BEFORE THE

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: THE NARRAGANSETT	)	
ELECTRIC COMPANY d/b/a NATIONAL	)	
GRID REVIEW OF POWER PURCHASE	)	Docket No. 4929
AGREEMENT PURSUANT TO	)	
R.I. GENERAL LAWS §39-31-1 TO 9	)	

DIRECT TESTIMONY OF

RALPH LUCIANI

NAVIGANT CONSULTING, INC.

ON BEHALF OF

DWW REV I, LLC

April 5, 2019

<u>Introduction</u>

Q. Please state your name and business address.

A. My name is Ralph Luciani and my business address is 1200 19th St. NW, Suite 700, Washington, DC 20036.

Q. By whom are you employed and in what capacity?

A. I am a Director in the Energy Practice in Navigant Consulting Inc.'s Washington, D.C. office.

Q. Please describe your qualifications and experience.

A. I have more than 25 years of consulting experience analyzing economic and financial issues affecting regulated industries. I focus on the electricity industry, where I assist electric utilities and generating companies with business planning, resource planning, power solicitations, ratemaking, transmission cost-benefit studies, fuel and power supply contract negotiations, and environmental compliance strategy.

Q: Does your curriculum vitae, which is attached to this prefiled testimony as Exhibit 1, fairly and accurately represent your experience?

A: Yes, it does.

Q. Have you previously testified before the Rhode Island Public Utilities Commission or other state or federal regulatory commissions?

A. I have not previously testified before the Rhode Island Public Utilities Commission, but as noted in my curriculum vitae, I have extensive experience testifying before the Federal Energy Regulatory Commission and the utility commissions of other states.

Q. What is the purpose of your testimony?

A. To sponsor certain reports prepared to support the request of DWW REV I, LLC (DWW) that the Rhode Island Public Utilities Commission (Commission) approve the power purchase agreement (PPA) dated as of December 6, 2018 between The Narragansett Electric Company, d/b/a National Grid (National Grid) and DWW.

Q. Which reports are you sponsoring?

A. I am sponsoring the Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project, dated October 5, 2018 (See National Grid Direct Testimony of Timothy J. Brennan and Corinne M. DiDomenico, Schedule NG-6 attached hereto as Exhibit 2) and the Advisory Opinion on the Environmental and Public Health Benefits of the Revolution Wind Project, dated October 1, 2018 (See Exhibit 3), both prepared by Navigant.

Q. Were these Exhibits prepared by you or under your direct supervision?

A. No, they were prepared under the direct supervision of a colleague. However, I have reviewed both the reports and the working papers that were prepared in connection with the development of the reports and can confirm that I would not have approached this assignment any differently, nor would I have reached a different conclusion.

Q. Can you summarize the findings of the Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project, dated October 5, 2018?

A. Yes. Of the total capital costs of $1.4 billion for the Revolution Wind Project, over $300 million is projected to be spent in Rhode Island, resulting in over 2,500 total job-years of work and over $250 million of Value Added in Rhode Island during the construction phase.[1] Over 800 job-years of work will take place directly at the site during the construction phase, with additional job-years driven by the increase in demand for goods and services from direct on-site spending and the resulting impact on local expenditures. During the plant's 25 years of operation, over $7 million is projected to be spent annually in Rhode Island, resulting in over 125 total annual jobs and over $14 million per year of Value Added in Rhode Island.

Q. Have you reviewed the Advisory Opinion prepared by the Rhode Island Commerce Corporation (RICC), which incorporates an economic impact analysis prepared by Appleseed?

A. Yes, I have.

Q. Can you address the differences between Appleseed's analysis and Navigant's analysis of the Revolution Wind Project?

A. Yes. As the Rhode Island Commerce Corporation notes, Appleseed used a different model than Navigant, but incorporated the same construction and operating expenditures for the Revolution Wind Project. Appleseed projects about 200 more job-years and $30 million more of Value Added than Navigant during the construction phase, and about 40 fewer job-years and $6 million less of Value Added during the operating phase. I have not performed an in-depth review of the Appleseed analysis, but agree with the Rhode Island Commerce Corporation that the differences appear to be primarily a result of two different modeling systems. While Navigant's findings are more conservative than those of Appleseed during construction and more optimistic during operations, the overall results appear to be roughly aligned and show substantial economic development benefits from the Project.

[1] A job-year is equivalent to the time worked by one person employed full-time for a year. Value Added in Rhode Island is a measure of the increase in Rhode Island's Gross Domestic Product (GDP).

Q. Can you summarize the findings of the Advisory Opinion on the Environmental and Public Health Benefits of the Revolution Wind Project, dated October 1, 2018?

