SIOW report, specifically that the cost of wind power is now comparable to current wholesale power purchases and that it is less than half of the cost with health and environmental impacts considered. Finally, a quote from the SIOW Director Kris Ohleth is included, and the article author(s) mention other state environmental policy initiatives such as the Renewable Portfolio Standards (RPS) and Climate Action Plan that wind power could help to satisfy.

Overall, this article announced the initial release of the report and contextualized it with surrounding state policy initiatives, written from the perspective of DNREC. The emphasis placed on the 2018 Offshore Wind Working Group in this article, paired with Secretary Garvin’s comments that the SIOW paper doesn’t “address all of the options put forward” by the working group, suggests that DNREC and much of the state are still framing the offshore wind conversation around their conclusions. Since the working group found that the state isn’t ready for wind power, the tendency for DNREC to prioritize the working group in the wind discussion suggests some hesitance in their approach to wind power now.

The next chronological media release was published by Delaware Public Media on April 8^{th}, a day after the SIOW report’s public release, titled “Offshore wind report says Delaware could procure power at less than half the current cost” (Hurdle 2022a). The report comments on how the SIOW report and another research paper from the University of Maryland could reflect upcoming state action on wind power. This report, like that from Delaware News, also highlighted the SIOW finding that wind power can be bought at half of the current market price if taking health and environmental costs into consideration, as mentioned in both the title and opening paragraph of the article. (For further reference to the relevant cost calculations in the SIOW report, see Figure 2 as displayed in this thesis). Hurdle summarized the objectives of the SIOW report along with this major finding, then included the statement by Secretary Garvin about the connection between this report and the Offshore Wind Working Group from the Delaware News release. Hurdle then quoted Dr. Kempton, who had stated that wind energy is much lower than what is was in 2018 due to recent development among nearby states. Hurdle further specified that eight east coast states have committed to 28,000 MW of wind power to be developed by 2035, a stark contrast from Delaware's reluctance to get involved with a procurement. The article continues to cite statements from Dr. Kempton, such as that technological improvements, bidder competition, and the federal income tax credit are key factors in driving down the cost of wind power. Hurdle mentions other changes to the wind market, such as that state subsidies are no longer required and that a single commercial-scale wind farm could meet a third of Delaware electricity needs. At the end of Hurdle's discussion of the SIOW report, he mentioned the prior success of SIOW reports in Massachusetts and New York, as well as the position of the SIOW to analyze costs and policies rather than advocate for wind power.

In total, the Delaware Public Media report included a thorough summary of the SIOW report and suggested that a lot has changed for the wind industry since the working group findings. Hurdle's mention of the working group based on Secretary Garvin's statement again implied that DNREC remains focused on the recommendation for inaction; it further demonstrated the impact that DNREC's portrayal of the paper could have on the continuing wind power discussion. That said, immediate media coverage following the report's release could suggest that the SIOW report is substantial enough to redirect the conversation, in the minds of other stakeholders.

On the same day as the Delaware Public Media release, WHYY published an article about the SIOW report, titled "Report says when accounting for climate and health, wind power is cheaper for Delaware" (Schmidt 2022). The article emphasizes that Delaware is "rare among coastal" states in that it doesn't have planned offshore wind, but that the SIOW report could represent a turning point for the state. Schmidt pointed out that an 800 MW wind farm would produce power within the same price range as current wholesale prices, and that wind power "looks even better" when environmental and health costs are accounted for. (Again, reference Figure 2 in this thesis for primary cost calculations from the SIOW for Delaware). The article provided a link to the SIOW report, then discussed the state options that are listed in the report for a lower electricity cost.

The WHYY article is the first media release from a non-local news source and the third significant news article released, which speaks to the greater impact that the SIOW report may have had on the East Coast energy industry. It's also the first article to focus strictly on report findings, rather than incorporate the context of other wind-related initiatives in the state such as the working group or existing energy policies.

