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U.S. Offshore Wind Prices (2018-2021)

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Preface, Acknowledgements, and Disclaimer

This report, developed during the fall of 2021, was sparked by the efforts of the Committee Chairs and Staff of the Massachusetts Legislature's Joint Committee on Telecommunications, Utilities, and Energy (TUE) to understand the prices associated with the development of the U.S. Offshore Wind (OSW) industry. The Committee's examination has served as preparation for the current 2022 legislative session wherein questions related to offshore wind development's economic benefits for Massachusetts are being discussed in detail. Central to this discussion is the current imposition of a "price cap" on Massachusetts offshore wind procurements which stipulates that each successive offshore wind procurement must have a price that is lower than the previous procurement. Advocates of the price cap credit its effectiveness for bringing the lowest U.S. offshore wind prices to Massachusetts. Critics of the price cap claim that it has left little room for offshore wind developers to include economic benefits to the Commonwealth of Massachusetts in their bids.

In an effort to understand better the relationship between offshore wind prices in 2022 dollars (reported in dollars per MWh or $/MWh) and putative economic benefits to a given state, we reviewed nine projects in Massachusetts, Rhode Island, New York and New Jersey, for which we were able to find contract pricing in the public record. We developed this study without any external funding and during our own free time. We progressed the work primarily on weekends during the months of October and November 2021 and then vetted it through a series of engagements during November 2021 through January 2022 with state lawmakers, state and federal employees, offshore wind developers, academic economists, finance professionals, infrastructure professionals, and representatives from labor and environmental organizations. We extend our gratitude to our colleagues who engaged with us in this discussion and who provided helpful feedback on this report.

We take full responsibility for the content and discussion herein. Any mistakes, omissions, and opinions within this document are ours alone, and we will be glad to receive further feedback as this document reaches a wider audience.

Eric Hines and Barbara Kates-Garnick
Tufts University, February 2022

Executive Summary

With the development of offshore wind (OSW) projects along the East Coast, each project will have a unique cost that its developer will aim to recover by negotiating an energy price, expressed in dollars per megawatt hour ($/MWh) for each year of the project's commercial operation. This price will be borne by ratepayers and is of primary interest to state decision makers evaluating the costs and benefits of competing projects. The "cost" of a project is proprietary information and cannot be known except to entities that plan, finance, and construct offshore wind projects. The "price" of a project, however, is a matter of public interest and can be gleaned directly from public documents.

When reviewed together, offshore wind prices facilitate comparisons between projects and reflect a price signal to which market participants respond. Tracking and comparing these prices assists both the public and private sectors with information relevant to decisions that will impact ratepayers over a period of years. Starting with a set of projects already approved and new projects now in the approval process, prices for offshore wind must be clear, understandable, and presented in a way that enables direct comparison between projects.

The prices discussed herein are from projects procured in Massachusetts, Rhode Island, New York, and New Jersey whose agreements for Power Purchase or Purchase of Offshore Renewable Energy Credits (ORECs) have been archived in the public record. In the paper we attempt to place these projects on a common footing by calculating and reporting their "levelized nominal price" (LNP). While the projects discussed represent approximately half of the U.S. OSW energy procured so far, we believe that their diversity provides useful information and insight regarding the emerging U.S. offshore wind market.

Offshore wind developments are large and sophisticated infrastructure projects with costs exceeding $3 Billion; long-term contracts[1] of 20-25 years; a critical relationship to public infrastructure such as ports and transmission; the simultaneous need for state and federal involvement in permitting, contracting, and regulation; and subsidies like investment tax credits.

Since the historically low prices for Vineyard Wind 1 were published by the Commonwealth of Massachusetts in 2018, state commitments to purchase offshore wind have grown to 40,210 MW and state procurements of offshore wind power have grown by 14,427 MW.[2] This report provides a comparison of publicly available offshore wind pricing for nine projects procured from 2018 to 2021 with a total rated capacity of 7458 MW. From this comparison, we estimate the levelized nominal price of U.S. offshore wind energy to be $95/MWh in 2022 dollars.[3]

[1] In this report, we use the words "contract" and "agreement" interchangeably to refer to the "long-term contracts" between state entities or utilities and offshore wind developers.
[2] Dominion Energy submitted its application for the 2587 MW CVOW Commercial Project on November 5, 2021. If this project is included, then the total procurement number becomes 17,014 MW.
[3] For purposes of this report, the levelized nominal price can be understood a summation of the lifetime costs divided by the energy produced and is defined mathematically later in this paper.

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1 Introduction

Since the signing of the Vineyard Wind Power Purchase Agreements on July 31, 2018 (VineyardWind1a, VineyardWind1b, 2018), the U.S. offshore wind (OSW) market has entered a new phase where state procurement volumes have steadily increased from the order of 400-800 MW to the order of 1,200-2,400 MW and many contract prices have come in below $100/MWh. To date, the states of Massachusetts, Rhode Island, New York, and New Jersey have made pricing for at least nine projects totaling 7458 MW available to the public.

Prior to the 2018 announcement of Vineyard Wind's $69.47/MWh price in 2017 dollars (MA-DOER, 2018), the published prices for Cape Wind (430 MW at $187/MWh) and Deepwater Wind's Block Island Wind Farm (30 MW at $244/MWh) had given the impression that it would be several more years before the U.S. could expect "European" prices for offshore wind. And even in the UK, as late as 2015, it was considered optimistic to imagine prices falling below £100/MWh (approximately $133/MWh) prior to 2020.

Given the projected growth of U.S. OSW, the challenge of understanding pricing regimes—among and between states and projects—is becoming ever more critical to the U.S. OSW market. If benefits are to be realized in terms of energy deployment, greenhouse gas (GHG) reduction, the environment, citizen equity, and jobs, it is critical to distinguish between rate payer costs for energy versus rate payer costs for investments in infrastructure, supply chain, and transmission. This pricing regime is one part of a larger picture involving: how various states have chosen to acquire the resource; the rules of the wholesale market; the expected time frames for the projects to operate; embedded subsidies; financing costs; and regulatory governance. It is important to note that the prices we discuss in this paper do not include the infrastructure associated with transmitting the resource once the electricity enters the grid.

Although methods vary among states, there is a basic process that impacts all energy procurements where public utility regulation plays a role, and there are multiple stakeholders who litigate the terms of the procurement, including: wind developers, economists, consumer advocates, load serving entities, utilities, business interests, environmentalists, suppliers, and interests directly impacted by wind development. Within the rubric of regulation, the principles of reliability, efficiency, fairness, and affordability come into play as they always have in relationship to public utilities.

As OSW procurements take place within this broader context of energy procurement, we can expect variations in approaches and objectives among the states in terms of their procurement processes and the values that decision makers weigh in terms of establishing these processes. Researchers at the National Renewable Energy Laboratory (NREL) have provided a clear road map of the processes and approaches of the procurements to date (Beiter et al., 2020). They have

provided a taxonomy of design criteria, policy instruments, solicitation approaches, linkages to the wholesale market, and the context of other state regulatory policies such as the renewable portfolio standard (RPS). This taxonomy informs our focus on better understanding the pricing underlying U.S. OSW contracts.

Although OSW procurement processes are occurring within the public sphere, the information and output is not always clearly understandable or transparent to the public. Much of the process to approve projects occurs based on submitted documents that are often redacted, public hearings that can be hard to follow for the average citizen, and final contract approvals that are based on closed deliberations at state regulatory commissions. Furthermore, basic understanding of prices requires analysis that relies on some knowledge of economics, finance, and energy markets. Offshore wind development requires the construction of large and sophisticated energy infrastructure projects. The projects are bid under competitive conditions and are based on assumptions related to the cost of capital and supply costs. There are assumptions about time frames and milestones involving penalties if not achieved. The parsing of the contracts requires lawyers, economists, financiers, and engineers. Furthermore, public-sector decisionmakers often need to employ their own experts to determine the public interest.

It is within this context that we offer our preliminary analysis. This report references public documents, and we do not have access to the many of the assumptions and proprietary documents underlying much of these materials. Nor have we conducted an exhaustive review of all the records underlying the contracts or the all the proceedings. Rather we are simply reviewing publicly available OSW prices with the goal of better understanding how they compare to one another. By doing so, we hope to provide a useful framework for future decision making related to this critical energy resource.