A. Yes. The output from the Revolution Wind Project delivered to Rhode Island is projected to reduce CO_2 emissions in the ISO-NE region by over 18,000 short tons (nearly 17,000 metric tonnes)[2] over the 25-year operating life of the project (from 2024 through 2048), or about 740 short tons per year on average. This reduction in CO_2 emissions provides an average annual benefit of between $10 and $37 million (2018 dollars) using a low and high range of CO_2 social cost estimates. Similarly, the Project will reduce average annual NO_x emissions in the ISO-NE region by 0.24 short tons per year, yielding an average annual benefit of between $0.5 and $2.9 million. The Project also will decrease SO_2 and PM_{10} emissions in the ISO-NE region.

Q: Do you have any additions, corrections or modifications to the reports?

A: No.

Q. Does this conclude your testimony?

A. Yes it does.

[2] 1 short ton (2,000 pounds) is equivalent to approximately 0.907 metric tonnes.

EXHIBIT 1

NAVIGANT

Ralph Luciani

Director

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1200 19th St. NW, Suite 700
Washington, DC 20036
Phone: 202.973.4537

Professional Summary

Ralph Luciani is a Director in the Energy Practice in Navigant's Washington, D.C. office. He has more than 25 years of consulting experience analyzing economic and financial issues affecting regulated industries. Mr. Luciani focuses on the electricity industry, where he has assisted electric utilities and generating companies with business planning, resource planning, power solicitations, ratemaking, transmission cost-benefit studies, fuel and power supply contract negotiations, and environmental compliance strategy.

He led the economic evaluation performed by the Eastern Interconnection Planning Collaborative (EIPC) in a two-year study of the expansion of the transmission system needed to support future generation. Mr. Luciani has also recently performed cost-benefit studies for electric utilities considering joining a Regional Transmission Organization (RTO). In 2016, he oversaw the economic evaluation performed of renewable energy proposals in the New England Clean Energy RFP.

Mr. Luciani has assisted clients and their legal counsel in the management of numerous complex litigation matters, including electric utility prudence and rate cases, and assessments of economic damages in commercial disputes. He has appeared as an expert witness in a number of Federal Energy Regulatory Commission (FERC) and state public utility commission regulatory proceedings.

Prior to joining Navigant, Mr. Luciani was a Vice President at Charles River Associates and a Director at Putnam, Hayes & Bartlett, Inc. He holds an M.S. in Industrial Administration from Carnegie Mellon University, and a B.S. in Electrical Engineering and Economics from Carnegie Mellon University.

Professional Experience

RTOs and Transmission

- **RTO Cost-Benefit Studies.** Performed a number of major cost-benefit studies of RTOs over the last ten years, and provided related testimony in state regulatory proceedings. Coordinated a utility team in implementing a transition into an RTO in 2015.
- **Transmission Planning**. On behalf of EIPC, led the economic evaluation in a two-year study of the potential build-out of the transmission system in the eastern U.S. needed through 2030.
- **Competitive Transmission.** Assisted a transmission owner in developing transmission proposals in a RTO competitive bidding process to pass cost-benefit and reliability screens.

- **RTO Administrative Costs and Rates**. Served as the lead consultant in a FERC settlement process in which PJM establishing stated rates for the recovery of its administrative costs.
- **Transmission Ratemaking.** On a number of occasions, filed testimony which developed OATT transmission, ancillary service, and reactive power rates.
- **Transmission Costing**. Provided testimony and negotiated settlement agreements in a FERC settlement process regarding the assignment of costs for through and out transmission charges.

Generation and Power Marketing

- **Power Solicitations.** Assisted electric utilities in conducting numerous solicitations for power, including serving as an independent evaluator, formulating the RFP, conducting bidder's conferences, negotiating term sheets and definitive agreements, and obtaining regulatory approvals.
- **Nuclear Power.** Assisted a utility in negotiating the sale of a nuclear plant, developed the financial model used in a utility's application for DOE-supported financing of a new nuclear facility, and provided testimony on CWIP financing in rates to support new nuclear plants.
- **Wind/Transmission Studies.** Performed a number of wind/transmission cost-benefit studies, including analyzing the economics and local employment impacts of installing 765 kV transmission lines to support new wind power in the Southwest Power Pool.
- **Generation Valuation Lecturer.** Served as the lead lecturer and instructor of an advanced training course on generation valuation under cost-of-service rates and under market-based pricing offered annually at a large U.S. investor-owned utility.
- **Power Marketing.** Prepared several affidavits at FERC analyzing wholesale trading activities of power marketers, developed utility cost-based rates for wholesale sales of capacity and energy, and assisted counsel in reaching an arbitration settlement regarding standby power charges.
- **Stranded Cost Derivation.** Presented testimony before four state utility commissions on the quantification of the stranded cost associated with the deregulation of generation.