Schmidt's summary solidified that, to many SIOW report readers, the most notable finding was that wind power costs are half the current market price with health and environmental costs considered.

Another local news publisher, Delaware Business Now, wrote a fourth article about the report's release and impact on April 9th, titled "UD report takes note of offshore wind's reduced generation costs" (2022). The article opens by stating that a new UD report sees offshore wind as a "cost-effective option," and that Delaware's reluctance to invest in wind power stems from the Bluewater Wind failure. Delaware Business Now provides a link to the report, then explains the agreement between the SIOW and DNREC. The rest of the piece is identical to the second half of the article published by Delaware News on April 7th, where Secretary Garvin's statement on the working group and the SIOW report, major report findings, a statement from Kris Ohleth, and discussion of state policy goals are all presented.

The Delaware Business Now article didn't contribute much new information to the growing pool of media releases, however its release showed that yet another local news source deemed the SIOW paper important enough to inform their readers of. Again, this article was largely guided by the Delaware News release and Secretary Garvin's focus on the 2018 working group.

The next instance of media coverage was a newsletter from an institute that generally opposes renewable sources of energy. Their piece was the first to directly oppose the conclusions reached by the SIOW report. It was published April 11th by the Caesar Rodney Institute (CRI) as a newsletter that's emailed to their subscribers, titled "University of Delaware research paper on offshore wind costs gets an 'F'" (Stevenson 2022). The newsletter mentions conclusions from the SIOW report and combats them with alternative statistics, such as that "wind power will be 3.5 to 5.7 times as expensive as the current wholesale price" (Stevenson 2022). The author then asks, "How did UD get this so wrong?" Stevenson then made several claims about wind power costs that are not supported by other sources in the newsletter, such as that *Skipjack 2* in Maryland predicts a capital cost of $4.8 billion/MW (or $6 billion/MW if including transmission). For reference, the estimated total cost of an 800 MW offshore wind farm per the SIOW report is under $3 billion total, a very different number than what Stevenson suggests. The newsletter then attacked the assumptions made in the SIOW report, attempted to instill fear in readers about much higher energy costs, and added that the state can meet its renewable energy goals without offshore wind.

The CRI newsletter identified parts of the SIOW paper to rebut, with several of their assertions appearing poorly supported. For example, the CRI claims that offshore wind power prices are much higher by citing the original, now superseded Skipjack 1 price, along with older data from the U.S. Energy Information Agency. This is in comparison to the Delaware SIOW report, which tabulates 15 firm contracts for offshore wind power and compares them on inflation-adjusted, equal basis. The CRI describes themselves as a “nonprofit, nonpartisan, public policy research organization” that “effectively promote(s) free markets, limited government, and individual liberty” (Stevenson 2022). Although self-identifying as nonpartisan, their mission statement appears to follow libertarian ideas, meaning that a government-procured large-scale offshore wind power project wouldn’t be likely to gain their support due to philosophical differences. While the CRI newsletter may shape some of the wind power conversation and influence a stakeholder group, its challenges to statements in the SIOW paper are not as well supported as the CRI counter-claims. I also note they are the only negative public statements for the paper thus far.

The next media coverage for the SIOW report came a couple of weeks later after the initial surge of media attention and was written on behalf of the international trade press publication, Recharge News. The article, published April 24th, is titled “Delaware: Will ‘First State’ finally get onboard now that US offshore wind is leaving harbour?” (Ferry 2022). The article highlighted that Delaware “stands apart” in the eastern seaboard region as behind in the wind power industry after termination of the “ill-fated Bluewater Wind project” (Ferry 2022). Ferry then introduced our report, identifying the SIOW as a “think tank” that was claiming “dramatic” changes for the economic potential of wind power since Bluewater. This is the first news article to identify the report’s point estimate for expected wind power cost, $71/MWh. Ferry added that the SIOW report includes “scale-up-focused” options for the state, that the

SIOW recommends an 800 MW project or larger with at least 15 MW turbines, and that other states have had varying priorities for their procurements. The article then mentioned immediate next steps for the state, such as changing current state code to allow PPAs with longer time frames and watching upcoming lease sales from BOEM in the Central Atlantic area. Ferry concludes by pointing out Delaware's initial advancements with offshore wind, recent stagnation, and the contrast between "ambitious sector development programmes" in Maryland and Virginia when compared to Delaware's inaction (Ferry 2022).