The Massachusetts "Price Cap"

The dramatic increases in U.S. project size coupled with reliable decreases in project price were impossible to imagine in 2016 when Massachusetts wrote its groundbreaking 83C legislation that created a mechanism for utilities to purchase up to 1600 MW of offshore wind by 2027 (Massachusetts, 2018). For this reason, the Massachusetts legislation carried a provision known as the "price cap" which limited the cost of future procurements to less than the previous procurement.

> "A staggered procurement schedule developed by the department of energy resources, if applicable, shall specify that a subsequent solicitation shall occur within 24 months of a previous solicitation; provided, however, that the department of public utilities shall not approve a long-term contract that results from a subsequent solicitation and procurement period if the levelized price per megawatt hour, plus associated transmission costs, is greater than or

> equal to the levelized price per megawatt hour plus transmission costs that resulted from the previous procurement." (Section 83C. (b), Massachusetts, 2018)

Since 2016, nine states along the U.S. Atlantic Coast have made commitments to purchase over 40,000 MW by 2040 as shown in Table 1. While these procurements date back to Rhode Island's 30 MW commitment in 2009 and Maryland's 368 MW commitment in 2013, this paper focuses primarily on post-2018 commitments, recognizing the Massachusetts Vineyard Wind 1 project as the first utility-scale U.S. offshore wind project that demonstrated the potential for a U.S. offshore wind market.

In 2021 Massachusetts began to debate new legislation that would raise its offshore wind procurement goals to 5600 MW and lift the price cap requirement. On Wednesday, October 13, 2021, Governor Baker of Massachusetts announced his support for lifting the price cap in the context of large-scale state and federal investments in the clean energy sector.

> "This legislation includes a historic, once-in-a-generation $750 million investment to spur the next phase of clean energy innovation and will help advance critical priorities in the offshore wind industry by making key policy changes to the procurement process, lifting the price cap on project proposals and transferring authority for selecting bids to DOER," said Governor Charlie Baker. "Massachusetts continues to be a national leader for climate action and by utilizing federal funding through the American Rescue Plan Act, we can capitalize on this opportunity and strengthen our nation-leading clean energy industry." (Press Release: Baker-Polito, 2021)

The tremendous growth in U.S. offshore wind state commitments and procurements since 2016 coupled with the competition between states to secure commitments for jobs and local content has given rise to a market which can now be assessed on a national scale based on existing post-2018 prices.

Table 1. State commitments to offshore wind.

State	Commitment	Last Updated
Maine	12	June 19, 2019
Massachusetts	5,600	March 26, 2021
Rhode Island	1,030	October 27, 2020
Connecticut	2,300	June 7, 2019
New York	9,000	July 18, 2018
New Jersey	7,500	November 19, 2019
Maryland	1,568	February 4, 2019
Virginia	5,200	March 10, 2020
North Carolina	8,000	June 9, 2021
Total	40,210	June 9, 2021

As Massachusetts debates the merits of the price cap from 2016 and whether to lift it for further procurements, we offer this report to provide a comparative framework for public-sector and non-project decision makers as they consider OSW procurements and prices to date.

2 Offshore Wind Contracts and Prices Since 2018

This report catalogues and compares the publicly available documents on offshore wind prices beginning with the Vineyard Wind 1 project. Table 2 lists offshore wind state procurements since 2018 and Table 3 lists pricing numbers for nine of these projects available in the public record during the development of this report. Figure 5 through Figure 18 in Appendix B provide copies of the pages from each contract that were used for the basis for the pricing information in Table 3.

Our analysis begins with a presentation of prices on a year-by-year basis in a form that relates as closely as possible to the actual published contracts. This presentation, provided Table 3, allows the reader to review contract pricing between projects with an understanding of the following differences between contracts:

1. Variations in project pricing over the contract term.
2. Contracts with differing time frames starting between 2023 and 2029.
3. Escalation in contract prices that vary between 0%, 2% and 2.5%.

Not directly visible, but clearly implicit, in Table 3 are other factors that have a major impact on price such as:

4. Assumptions about capacity payments.
5. Use of the Federal Investment Tax Credit (ITC).
6. The level of economic benefits.

It is well-known that capacity payments, economic benefits, and the ITC could be used to explain many of the differences between the contracts reported Table 3. Attempting to incorporate these factors into an understanding of the costs and pricing of offshore wind has been the subject of the National Renewable Energy Laboratory's (NREL) work on the levelized revenue of energy (LROE) and the levelized revenue and value of electricity (LRVE) (Beiter et al., 2019; Beiter et al., 2021). In this report, however, we wish to focus primarily on factors 1, 2, and 3 in order to present a common language for discussing the prices as they appear in public documents.

We believe that the contract prices reported in Table 3 are a useful starting point for conversations on U.S. offshore wind prices. Different entities will stress the importance of different interpretations of these values. Nevertheless, the values listed in Table 3 share a

common purpose as public exhibits in legal agreements related to the procurement of offshore wind. It is our hope that in the future, states will converge on a common understanding of how to present offshore wind prices in both nominal and real terms. Until then, we hope that the following data, analysis and discussion will be helpful to anyone who has experienced some confusion in their attempts to compare one project price to another during the early days of this new U.S. industry.

State Procurements of Offshore Wind

Table 2 lists projects according in chronological order according to contract date. For each project, the state, the name of the project, the project size in megawatts (MW), and the developers are listed. The "Contract Date" is the date that the contract was signed between the developers and the utilities. These contracts are the publicly available documents from which the figures in Appendix B containing pricing information were obtained. The label "Operational" provides the dates of commercial operation that we have either read in the contracts of that we have assumed based on the qualifications listed in the relevant footnotes.

Table 2. Offshore wind procurements by state since 2018.

State	Project Name	Size (MW)	Developer	Contract Date	Operational
MA	Vineyard Wind 1a	400	CIP + Avangrid	07/31/2018	01/15/2022[1]
MA	Vineyard Wind 1b	400	CIP + Avangrid	07/31/2018	01/15/2023[1]
RI	Revolution Wind 1	400	Ørsted + Eversource	12/06/2018	01/15/2024
CT	Revolution Wind	304	Ørsted + Eversource	N/A	est. 2025[2]
NJ	Ocean Wind 1	1,100	Ørsted + PSEG	06/21/2019	05/24/2024
NY	Empire Wind 1	857	Equinor + BP	10/23/2019	N/A (2024)[3]
NY	Sunrise Wind	924	Ørsted + Eversource	10/23/2019	N/A (2024)[3]
MA	Mayflower Wind	804	Shell + EDPR	01/10/2020	09/01/2025
CT	Park City Wind	804	CIP + Avangrid	05/21/2020	12/31/2028
NJ	Atlantic Shores 1	761.6 + 748 = 1,509.6	Shell + EDF	06/30/2021	09/2027 + 04/2028
NJ	Ocean Wind 2	392 + 378 + 378 = 1,148	Ørsted + PSEG	06/30/2021	08/2028 + 10/2028 + 01/2029
NY	Empire Wind 2	1260	Equinor + BP	N/A[4]	N/A[4]
NY	Beacon Wind	1230	Equinor + BP	N/A[4]	N/A[4]
VA	CVOW Commercial[5]	2587	Dominion	application[5]	2027
MD	U.S. Wind 2	808.5	Renexia (80%)	12/17/2021	2026
MD	Skipjack Phase 2.1	846	Ørsted	12/17/2021	2026
MA	Mayflower 2	400	Shell + EDPR	N/A[6]	N/A[6]
MA	Commonwealth	1232	Avangrid	N/A[6]	N/A[6]
Total		17,014			

1. Original date of operation delayed due to delays in federal permitting.
2. Connecticut contract for Revolution Wind not located. Date estimated from Revolution Wind website.
3. Commercial Operation Date not listed in contracts. This date was taken from Table 7 in the DOE Offshore Wind Market Report: 2021 Edition (US DOE, 2021).
4. Not yet published by NYSERDA as of January 2022.
5. Application was filed as Case No. PUR-2021-000142 on 11/5/2021.
6. Not yet published by MA-DPU as of January 2022.