Financial Evaluation

- **Cost of Capital.** Testified before the U.S. Bankruptcy Court and assisted counsel in arbitration proceedings regarding the proper discount rate to apply in assessing termination payments for wholesale power contracts, and assessed capital structure and rates for use in FERC proceedings.
- **Municipalization.** Assisted an electric utility in deriving the exit charges to be assessed for a proposed municipalization of a portion of the electric utility's service territory.
- **Mergers and Acquisitions.** Analyzed the potential acquisition of electric utilities and formulated transmission and distribution pro forma financials.

Ralph Luciani

Director

- **Organizational Restructuring.** Lead facilitator in a 12-month project that functionally unbundled the operation of an integrated electric utility into stand-alone profit centers.

Distribution and Retail

- **Distribution Performance-Based Rates.** Formulated a performance-based ratemaking (PBR) plan, for an electric utility, and presented the plan to the state public utility commission.

- **Efficiency Programs.** Developed a financial and rate incentive model for an electric utility to evaluate the impact on rates and earnings of adopting energy efficiency programs.

- **Retail Market Strategy.** Formulated models to assess the profitability of new retail loads in a competitive market and a product to reduce on-peak demand in residences.

Environmental and Fuel

- **Environmental Regulations.** Assisted utilities in formulating strategies for Clean Air Act provisions regarding SO_2 and NO_x, and in assessing potential climate change regulations.

- **Fuel Supply.** Assisted an electric utility in negotiating the terms of a buyout and replacement of a long-term coal supply contract, and in obtaining approval for the rate treatment.

- **Nuclear.** Assisted counsel in litigation involving the responsibility for costs incurred in nuclear spent fuel storage and the estimation of damages related to steam generator replacement

Professional History

Director, Navigant Consulting, Inc.
Vice President, Charles River Associates
Senior Vice President, PHB Hagler Bailly
Director, Putnam, Hayes & Bartlett, Inc.
Edison Engineer, General Electric Company (GE)

Education

M.S., Industrial Administration, Carnegie Mellon University
B.S., Electrical Engineering and Economics, Carnegie Mellon University

Expert Testimony Experience

- Testified before the Arkansas, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Ohio, Pennsylvania, Texas and Wisconsin public utility commissions, the Ontario Energy Board, the U.S. Bankruptcy Court, the U.S. Postal Service Commission, and the Federal Energy Regulatory Commission (FERC).

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Ralph Luciani

Director

Testimony or Expert Report Experience

Date	Case	Venue
2018	Application of East Kentucky Power Cooperative, Inc. for a Certificate of Public Convenience and Necessity for the Construction of Backup Fuel Facilities, Case No. 2018-00292	Kentucky Public Service Commission
2017	Application of East Kentucky Power Cooperative, Inc. for Approval to Amend its Environmental Compliance Plan and Recover Costs Pursuant to its Environmental Surcharge and Issuance of a Certificate of Public Convenience and Necessity, Case No. 2017-00376	Kentucky Public Service Commission
2015	Application of Wisconsin Power and Light Company for a Certificate of Public Convenience and Necessity to Build an Approximately 650 Megawatt Natural Gas-Fuel Power Plant, Docket No. 6680-CE-176	Public Service Commission of Wisconsin
2015	Application of East Kentucky Power Cooperative, Inc. for Approval of the Acquisition of Existing Combustion Turbine Facilities from Bluegrass Generation Company, LLC, Case No. 2015-00267	Kentucky Public Service Commission
2013	Westar Generating, Inc., Purchase Power Agreement, Analysis of the Affiliate Transaction under the Commission's *Boston Edison Co. Re: Edgar Electric Energy Co.*, 55 FERC ¶ 61,382 (1991) ("*Edgar*") Precedent, Docket No. ER13-1210-002	Federal Energy Regulatory Commission
2013	In the Matter of the Application of Duke Energy Ohio, Inc. For the Establishment of a Charge Pursuant to Revised Code Section 4909.18. Case No. 12-2400-EL-UNC	Public Utilities Commission of Ohio
2012	Application of East Kentucky Power Cooperative, Inc. to Transfer Functional Control of Its Transmission Assets to the PJM Interconnection, L.L.C., PSC Case No. 2012-00169	Kentucky Public Service Commission
2012	Show Cause Order Directed to Entergy Arkansas, Inc. Regarding Its Continued Membership in the Current Entergy System Agreement and Regarding the Future Operation and Control of Its Transmission Assets, Docket No. 10-011-U	Arkansas Public Service Commission
2012	Application of Entergy Texas, Inc. for Approval to Transfer Operational Control of Its Transmission Assets to the MISO RTO, Docket No. 40346	Texas State Office of Administrative Hearings
2012	Joint Application of Entergy Mississippi, Inc., and the Midwest Independent Transmission System Operator, Inc., for Transfer of Functional Control of Entergy Mississippi's Transmission Facilities to MISO, Docket No. 2011-UA-376	Mississippi Public Service Commission
2012	Joint Application of Entergy New Orleans, Inc. and Entergy Louisiana, L.L.C. Regarding Transfer of Functional Control of Certain Transmission Assets to the Midwest Independent Transmission System Operator, Docket No. UD-11-01	New Orleans City Council