Recharge News is described by its website as "global news and intelligence for the energy transition," suggesting that it covers offshore wind and other renewable energy interests often and in areas around the world. The day of this article's release, it was on the front page of the Recharge News home page for all viewers. While this publisher is more likely to paint the report in a positive light due to its involvement in the renewable energy industry, in my judgment, the points made by Ferry provide an informed and logical summary of the SIOW report and surrounding context.

The final media release within this thesis' time frame of reactions reporting is a second article from Delaware Public Media, titled "Delaware moving toward decision on whether to buy offshore wind power" and published on May 13th (Hurdle 2022b). The article first reminded the audience that the SIOW report was released just over a month ago; here, Hurdle aimed to update readers about progress in the state. The author included new statements from Secretary Garvin that “suggest[ed]… Delaware is poised to join every other Northeastern state by committing to procuring offshore wind power,” although Secretary Garvin then “declined to say when a decision could be made.” The DPM article then re-summarized report highlights, mentioned the 2018 working group, and emphasized the cost-competitiveness of wind power now. Hurdle then introduced comments from a House Republican, whose response to offshore wind was that costs remain an issue and that the tourist industry could be harmed by wind farms. Although Hurdle pointed out that legislative action during this session would be ideal to secure the federal tax credit, he also noted that the session is nearing its end and it would prove difficult to codify a wind procurement by the end of June 2022. The article continued to discuss the prominence of wind power in other nearby states and ended by stating that DNREC plans to have an outside consultant review potential action steps for the procurement of wind power.

The continued pursuit of media coverage on Delaware offshore wind action by DPM suggests the long-term interest in potential wind for the state by readers. The second DPM article also focused much less on the 2018 working group, which could imply that the conversation may be shifting away from the working group’s findings and more toward future development in the state, speaking to the impact of the SIOW report. That said, it is possible (albeit unfortunate in the minds of wind advocates) that the state won’t pass legislation in the 2022 session to procure offshore wind. While future media press or state action will not be covered by this thesis past May 13^{th}, 2022, the near-future status of wind in Delaware is unclear and state policy decisions are still developing.

POWER Meetings and Feedback

The final stakeholder meetings to be addressed here were part of a series held by People for Offshore Wind Energy Resources (POWER). POWER was created by Peggy Schultz, by recruiting a lead representative from other engaged interest groups, including the League of Women Voters, Citizens' Climate Lobby, Delaware Electric Vehicle Association, Sierra Club, and Delaware IP&L; the involved members of those other groups generally have more offshore wind knowledge. Their first reaction to the SIOW report was an official statement on April 7th – the same day that the report was released by DNREC – in which prominent POWER members voiced their support for offshore wind in Delaware based on the report's claims and other factors. Advocates quoted were mostly leaders of other stakeholder groups in the state.

Their first recorded meeting in response to the SIOW report was on April 18th, with POWER requesting that the SIOW co-authors summarize the report and answer questions. It was also held for POWER members to discuss next policy steps, potential bill writing, and comparisons of Delaware's wind power strategy to that used in 2016 for the first Massachusetts procurement. While I have been asked to keep some discussion in the strategy meeting confidential, it was generally an opportunity for

SIOW authors to connect with wind advocates and clarify any confusing points made by the report. Note that POWER, in addition to Delaware state government, provided initial motivation for execution of the SIOW report; the group is now carrying out briefings with the legislative and administrative branches, as well as other organizations requesting such.