The first Massachusetts project, Vineyard Wind 1, is divided into two 400 MW projects which were contracted at the same time but staggered by a year under different pricing schemes as shown in Figure 5 and Figure 6 in Appendix B. The contracts for the Vineyard Wind 1 projects list an operation date in January of 2022, however, these projects are known to have experienced an approximately year and a half delay due to the Trump Administration's requirement for an additional cumulative assessment of offshore wind environmental and fisheries impacts (OER, 2019) as noted in Footnote 1 of Table 2.

Offshore Wind Projects Selected for this Study

Table 3 shows contract pricing for the following projects:

1. Vineyard Wind, MA (VW1a and VW1b).
2. Revolution Wind, RI (Rev1_RI).
3. Ocean Wind 1, NJ.
4. Empire Wind 1, NY.
5. Sunrise Wind, NY.
6. Mayflower Wind, MA.
7. Atlantic Shores Wind, NJ.
8. Ocean Wind 2, NJ.

The first year listed in Table 3 is 2022, the present year, which is highlighted in blue. Estimated commercial operation dates are highlighted in yellow, and the prices in these cells are known as year-1 strike prices[4]. Years between 2022 and the estimated commercial operation date are left blank. The year 2030, marking the Biden-Harris Administration's commitment to 30 GW, is also highlighted in blue for reference. Commercial operation dates listed in Table 3 are consistent with the DOE 2021 Offshore Wind Market Report (US DOE, 2021). Prices for each project in Table 3 can be found in the corresponding figures in Appendix B.

[4] The strike price, according to Merriam-Webster, is "an agreed-upon price at which an option contract can be exercised." In offshore wind contracts, strike prices are guaranteed payment prices listed within the contract or agreement.

Table 3. Publicly available offshore wind prices by project.

year	VW1a	VW1b	Rev1_RI	OceanWind1	EmpireWind	SunriseWind	Mayflower	AtlShores	OceanWind2
size	400	400	400	1100	816	880	804	1510	1148
2022									
2023	$ 74.00		$ 98.43						
2024	$ 75.85	$ 65.00	$ 98.43	$ 98.10	$ 99.08	$ 110.37			
2025	$ 77.75	$ 66.63	$ 98.43	$ 100.06	$ 101.06	$ 110.37	$ 77.76		
2026	$ 79.69	$ 68.29	$ 98.43	$ 102.06	$ 103.08	$ 110.37	$ 77.76		
2027	$ 81.68	$ 70.00	$ 98.43	$ 104.10	$ 105.14	$ 110.37	$ 77.76		
2028	$ 83.72	$ 71.75	$ 98.43	$ 106.19	$ 107.25	$ 110.37	$ 77.76	$ 86.62	
2029	$ 85.82	$ 73.54	$ 98.43	$ 108.31	$ 109.39	$ 110.37	$ 77.76	$ 88.79	$ 84.03
2030	$ 87.96	$ 75.38	$ 98.43	$ 110.48	$ 111.58	$ 110.37	$ 77.76	$ 91.01	$ 85.71
2031	$ 90.16	$ 77.26	$ 98.43	$ 112.69	$ 113.81	$ 110.37	$ 77.76	$ 93.28	$ 87.42
2032	$ 92.42	$ 79.20	$ 98.43	$ 114.94	$ 116.09	$ 110.37	$ 77.76	$ 95.61	$ 89.17
2033	$ 94.73	$ 81.18	$ 98.43	$ 117.24	$ 118.41	$ 110.37	$ 77.76	$ 98.00	$ 90.96
2034	$ 97.09	$ 83.21	$ 98.43	$ 119.58	$ 120.78	$ 110.37	$ 77.76	$ 100.45	$ 92.78
2035	$ 99.52	$ 85.29	$ 98.43	$ 121.98	$ 123.19	$ 110.37	$ 77.76	$ 102.96	$ 94.63
2036	$ 102.01	$ 87.42	$ 98.43	$ 124.41	$ 125.66	$ 110.37	$ 77.76	$ 105.54	$ 96.52
2037	$ 104.56	$ 89.60	$ 98.43	$ 126.90	$ 128.17	$ 110.37	$ 77.76	$ 108.18	$ 98.45
2038	$ 107.17	$ 91.84	$ 98.43	$ 129.44	$ 130.73	$ 110.37	$ 77.76	$ 110.88	$ 100.42
2039	$ 109.85	$ 94.14	$ 98.43	$ 132.03	$ 133.35	$ 110.37	$ 77.76	$ 113.65	$ 102.43
2040	$ 112.60	$ 96.49	$ 98.43	$ 134.67	$ 136.02	$ 110.37	$ 77.76	$ 116.49	$ 104.48
2041	$ 115.41	$ 98.91	$ 98.43	$ 137.36	$ 138.74	$ 110.37	$ 77.76	$ 119.41	$ 106.57
2042	$ 118.30	$ 101.38	$ 98.43	$ 140.11	$ 141.51	$ 110.37	$ 77.76	$ 122.39	$ 108.70
2043		$ 103.91		$ 142.91	$ 144.34	$ 110.37	$ 77.76	$ 125.45	$ 110.88
2044				$ 145.77	$ 147.23	$ 110.37	$ 77.76	$ 128.59	$ 113.09
2045				$ 148.69	$ 150.17	$ 110.37		$ 131.80	$ 115.36
2046					$ 153.18	$ 110.37		$ 135.10	$ 117.66
2047					$ 156.24	$ 110.37		$ 138.48	$ 120.02
2048					$ 159.36	$ 110.37		$ 141.94	$ 122.42
2049									$ 124.86
2050									
EF	2.50%	2.50%		2.0%	2.0%			2.5%	2.0%
LNP	$ 89.49	$78.61	$ 98.43	$ 115.48	$ 118.64	$ 110.37	$ 77.76	$ 105.59	$ 98.33

Escalation Factor (EF)

The row just above the bottom row of Table 3 lists the escalation factor (EF) used in each contract as an approximate value for inflation. Vineyard Wind 1 and Atlantic Shores carried an escalation factor of 2.5%, while Ocean Wind 1, Empire Wind, and Ocean Wind 2 carried an escalation factor of 2.0%. Revolution Wind, RI, Sunrise Wind and Mayflower Wind carried no escalation factor and provided a flat price for each year of the contract.

3 Methodology for Comparing Offshore Wind Prices: Levelized Nominal Price (LNP)

In order to compare projects that have different price escalations over 20-25 years and different dates for commercial operations from 2023 to 2029, we propose a methodology that puts them on a common footing. We refer to this common footing as a "levelized nominal price" (LNP). This levelized nominal price may then be converted into 2022 dollars by adjusting it according to an assumed rate of inflation.

The LNP is a single value that describes the pricing for an entire project in nominal terms. Our LNP calculations produce similar results (to within approximately 1% as shown Table 5 in Appendix A) to the values published by Massachusetts, New York, and New Jersey.

Levelized Nominal Price (LNP)

The mathematics of the LNP are similar to the mathematics of the more familiar term "levelized cost of energy" (LCOE). Therefore, in order to understand the mathematics behind the LNP, we think it is helpful to begin with the mathematics of the LCOE. The following five equations demonstrate how we arrived at LNP and its value in 2022 dollars from the equation for LCOE. The levelized cost of energy (LCOE) is defined as the

> cost that, if assigned to every unit of energy produced (or saved) by the system over the analysis period, will equal the [total life cycle cost] TLCC when discounted back to the base year (Short et al., 1995)

Mathematically, LCOE is defined as the single value that satisfies the following equation:

Equation 1

$$\sum_{t=1}^{T} \frac{CAPEX_t + OPEX_t}{(1+DR)^t} = \sum_{t=1}^{T} \frac{(LCOE)(AEP_t)}{(1+DR)^t}$$

where:

- T = project term in years.
- t = project year, ranging from 1 to T.
- $CAPEX_t$ = the capital expenditure in year t.
- $OPEX_t$ = the operations and maintenance expenditure in year t.
- DR = the discount rate, based on the weighted average cost of capital (WACC).
- $LCOE$ = levelized cost of energy.
- AEP = annual energy production.