POWER continued their work in the state between the report's release and May 13th (though note that their involvement is likely to continue in the near future). The group drafted potential procurement legislation to present to state policymakers and arranged meetings with several leading senators and representatives in attempts to gain their support and/or sponsorship for a wind power procurement bill. In some of these later POWER meetings, state legislators expressed frustration that the state administration (DNREC) wasn't working more closely with them or efficiently, but nevertheless these policymakers showed support for an offshore wind procurement bill. As of May 13th, POWER has had one-on-one meetings with 3 representatives or senators, with several more planned. Also as of May 13th, at least two additional legislators have been in attendance to stakeholder meetings that were held to review the SIOW report (such as the Green Drinks meeting, IP&L meeting, etc.)

While report reactions are still evolving, those recorded between February 21st and May 13th of 2022 show that the state is very much re-engaged in wind power as a result of the report's release. Most reactions to the report have been positive, with the noted negative reactions being from the CRI newsletter; in addition, mention of the 2018 working group findings dwindled as DNREC released more offshore wind-supportive statements over time. Many legislators have also engaged with the idea of a wind power procurement, though it seems unlikely that there will be legislative action before the end of the 2022 Delaware legislative session, which increases the risk of not achieving the power cost reductions that would stem from the federal tax credit. Development between May 13th and June 30th, the end of the session, will answer more questions about the intent of the state House and Senate to support administration of a PPA for offshore wind.

Chapter 5

Discussion and Conclusion

Content from the results section above can be described as a “case study” for Delaware pre-procurement analysis. This includes the state options and cost calculations that we completed for the SIOW report as well as subsequent reactions from initial stakeholders. The state is now one of three that has requested and been provided a report by the SIOW, after which some form of progress toward offshore wind power has been made for each state (although just starting in Delaware). The detailed cost and policy projections for Delaware can be further contextualized by data from Massachusetts and New York procurements that were preceded by SIOW reports.

Data on Massachusetts were more readily available than data for the state of New York; therefore, the sections below delve into the work done by the SIOW in Massachusetts. The literature review of this thesis includes more information about the New York SIOW report and outcomes.

The SIOW published their reports for Massachusetts in 2016, meaning that any offshore wind development since then would have had much more time to mature than development in Delaware. After reviewing the Massachusetts case, this thesis will analyze the impact of the Delaware SIOW report and stakeholder feedback, then suggest next steps for the offshore wind industry and procurement processes of the Eastern seaboard.

Success of a Pre-Procurement Analysis for Massachusetts

The SIOW study for the Commonwealth of Massachusetts estimated power costs for a 2000 MW project deployed on the OCS of Massachusetts (Kempton et al. 2016). The study details the thorough methodology employed in attaining Levelized Cost of Energy (LCOE) estimate values, based on reasonable projections of the effect of market visibility and a learning curve on the Massachusetts OSW industry from 2020-2030. External public influences on price – RECs, carbon fees, tax credits, subsidies, etc. – that would further lower the cost of energy are not incorporated into this analysis. This study uses expert industry input for construction and manufacturing costs and an expert model to estimate annual energy production, similar the model considered by Method 2 of the Delaware SIOW report. The Massachusetts report also utilized a simplified transmission analysis that was performed by the SIOW. The study concludes that a 400 MW project (or "Tranche") generating energy by 2023 would cost $162/MWh, and that by 2026 and 2029, two 800 MW installments would provide electricity to ratepayers at $128 and $108/MWh, respectively.