Therefore:

Equation 2

$$LCOE = \frac{\sum_{t=1}^{T} \frac{CAPEX_t + OPEX_t}{(1+DR)^t}}{\sum_{t=1}^{T} \frac{AEP_t}{(1+DR)^t}}$$

Equation 2 is the well-known equation for calculating the LCOE. Considering, however, the "proprietary" nature of *CAPEX*, *OPEX*, and *AEP*, LCOE is a difficult number to derive precisely and discuss publicly. The *Price* of a project, however, is publicly available in $/MWh, as shown

in Appendix B and in Table 3 of this paper.[5] It is possible, therefore, to imagine a levelized nominal price (LNP) of energy derived from the relationship:

Equation 3

$$\sum_{t=1}^{T} \frac{(Price_t)(AEP)_t}{(1+DR)^t} = \sum_{t=1}^{T} \frac{(LNP)(AEP_t)}{(1+DR)^t}$$

where $Price_t$ is the contract price listed for year t. If one assumes a constant AEP_t for all project years, Equation 3 can be re-written on a per MWh basis as:

Equation 4

$$LNP = \frac{\sum_{t=1}^{T} \frac{Price_t}{(1+DR)^t}}{\sum_{t=1}^{T} \frac{1}{(1+DR)^t}}$$

In order to convert nominal prices into 2022 dollars, it is necessary to apply an escalation factor (EF) that represents an assumed rate of inflation. This EF can then be applied as:

Equation 5

$$Nominal\ Price\ in\ 2022\ \$ = \frac{nominal\ price}{(1+EF)^n}$$

Where n = the assumed year of commercial operation date minus 2022.

Discussion of an Approach to Price Analysis that Enables Projects to be Reviewed on a Common Footing[6]

Even in their simplest form, offshore wind prices require assumptions about two factors related to the present value of money. The first is a "discount rate" (DR), used in Equation 4, which represents the weighted average cost of capital. We assume DR = 7%, which is consistent with the assumption made by NREL in their 2019 study of the Vineyard Wind Project (Beiter et al., 2019). The second is an "escalation factor" (EF) which represents the value of inflation used to translate nominal dollars into 2022 dollars. We assume EF = 2%, which both reflects the U.S. federal long-term target rate of inflation[7] and is close to the values used within the contracts themselves, which include escalation factors of 0%, 2.0%, and 2.5%.

[5] Table 3 lists prices for only a portion of the projects listed in Table 2.

[6] Exogenous to our analysis are capacity payments, economic and environmental benefits, and the role of the federal investment tax credit (ITC); all of which rely on policy decisions that are beyond this scope of this paper.

[7] We recognize that 2022 inflation rates are higher than 2%, however, since our objective is to place multiple long-term contracts on a similar footing, recognizing that these contracts were negotiated prior to the present rise in inflation, and inflation rates (escalation factors) assumed in the contracts vary between 0% and 2.5%, we have chosen 2% as a reasonable baseline for comparing 2022-dollar prices for projects planned to achieve commercial operation between 2022 and 2029.

The LNP has been referred to by Massachusetts as the "levelized price" (MA-DOER, 2020); it was referred to by New York as the "weighted average nominal Index OREC Strike Price" when the levelized nominal prices for Empire Wind and Sunrise Wind were combined into a single average value (NYSERDA, 2019); it has been referred to by New Jersey as the "levelized OREC purchase price" (LOPP) (Levitan, 2021); and it has been referred to by the National Renewable Energy Laboratory (NREL) as the Present Value of Power Purchase Agreement (PV of PPA) revenue (Beiter et al., 2019).

We prefer the term LNP for its simplicity, its descriptive quality, and the fact that it refers to an all-in contract price for offshore wind procurements. In summary:

- LCOE = the levelized cost of energy, which can only be known when the CAPEX, OPEX and AEP for each project year are known. This is generally a proprietary value.
- LNP = the levelized nominal price, which is the price to ratepayers. LNP can be estimated using Equation 4, and it serves as the basis for our analysis in this paper. For cases where no escalation is assumed for a project, such as Mayflower Wind, Revolution Wind or Sunrise Wind, the LNP is the same as the year-1 strike price shown in Table 3 and Table 4.

The analysis herein focuses on LNP as the most direct means to discuss rate payer costs.

Table 4 provides four price values for each project:

1. The nominal year-1 strike price, shown in the yellow cells of Table 3;
2. The levelized nominal price (LNP);
3. The year-1 strike price in 2022 dollars; and
4. LNP in 2022 dollars.

Our analysis assessed contract terms according to the nearest whole year, so projects such as Ocean Winds 1, Atlantic Shores 1, and Ocean Winds 2 in New Jersey, which split the first year or two of commercial operations into distinct phases are treated as if the entire project would begin in year one of commercial operation. For Vineyard Wind 1, the two phases (a) and (b) are treated separately because they were negotiated with two distinct pricing regimes and two distinct agreements.

Table 4. Project pricing for four cases: nominal year-1 strike price; levelized nominal price (LNP); year-1 strike price in 2022 dollars; and LNP in 2022 dollars.

				Nominal Price		2022 $	
Project	**State**	**size (MW)**	**weight**	**Yr 1 Strike**	**LNP**	**Yr 1 Strike**	**LNP**
VW1a	MA	400	0.054	$ 74.00	$ 89.49	$ 72.55	$ 87.74
VW1b	MA	400	0.054	$ 65.00	$ 78.61	$ 62.48	$ 75.56
Rev1_RI	RI	400	0.054	$ 98.43	$ 98.43	$ 96.50	$ 96.50
OceanWind1	NJ	1100	0.147	$ 98.10	$ 115.48	$ 94.29	$ 111.00
EmpireWind	NY	816	0.109	$ 99.08	$ 118.64	$ 95.23	$ 114.03
SunriseWind	NY	880	0.118	$ 110.37	$ 110.37	$ 106.08	$ 106.08
Mayflower	MA	804	0.108	$ 77.76	$ 77.76	$ 73.27	$ 73.27
AtlShores	NJ	1510	0.202	$ 86.62	$ 105.59	$ 76.92	$ 93.76
OceanWind2	NJ	1148	0.154	$ 84.03	$ 98.33	$ 73.15	$ 85.60
Total		7458	1.00				
mean		829	0.111	$ 88.15	$ 99.19	$ 83.39	$ 93.73
std. dev.		364	0.049	$ 14.50	$ 14.95	$ 14.79	$ 14.67
wt. mean				$ 89.92	$ 102.23	$ 83.99	$ 95.36
wt. std. dev.				$ 12.67	$ 13.90	$ 13.74	$ 14.22

For cases where projects were contracted with zero escalation (Revolution Wind, RI; Sunrise Wind, NY; and Mayflower Wind, MA) note that the "Year-1 Strike Price" and "LNP" are the same. Since the projects studied vary in size from 400 MW to 1510 MW, we have assigned a weight to each project (Table 4, Column 4). With this weight, we have calculated the weighted mean price (wt. mean) and the weighted standard deviation (wt. std. dev.) for each of the four cases in addition to the mean and standard deviation (which assume equal weights between the projects). For reporting purposes, we refer to the weighted mean price values, highlighted in green and yellow.

We suggest $95/MWh as a reasonable approximation for understanding current commercial scale U.S. OSW prices on a common footing. This value is the average weighted mean LNP in 2022 dollars for the project listed and is highlighted in yellow.

Visualizing the Variations in Offshore Wind Prices

A helpful way to visualize the data presented in Table 4, is to represent it through histograms which display the prices above and below the mean. These histograms provide insights into the distributions of U.S. offshore wind prices that are not readily apparent by considering only the mean and the standard deviation. Figure 1 shows a histogram for the LNP in 2022 dollars, with a weighted mean of $95.36/MWh. Price bins are shown in $5 increments from $60 to $120, with data ranging between $73.27 and $114.03. It is worth noting that the mean value of the highest

and the lowest price is $93.65, which is within -1.8% of the weighted mean for all projects. Above each data bin, Figure 1 provides the total number of megawatts in that bin.