Two news articles detailing the legislative process provided insight into public perception of the wind power procurement. One article published May 24th of 2016 and titled “Rep. Haddad ‘thrilled’ about wind-energy plan’s inclusion in state House Bill,” was written in celebration of HB4568 being moved out of committee (Lawrence 2016). The second article, “Now, it’s real: The tumultuous path to state law” was published December 31st of 2016, after HB4568 passed both houses in the 2016 session and was signed by the governor of Massachusetts that August (Holtzman 2016). The latter article also highlights Rep. Haddad’s immense role in this project and lists some of the additional elements that were essential in preparing Massachusetts for the passing of this law. The list included 2 trade missions to Europe by statewide power players; the construction, permitting, and preparation of the Marine Commerce Terminal, fully funded by the Commonwealth of Massachusetts; the establishment of the New Bedford Wind Energy Center, several university-supported studies (such as the SIOW study); and endless public forums, meetings at the statehouse with the governor’s administration, and international correspondence. The December 2016 article was written with a sense of hope for the future prosperity for New Bedford, MA, with predictions that a new industry would come with this groundbreaking step toward offshore wind energy generation.

The text of HB4568 displays the mechanisms through which the Massachusetts legislature attempted to procure this electricity, and how they prompted utility companies to take the next steps in interacting and contracting with potential offshore wind developers (Massachusetts House of Representatives, 2016). It required that by June 30th of 2017, every distribution company “jointly and competitively” solicit proposals for offshore wind generation. The Massachusetts procurement bill also required that distribution companies enter contracts for an aggregate 1600MW of capacity no later than June 30th of 2027. The legislation also incorporated a REC system, unlike the SIOW's current recommendations for the state of Delaware. At the time of the 2016 Massachusetts procurement bill, wind power was more expensive and state subsidy creation was more of a necessity.

It is clear that the 2016 SIOW study played an integral role in a very complex legislative process for the Commonwealth of Massachusetts and was one of many factors that led to the passage of HB4568. With concise methodology, reasonable assumptions based on offshore wind cost reduction trends through recent history, limited industry bias but utilization of industry expertise, and a publicly attainable price calculator, the SIOW crafted a comprehensive evaluation that was both transparent and rational. In these ways, the SIOW Delaware report is strikingly similar to that written for Massachusetts 6 years prior. The Massachusetts study made an argument for the cost-competitiveness of offshore wind that was rarely emphasized at this time, and which could be used to effectively combat the strongest opposing arguments to an offshore wind procurement in 2016. The story of the Massachusetts study-to-bill process highlights the importance of a credible, independent cost analysis in convincing skeptics that electricity from offshore wind power isn't necessarily a bad choice for ratepayers.

The next significant procurement step for Massachusetts was completion of the RFP process. The MA Department of Energy Resources in conjunction with five Massachusetts utility companies posted a request for proposals on June 29th of 2017 (MA DER, 2016). The RFP gave an overview of stages taken by the Evaluation Team (ET) in reviewing proposals; referenced procurement legislation criteria; reviewed components that bidders were required to include in their proposal; and specified preferences that the ET had for project proposals (MA DER, 2016). The preferences of the ET focus mostly on minimizing risk for and adding value to Massachusetts ratepayers. Other priorities include cost-effectiveness, feasibility/viability, and any benefits to the distribution companies that the bidder is willing to provide (i.e., entitlement to RECs).

After a proposal drafting, submission, and evaluation period, the ET chose Vineyard Wind as the winning developer for the first commercial scale offshore wind power procurement in Massachusetts. Their project, Vineyard Wind I, is planned to produce 800 MW of wind power. As of early 2022, the project has come to a financial close and construction is underway (Vineyard Wind LLC, 2022). Since HB4568 was initially passed, another procurement process was initiated in the commonwealth with the signing of "An Act to Advance Clean Energy" in August 2018 (Commonwealth of Massachusetts 2022). The new legislation required an additional 1600 MW of offshore wind power solicitation, which led to a second request for proposals on May 23rd of 2019 (MA DER, 2019). In December of 2021, the Massachusetts governor announced that a project from Mayflower Wind and a second project from Vineyard Wind were selected to supply this power to the commonwealth (MacCormack 2021).