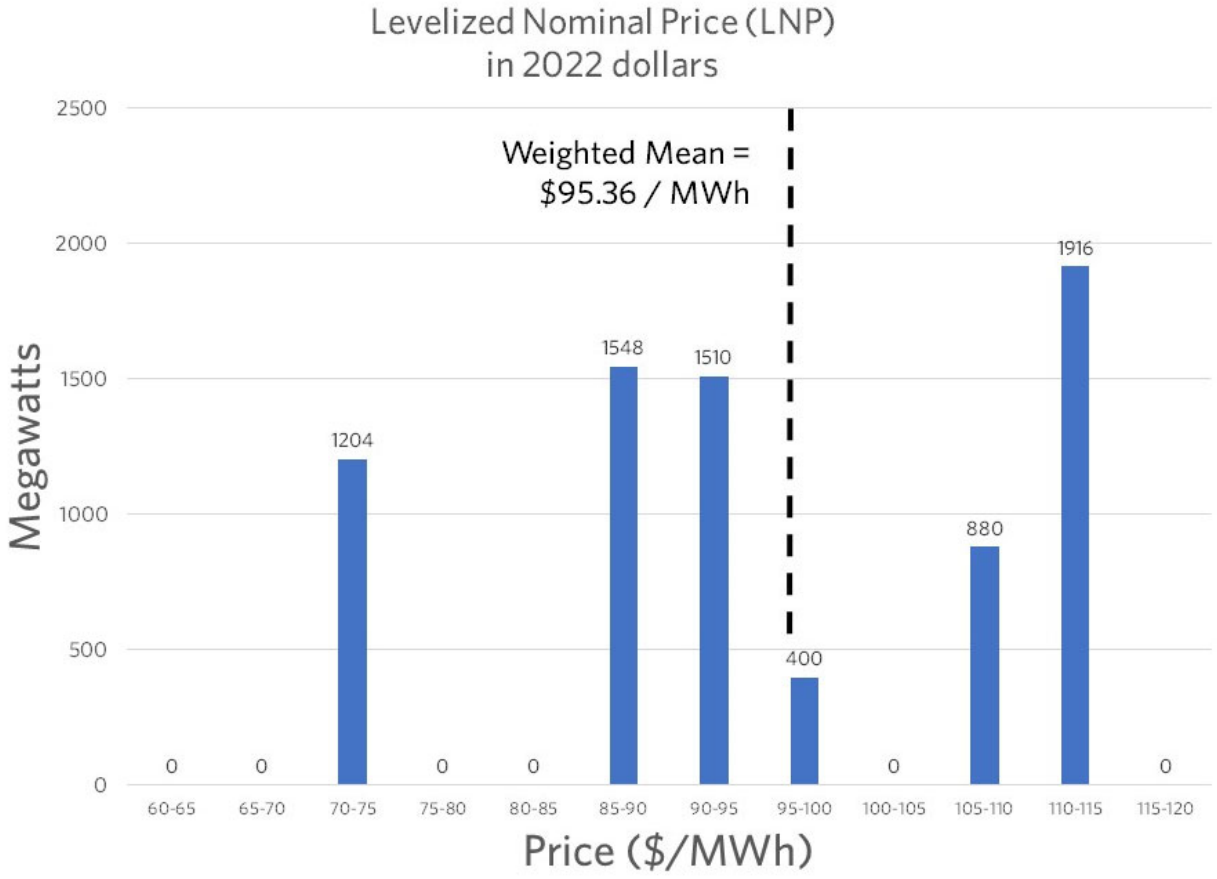

Figure 1. LNP in 2022 dollars.

Figure 2 through Figure 4 show the other price formulations presented in Table 4. Figure 2 shows the nominal year-1 strike price with a weighted mean value of $89.92/MWh. Figure 3 shows the LNP with a weighted mean value of $102.23/MWh. Figure 4 shows the year-1 strike price in 2022 dollars with a weighted mean value of $83.99/MWh.

Figure 2. Nominal year-1 strike price.

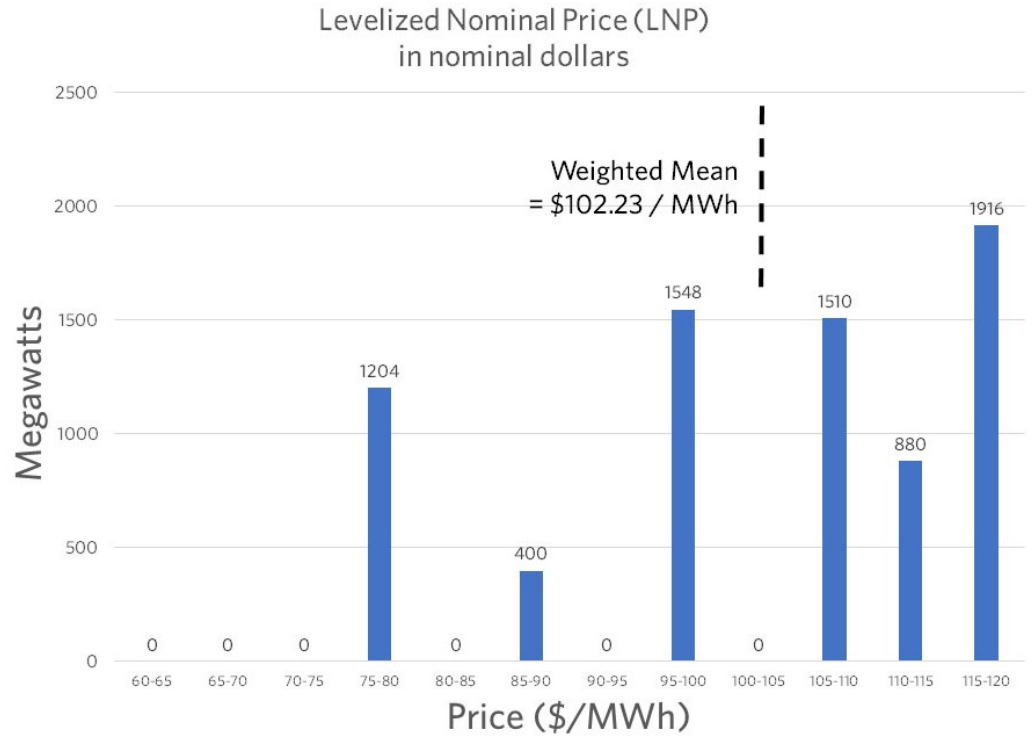

Figure 3. Levelized nominal price.

Figure 4. Year-1 strike price in 2022 dollars.

4 Conclusions

For the projects reviewed in this report, the weighted mean levelized nominal price (LNP) is estimated to be $95 in 2022 dollars. This preliminary analysis underscores the importance of understanding OSW prices across multiple states and projects. Each project has its own cost components, development contracts, and arrangements. Nevertheless, it is important to understand and learn from the published pricing as one compares projects over time and identifies the proper benefits for ratepayers.

These considerations will come into play as Massachusetts considers the role of the "price cap" in future solicitations. If Massachusetts ratepayers are to pay higher prices for future offshore wind generation projects in exchange for economic benefits to the state, policy makers should consider their authority to clearly identify the prices of these benefits and to ensure that these benefits are actualized in the manner intended.

The energy agreements in question are not construction contracts, and yet many of the desired economic benefits relate directly to the construction of these massive and sophisticated offshore wind projects. How the public sector, through policy initiatives and analysis, choses to monitor the development and construction of these projects and their associated supply chain will determine both how economic benefits and rate-payer benefits are realized over their lifetimes.

Appendix A: State Reported Levelized Nominal and Real Prices

In order to translate project prices into real dollars for earlier years, it appears that the Massachusetts Department of Energy Resources (DOER) adopted a discount rate of 4.89% for Vineyard Wind 1 (TCR, 2018) and a discount rate of 5.05% for Mayflower (TCR, 2020) to calculate the adjusted prices it reported for these two projects. The Massachusetts DOER reported these values as the following:

1. Vineyard Wind 1: "$84.23 per MWh in levelized nominal terms. This is equivalent to a levelized net present value price of 2017 dollars of $69.47 per MWh." (MA-DOER, 2018).
2. Mayflower Wind: "The levelized price for the 804 MW Mayflower Wind Project in real 2019 dollars, which accounts for inflation and the time value of money, is $58.47." (MA-DOER, 2020).

New York reported the "Index OREC Strike Price, 2018 $ per megawatt hour" as $83.36 in Table 1 of their report "Launching New York's Offshore Wind Industry: Phase 1 Report" (NYSERDA, 2019). Footnote 41 on this row of the "Phase 1 Report" Table 1 states:

> Corresponds to a $114.58 weighted average nominal Index OREC Strike Price as presented in the OREC Purchase and Sale Agreements of Sunrise Wind and Empire Wind, together.

Although we were unable to identify specific information related to how NYSERDA translated the nominal value of $114.58/MWh into $83.36/MWh in 2018 dollars, we calculated an effective discount rate of 5.44% by assuming a commercial operation date of 2024 (as listed in Table 7 of the 2021 DOE Offshore Wind Market Report (US DOE, 2021)).

Table 5 shows that our calculated LNP numbers are within approximately 1% of the numbers reported by Massachusetts, New York, and New Jersey for the cases discussed above. We attribute these minor differences to differences in discount rates as well as the fact that we considered projects in whole-year terms, ignoring the fact that some projects are planned to have phased construction in the first year or two.

Without seeing the actual calculations for the Massachusetts prices in real terms, as shown in points 1 and 2 above, we were able to calculate values that match to within 1.04% for Mayflower Wind and to within 0.11% for Vineyard Wind 1. For Mayflower Wind, this involved applying Equation 5 with EF = 5.05%. For Vineyard Wind 1, this involved applying Equation 5 with an EF = 4.89% and assuming only 6 months for the years 2022 and 2017.

Table 5. Comparison of levelized nominal prices between state reported values and this study.
(* Massachusetts and New York presented their Phase 1 procurements as average values.)

			Levelized Nominal Price		
Project	**State**	**size (MW)**	**State Reported**	**LNP**	**% difference**
VW1a*	MA	400	$ 84.23	$ 84.05	-0.21%
VW1b*	MA	400			
Rev1_RI	RI	400	$ 98.43	$ 98.43	0.00%
OceanWind1	NJ	1100	$ 116.82	$ 115.48	-1.15%
EmpireWind*	NY	816	$ 114.58	$ 114.51	-0.07%
SunriseWind*	NY	880			
Mayflower	MA	804	$ 77.76	$ 77.76	0.00%
AtlShores	NJ	1510	$ 106.18	$ 105.59	-0.56%
OceanWind2	NJ	1148	$ 98.49	$ 98.33	-0.17%

Appendix B: Offshore Wind Prices as Listed

EXHIBIT D

PRODUCTS AND PRICING

1. Price for Buyer's Percentage Entitlement of Products up to the Contract Maximum Amount. The Price for the Buyer's Percentage Entitlement of Delivered Products up to the Contract Maximum Amount in nominal dollars shall be as follow:

(a) Product Price –Commencing on the Commercial Operation Date, the Price per MWH for the Products shall be as follows. The Price per MWh for each billing period shall be allocated between Energy and RECs as follows:

Year		Price ($/MWh)	Energy Price ($/MWh)	REC Price ($/REC)
1		74.00	70.55	3.45
2		75.85	72.31	3.54
3		77.75	74.13	3.62
4		79.69	75.97	3.72
5		81.68	77.87	3.81
6		83.72	79.82	3.90
7		85.82	81.82	4.00
8		87.96	83.86	4.10
9		90.16	85.96	4.20
10		92.42	88.11	4.31
11		94.73	90.31	4.42
12		97.09	92.56	4.53
13		99.52	94.88	4.64
14		102.01	97.25	4.76
15		104.56	99.69	4.87
16		107.17	102.17	5.00
17		109.85	104.73	5.12
18		112.60	107.35	5.25
19		115.41	110.03	5.38
20		118.30	112.78	5.52

If the LMP at the Delivery Point in the Real-Time Energy Market for Energy Delivered by Seller is negative in any hour, the payment to Seller for Deliveries of Energy shall be reduced by the difference between the absolute value of the hourly LMP at the Delivery Point and $0.00 per MWh for that Energy for each such hour. Each monthly invoice shall reflect a reduction for all hours in the applicable month in which the LMP for the Energy at the Delivery Point is less than $0.00 per MWh.

Examples. If Delivered Energy equals 1 MWh and Price equals $50.00/MWh:

Figure 5. Vineyard Wind 1a price, Massachusetts (VineyardWind1a, 2018).

EXHIBIT D

PRODUCTS AND PRICING

1. Price for Buyer's Percentage Entitlement of Products up to the Contract Maximum Amount. The Price for the Buyer's Percentage Entitlement of Delivered Products up to the Contract Maximum Amount in nominal dollars shall be as follow:

(a) Product Price – Commencing on the Commercial Operation Date, the Price per MWH for the Products shall be as follows. The Price per MWh for each billing period shall be allocated between Energy and RECs as follows:

Year		Price ($/MWh)	Energy Price ($/MWh)	REC Price ($/REC)
1		65.00	61.55	3.45
2		66.63	63.09	3.54
3		68.29	64.67	3.62
4		70.00	66.28	3.72
5		71.75	67.94	3.81
6		73.54	69.64	3.90
7		75.38	71.38	4.00
8		77.26	73.16	4.10
9		79.20	75.00	4.20
10		81.18	76.87	4.31
11		83.21	78.79	4.42
12		85.29	80.76	4.53
13		87.42	82.78	4.64
14		89.60	84.84	4.76
15		91.84	86.97	4.87
16		94.14	89.14	5.00
17		96.49	91.37	5.12
18		98.91	93.66	5.25
19		101.38	96.00	5.38
20		103.91	98.39	5.52

If the LMP at the Delivery Point in the Real-Time Energy Market, for Energy Delivered by Seller is negative in any hour, the payment to Seller for Deliveries of Energy shall be reduced by the difference between the absolute value of the hourly LMP at the Delivery Point and $0.00 per MWh for that Energy for each such hour. Each monthly invoice shall reflect a reduction for all hours in the applicable month in which the LMP for the Energy at the Delivery Point is less than $0.00 per MWh.

Examples. If Delivered Energy equals 1 MWh and Price equals $50.00/MWh:

Figure 6. Vineyard Wind 1b product price, Massachusetts (VineyardWind1b, 2018).

EXHIBIT D

PRODUCTS AND PRICING

1. Price for Buyer's Percentage Entitlement of Products. The Price for the Buyer's Percentage Entitlement of Delivered Products in nominal dollars shall be as follow:

(a) Product Price - Commencing on the Commercial Operation Date, the Price per MWh for the Products shall be $98.425/MWh.

The Price will be allocated between Energy and RECs as follows:

(i) Energy= The $/MWh price of Energy for the applicable month shall be equal to the weighted average of the **Real-Time or Day Ahead** Locational Marginal Price (as applicable consistent with Section 4.2(s)) in that month (also on a $/MWh basis) for the Node on the Pool Transmission Facilities that is the Delivery Point. to which the Facility is interconnected.

(ii) RECs = The Price less the Energy allocation determined above for the applicable billing period, expressed in $/MWh.

(b) The Adjusted Price shall be as follows: $71.925/MWh

If the market price at the Delivery Point in the Real-Time or Day-Ahead markets, as applicable, for Energy Delivered by Seller is negative in any hour, the payment to Seller for deliveries of Energy shall be reduced by the difference between the absolute value of the hourly LMP at the Delivery Point and $0.00 per MWh for that Energy for each such hour. Each monthly invoice shall reflect a reduction for all hours in the applicable month in which the LMP for the Energy at the Delivery Point is less than $0.00 per MWh.

Examples. If delivered Energy equals 1 MWh and Price equals $50.00/MWh:

LMP at the Delivery Point equals (or is greater than) $0.00/MWh
Buyer payment of Price to Seller $50.00
Seller credit/reimbursement for negative LMP to Buyer $0.00
Net Result: Buyer pays Seller $50 for that hour

LMP at the Delivery Point equals -$150.00/MWh
Buyer payment of Price to Seller $50.00
Seller credit/reimbursement for negative LMP to Buyer $150.00
Net Result: Seller credits or reimburses Buyer $100 for that hour

000114

Figure 7. Revolution Wind price, Rhode Island (RevolutionWind1, 2018).