Impact of Delaware SIOW report on state action

Advancement of a Delaware wind power procurement process could parallel that accomplished in Massachusetts. As suggested by the media coverage for MA, it required a massive effort to launch procurement legislation, after which a successful and informed procurement process could take place. Delaware currently stands where Massachusetts did in 2016. Stakeholders have access to the most up-to-date cost estimates for wind power in the state, and despite clear interest in wind power from many groups, several state leaders still have their reservations about a commercial-scale offshore wind project. It will require a concerted effort from all engaged parties to push wind power legislation through the Delaware House and Senate, if enough stakeholders eventually decide that wind power is a worthy legislative goal. It's possible that by 2028, 6 years after the release of the most recent SIOW report, Delaware will sit where Massachusetts does now, with offshore wind power under construction. Delaware cannot move forward on this front without legislative action and cannot deduct the market price of offshore wind power until an RFP process is initiated. As the state conversation moves forward with offshore wind, the price of wind power trends downward, technology improves, and this resource becomes more and more favorable.

Looking Ahead

The SIOW reports played a significant role in initiating wind power procurements in Massachusetts and New York and a return to the offshore wind conversation in Delaware. These reports further informed policymakers about legislative options, therefore optimizing content in the procurement bill. There were also substantial differences—both NY and MA were considering action before the industry had started in the US, so a major effect on price was reaching enough MW of state commitments for "market visibility" and thus investments to create a cost-effective industry in the U.S. By early 2022, the market visibility was already several times the size anticipated in 2015 and 2016, therefore the Delaware report concentrated on how to do a procurement and associated policies to reduce cost (and/or to create more employment). All three reports provided advice on how to efficiently do procurements, but the Delaware report – based on six years of subsequent experience – was more targeted in procurement policy recommendations, emphasized by the cost impact estimates for most of those recommendations. Thus, the Delaware report is much closer to what might be provided for subsequent states than the NY or MA reports.

The success of the three case studies discussed throughout this thesis provides strong evidence of the significance of SIOW contributions. Moving forward, the question becomes: how can this form of analysis be cemented as a standard precursor to any offshore wind power procurement, especially for entities that haven't yet had a successful wind power solicitation? Think tanks such as the SIOW are strong contenders for continued work in this field. But the necessary skills are not widespread — both NY and MA had prior, high-paid consulting groups to address similar issues, but concluded future price estimates that were way too high and lacked the essential policy recommendations that later succeeded. As wind power needs increase (whether on the East Coast, nationally, or internationally), the SIOW itself cannot provide an in-depth cost analysis of every potential procurement. More wind power experts will need to emerge, and new think tanks will need to be formed for these analyses to meet the wind power demand. Fortunately, industry growth is paired with the expansion of wind advocacy groups, wind power education programs, and general knowledge of offshore wind in society. As the international community launches toward an unprecedented renewable energy transition, it is imperative now more than ever that SIOW-like groups be expanded and tasked with pre-procurement cost analysis.

Research Contributions

While compiling this thesis, I pulled from several existing sources and relied on the knowledge of field experts, however, I performed many analyses and independently added to the body of knowledge surrounding offshore wind procurements and cost projections. Listed below are my individual contributions:

- I was the second author on the 2022 Delaware SIOW report. My work on this report involved policy research, expertise from the Massachusetts procurement processes, content review of other author's writing, technical writing and communication, and research for and production of figures and tables.
- I performed a legal analysis of two recent Massachusetts offshore wind procurement processes that resulted in PPAs for Vineyard Wind 1 and Vineyard Wind 2. This analysis included deep research on the procurement bills, RFP documents, winning developer proposals, surrounding media coverage, and future outcomes of each procurement.
- I diligently recorded any initial reactions to the SIOW report after seeking out and attending every listed meeting with stakeholders. I also conducted thorough research to gather instances of media coverage on the SIOW report between April 7th and May 13th, as well as research into the credibility and bias of each media source and stakeholder group.
- I performed the first known thorough review (among available literature) of the impact of a pre-procurement offshore wind cost and policy analysis report for a state.

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