ATTACHMENT A – ANNUAL OREC PRICING SCHEDULES

Annual OREC Price Schedule and Planned Output Schedule
1,100 MW Ocean Wind Project

		Phase 1	Phase 2	Phase 3
Nameplate Capacity (MW)		368	368	368
COD (month/year)		May-24	Sep-24	Dec-24
Energy Year, ending May 31 of	All-in OREC Price ($/OREC)	Phase 1 Output (months)	Phase 2 Output (months)	Phase 3 Output (months)
2024	$ 98.10	1	-	-
2025	$ 100.06	12	9	6
2026	$ 102.06	12	12	12
2027	$ 104.10	12	12	12
2028	$ 106.18	12	12	12
2029	$ 108.30	12	12	12
2030	$ 110.47	12	12	12
2031	$ 112.68	12	12	12
2032	$ 114.93	12	12	12
2033	$ 117.23	12	12	12
2034	$ 119.57	12	12	12
2035	$ 121.96	12	12	12
2036	$ 124.40	12	12	12
2037	$ 126.89	12	12	12
2038	$ 129.43	12	12	12
2039	$ 132.02	12	12	12
2040	$ 134.66	12	12	12
2041	$ 137.35	12	12	12
2042	$ 140.10	12	12	12
2043	$ 142.90	12	12	12
2044	$ 145.76	11	12	12
2045	$ 148.68	-	3	6

Note: The "All-in" OREC Price is prior to the requested true-up of system upgrade costs.

Figure 8. Ocean Wind 1 price, New Jersey (OceanWind1, 2019).

the port upgrades identified in the definition of Contingency Event are completed and 180 days, or (y) the number of days after January 1, 2025 that the Selected Project achieves Commercial Operation.

Section 4.02. Fixed OREC Price. In the event that the Fixed OREC Price becomes the Applicable OREC Price pursuant to Section 4.01(a) of this Agreement, the Fixed OREC Price for each month in the respective Contract Years shall be:

Contract Year 1:	$36.35
Contract Year 2:	$37.07
Contract Year 3:	$37.82
Contract Year 4:	$38.57
Contract Year 5:	$39.34
Contract Year 6:	$40.13
Contract Year 7:	$40.93
Contract Year 8:	$41.75
Contract Year 9:	$42.59
Contract Year 10:	$43.44
Contract Year 11:	$44.31
Contract Year 12:	$45.19
Contract Year 13:	$46.10
Contract Year 14:	$47.02
Contract Year 15:	$47.96
Contract Year 16:	$48.92
Contract Year 17:	$49.90
Contract Year 18:	$50.90
Contract Year 19:	$51.91
Contract Year 20:	$52.95
Contract Year 21:	$54.01
Contract Year 22:	$55.09
Contract Year 23:	$56.19
Contract Year 24:	$57.32
Contract Year 25:	$58.46

Section 4.03. Index OREC Price.

(a) For each month, the Index OREC Price shall equal the Index OREC Strike Price minus the Reference Energy Price minus the Reference Capacity Price.

(1) The Index OREC Strike Price, for each month in the respective Contract Years shall be:

Contract Year 1:	$99.08
Contract Year 2:	$101.06
Contract Year 3:	$103.08
Contract Year 4:	$105.14

Figure 9. Empire Wind 1 price (page 1 of 2), New York (NYSERDA, 2019).

Contract Year 5:	$107.24
Contract Year 6:	$109.39
Contract Year 7:	$111.58
Contract Year 8:	$113.81
Contract Year 9:	$116.09
Contract Year 10:	$118.41
Contract Year 11:	$120.77
Contract Year 12:	$123.19
Contract Year 13:	$125.65
Contract Year 14:	$128.17
Contract Year 15:	$130.73
Contract Year 16:	$133.35
Contract Year 17:	$136.01
Contract Year 18:	$138.73
Contract Year 19:	$141.51
Contract Year 20:	$144.34
Contract Year 21:	$147.22
Contract Year 22:	$150.17
Contract Year 23:	$153.17
Contract Year 24:	$156.24
Contract Year 25:	$159.36

(2) Using data published by NYISO for its day-ahead energy market, NYSERDA shall calculate the Reference Energy Price for each month by:

(i) identifying the location-based marginal price ("LBMP") for each hour of the month in both Zone J and Zone K, and the amount of electric energy in MWh consumed in each zone in each hour ("Hourly Zonal Load");

(ii) for each such hour, calculating a "Load-Weighted Average Price" by dividing the sum of (A) the product of the LBMP for Zone J and the Hourly Zonal Load for Zone J, and (B) the product of the LBMP for Zone K and the Hourly Zonal Load for Zone K, by the sum of the Hourly Zonal Load for Zone J and the Hourly Zonal Load for Zone K;

(iii) taking the simple (not load-weighted) average of the Load-Weighted Average Prices across the two zones for each hour of the month to determine the Reference Energy Price.

(3) Using data published by NYISO for its monthly spot market unforced capacity ("UCAP") prices, NYSERDA shall calculate the Reference Capacity Price for each month by:

(i) identifying the UCAP prices in dollars per kW-month for NYISO Zones G, H, I, J, and K (the "Applicable Zones"), and the energy consumed in MWh for each zone ("Monthly Zonal Load");

Figure 10. Empire Wind 1 price (page 2 of 2), New York (NYSERDA, 2019).

shall remain the Fixed OREC Price unless and until a change in Applicable Law occurs that once again renders the Index OREC Price lawful notwithstanding previously being held invalid. In such case, NYSERDA will so notify Seller and the Applicable OREC Price shall revert to the Index OREC Price, effective as of the date of such notification by NYSERDA. Any and all changes to the Applicable OREC Price under this Subsection 4.01(b) shall be prospective from the effective date of such change.

(c) If, pursuant to Subsection 4.01(b), the Applicable OREC Price changes in the middle of the month, NYSERDA will pay Seller for that month: (1) the Index OREC Price for each OREC created during the portion of the month in which the Index OREC price was the Applicable OREC Price, and (2) the Fixed OREC Price for each OREC created during the portion of the month in which the Fixed OREC Price was the Applicable OREC Price.

Section 4.02. Fixed OREC Price. In the event that the Fixed OREC Price becomes the Applicable OREC Price pursuant to Section 4.01(a) of this Agreement, the Fixed OREC Price for each month in the respective Contract Years shall be:

Contract Year 1:	$61.87
Contract Year 2:	$61.87
Contract Year 3:	$61.87
Contract Year 4:	$61.87
Contract Year 5:	$61.87
Contract Year 6:	$61.87
Contract Year 7:	$61.87
Contract Year 8:	$61.87
Contract Year 9:	$61.87
Contract Year 10:	$61.87
Contract Year 11:	$61.87
Contract Year 12:	$61.87
Contract Year 13:	$61.87
Contract Year 14:	$61.87
Contract Year 15:	$61.87
Contract Year 16:	$61.87
Contract Year 17:	$61.87
Contract Year 18:	$61.87
Contract Year 19:	$61.87
Contract Year 20:	$61.87
Contract Year 21:	$61.87
Contract Year 22:	$61.87
Contract Year 23:	$61.87
Contract Year 24:	$61.87
Contract Year 25:	$61.87

Section 4.03. Index OREC Price.

(a) For each month, the Index OREC Price shall equal the Index OREC Strike Price minus

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Figure 11. Sunrise Wind price (page 1 of 2), New York (NYSERDA, 2019).

the Reference Energy Price minus the Reference Capacity Price.

(1) The Index OREC Strike Price, for each month in the respective Contract Years shall be:

Contract Year 1:	$110.37
Contract Year 2:	$110.37
Contract Year 3:	$110.37
Contract Year 4:	$110.37
Contract Year 5:	$110.37
Contract Year 6:	$110.37
Contract Year 7:	$110.37
Contract Year 8:	$110.37
Contract Year 9:	$110.37
Contract Year 10:	$110.37
Contract Year 11:	$110.37
Contract Year 12:	$110.37
Contract Year 13:	$110.37
Contract Year 14:	$110.37
Contract Year 15:	$110.37
Contract Year 16:	$110.37
Contract Year 17:	$110.37
Contract Year 18:	$110.37
Contract Year 19:	$110.37
Contract Year 20:	$110.37
Contract Year 21:	$110.37
Contract Year 22:	$110.37
Contract Year 23:	$110.37
Contract Year 24:	$110.37
Contract Year 25:	$110.37

(2) Using data published by NYISO for its day-ahead energy market, NYSERDA shall calculate the Reference Energy Price for each month by:

(i) identifying the location-based marginal price ("LBMP") for each hour of the month in both Zone J and Zone K, and the amount of electric energy in MWh consumed in each zone in each hour ("Hourly Zonal Load");

(ii) for each such hour, calculating a "Load-Weighted Average Price" by dividing the sum of (A) the product of the LBMP for Zone J and the Hourly Zonal Load for Zone J, and (B) the product of the LBMP for Zone K and the Hourly Zonal Load for Zone K, by the sum of the Hourly Zonal Load for Zone J and the Hourly Zonal Load for Zone K;

(iii) taking the simple (not load-weighted) average of the Load-Weighted Average Prices across the two zones for each hour of the month to determine the Reference Energy Price.

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Figure 12. Sunrise Wind price (page 2 of 2), New York (NYSERDA 2019).

EXHIBIT D

PRODUCTS AND PRICING

The Price for Buyer's Percentage Entitlement of Delivered Products in nominal dollars shall be as follows:

(a) Product Price - Commencing on the Commercial Operation Date, the Price per MWh for the Products shall be equal to $77.76 per MWh. The Price per MWh for each billing period shall be allocated between Energy and RECs as follows:

(i) Energy = $73.87 per MWh

(ii) RECs = $3.89 per REC.

(b) Price Adjustment for ITC Increase - If as a result of either the Further Consolidated Appropriations Act, 2020 or a change in Law affecting the ITC that occurs prior to the Commercial Operation Date, Seller is able to qualify for an ITC that is in excess of twelve percent (12%) of the Seller's eligible basis, then the Price for Buyer's Percentage Entitlement of Delivered Products in nominal dollars shall be as set forth below; provided, however, that, Seller shall maximize the ITC for which it qualifies to the extent permitted under applicable Law and if, as a result of a change in the requirements for eligibility to qualify for an ITC, Seller cannot qualify for the increased ITC, then the Price shall not be reduced or otherwise affected.

The ITC percentage for which Seller qualifies:		Price ($/MWh)	Energy Only Price ($/MWh)
13%		$77.34	$73.47
14%		$76.93	$73.08
15%		$76.51	$72.68
16%		$76.09	$72.29
17%		$75.68	$71.89
18%		$75.26	$71.50
19%		$74.84	$71.10
20%		$74.43	$70.70
21%		$74.01	$70.31
22%		$73.59	$69.91
23%		$73.18	$69.52
24%		$72.76	$69.12
25%		$72.34	$68.72
26%		$71.93	$68.33
27%		$71.51	$67.93
28%		$71.09	$67.54
29%		$70.68	$67.14
30%		$70.26	$66.75

Figure 13. Mayflower Wind price, Massachusetts (Mayflower, 2020).

EXHIBIT D

PRODUCTS AND PRICING

1. Price for Buyer's Percentage Entitlement of Products up to the Contract Maximum Amount. The Price for the Buyer's Percentage Entitlement of Delivered Products up to the Contract Maximum Amount in nominal dollars shall be as follows:

(a) Commencing on the Commercial Operation Date, the Price per MWh or REC for the Products shall be as follows:

- Fixed Contract Price

Contract Year		Energy Price[1] ($/MWh)	REC Price ($/REC)
1		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
2		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
3		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
4		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
5		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
6		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
7		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
8		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**

[1] The Energy Price listed above is the price for Energy and other wholesale market components.

Figure 14. Park City Wind price (page 1 of 2), Connecticut (ParkCity, 2020).

9		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
10		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
11		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
12		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
13		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
14		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
15		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
16		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
17		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
18		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
19		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**
20		**[Vineyard Wind Confidential]**	**[Vineyard Wind Confidential]**

(b) Price Adjustment **[Vineyard Wind Confidential]** .

(c) If the LMP at the Delivery Point in the Real-Time or Day-Ahead markets, as applicable, for Energy Delivered by Seller is negative in any hour, the payment to Seller for deliveries of Energy shall be reduced by the difference between the absolute value of the hourly LMP at the Delivery Point and $0.00 per MWh for that Energy for each such hour. Each monthly invoice shall reflect a reduction for all hours in the applicable month in which the LMP for the Energy at the Delivery Point is less than $0.00 per MWh.

Figure 15. Park City Wind price (page 2 of 2), Connecticut (Park City, 2020).

ATTACHMENT A – ANNUAL OREC PRICING SCHEDULE

Annual OREC Price Schedule and Planned Output Schedule
Atlantic Shores Project

Nameplate Capacity (MW)		Phase 1	Phase 1A
		761.6	748
COD (month/year)		9/2027	4/2028
Energy Year, Ending May 31 of	All-in OREC Price ($/OREC)[102]	Output (months)	Output (months)
2028	$86.62	8	1
2029	$88.79	12	12
2030	$91.01	12	12
2031	$93.29	12	12
2032	$95.62	12	12
2033	$98.01	12	12
2034	$100.46	12	12
2035	$102.97	12	12
2036	$105.54	12	12
2037	$108.18	12	12
2038	$110.88	12	12
2039	$113.65	12	12
2040	$116.49	12	12
2041	$119.40	12	12
2042	$122.38	12	12
2043	$125.44	12	12
2044	$128.58	12	12
2045	$131.79	12	12
2046	$135.08	12	12
2047	$138.46	12	12
2048	$141.92	4	11

[102] The "All-in" OREC Price is prior to the true-up for PJM transmission system upgrade costs

Figure 16. Atlantic Shores 1 price, New Jersey (AtlanticShores1, 2021).

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ATTACHMENT A – ANNUAL OREC PRICING SCHEDULES

Annual OREC Price Schedule and Planned Output Schedule
OW2 Project B

Nameplate Capacity (MW)		Phase 1	Phase 2	Phase 3
		392.0	378.0	378.0
COD (month/year)		08/2028	10/2028	01/2029
Energy Year, Ending May 31 of	All-in OREC Price ($/OREC)[118]	Output (months)	Output (months)	Output (months)
2029	$84.03	9	7	4
2030	$85.71	12	12	12
2031	$87.42	12	12	12
2032	$89.17	12	12	12
2033	$90.95	12	12	12
2034	$92.77	12	12	12
2035	$94.63	12	12	12
2036	$96.52	12	12	12
2037	$98.45	12	12	12
2038	$100.42	12	12	12
2039	$102.43	12	12	12
2040	$104.48	12	12	12
2041	$106.57	12	12	12
2042	$108.70	12	12	12
2043	$110.87	12	12	12
2044	$113.09	12	12	12
2045	$115.35	12	12	12
2046	$117.66	12	12	12
2047	$120.01	12	12	12
2048	$122.41	12	12	12
2049	$124.86	3	5	8

[118] The "All-in" OREC Price is prior to the true-up for PJM transmission system upgrade costs

Figure 17. Ocean Wind 2 price (page 1 of 2), New Jersey (OceanWind2, 2021).

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ATTACHMENT A-1 – ANNUAL OREC PRICING SCHEDULES

Annual OREC Price Schedule and Planned Output Schedule
OW2 Project A

Nameplate Capacity (MW)		Phase 1	Phase 2	Phase 3
		392.0	378.0	378.0
COD (month/year)		08/2028	10/2028	01/2029
Energy Year, Ending May 31 of	All-in OREC Price ($/OREC)[119]	Output (months)	Output (months)	Output (months)
2029	$82.71	9	7	4
2030	$84.36	12	12	12
2031	$86.05	12	12	12
2032	$87.77	12	12	12
2033	$89.52	12	12	12
2034	$91.31	12	12	12
2035	$93.41	12	12	12
2036	$95.00	12	12	12
2037	$96.90	12	12	12
2038	$98.84	12	12	12
2039	$100.82	12	12	12
2040	$102.84	12	12	12
2041	$104.89	12	12	12
2042	$106.99	12	12	12
2043	$109.13	12	12	12
2044	$111.31	12	12	12
2045	$113.54	12	12	12
2046	$115.81	12	12	12
2047	$118.13	12	12	12
2048	$120.49	12	12	12
2049	$122.90	3	5	8

[119] The "All-in" OREC Price is prior to the true-up for PJM transmission system upgrade costs

Figure 18. Ocean Wind 2 (page 2 of 2), New Jersey (OceanWind2, 2021).

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