Ralph Luciani

Director

2010	Application of Big Rivers Electric Corporation for Approval to Transfer Functional Control of its Transmission System to Midwest Independent Operator, Inc., Case No. 2010-00043	Kentucky Public Service Commission
2010	Cost-based Revenue Requirement for the Provision of Reactive Supply and Voltage Control from Generation Sources under Schedule 2 of the PJM Transmission Tariff, Docket No. ER10-865-000	Federal Energy Regulatory Commission
2010	Application by Ontario Power Generation Inc., Payment Amounts for Prescribed Facilities for 2011 and 2012, Docket No. EB-2010-0008	Ontario Energy Board
2008	Application of Ameren Energy Marketing Company under Section 205 of the Federal Power Act, Docket No. ER09-398-000	Federal Energy Regulatory Commission
2008	Application of Aquila, Inc. for Authority to Transfer Operational Control of Transmission Assets to Midwest ISO, Docket No. EO-2008-0046	Missouri Public Service Commission
2008	Arizona Public Service Company, Docket No. ER08-514-000	Federal Energy Regulatory Commission
2007-8	TransCanada Pipelines Ltd. vs. USGen New England, Inc., Case Number 03-30465	U.S. Bankruptcy Court for the District of Maryland
2007	Application of Big Rivers Electric Corporation for Approval of Wholesale Tariff Additions, Case No. 2007-00455	Kentucky Public Service Commission
2006	Postal Rate and Fee Changes, Docket No. R2006-1	U.S. Postal Rate Commission
2006	Arizona Public Service Company, Docket No. ER07-23-000	Federal Energy Regulatory Commission
2006	Midwest Independent Transmission System Operator, Docket No. ER-05-6-001	Federal Energy Regulatory Commission
2006	Generic Issues, RP-2005-0020/EB-2005-0529, 2006 Distribution Rates	Ontario Energy Board
2005	Investigation of Practices of the California Independent System Operator, Docket No. EL-00-95-000	Federal Energy Regulatory Commission
2005	Investigation of Practices of the California Independent System Operator, Docket No. EL-00-95-000	Federal Energy Regulatory Commission
2005	Application of Southwest Power Pool for a Certificate of Public Convenience and Necessity, Docket No. 04-137-U	Arkansas Public Service Commission
2005	Application of Southwest Power Pool for a Certificate of Convenience, Docket No. 06-SPPE-202	Kansas State Corporation Commission
2005	Policy Issues Related to Southwest Power Pool, Case No. EO-2006-0142	Missouri Public Service Commission
2003	Investigation of Practices of the California Independent System Operator, Docket No. EL-00-95-000	Federal Energy Regulatory Commission
2003	Midwest Independent Transmission System Operator, Docket No. EL02-111-000	Federal Energy Regulatory Commission

EXHIBIT 2

Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project

Prepared for:

DWW Rev I, LLC

Submitted by:

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October 5, 2018

REDACTED

NAVIGANT

Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project

TABLE OF CONTENTS

REDACTED

DISCLAIMER

This report was prepared by Navigant Consulting, Inc. for DWW Rev I, LLC. The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.

NAVIGANT

Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project

1. EXECUTIVE SUMMARY

This advisory opinion was prepared by Navigant Consulting Inc. ("Navigant") at the request of DWW Rev I, LLC ("Deepwater") to assist with the evaluation of direct, indirect, and induced jobs and economic value added that will result from the Revolution Wind Rhode Island project, as defined in Section 2.1 below.

As shown in Table 1-1, the Value Added in Rhode Island that is attributable to the Revolution Wind Rhode Island project is approximately $251 million in the construction phase (starting in 2021) and approximately $14 million on an annual basis in the operations phase (in 2018 dollars). The project will support an estimated 2,583 local job-years[1] during the construction phase and approximately 128 additional local annual jobs during the operations phase.

Table 1-1. Summary of Jobs and Investment Impacts in Rhode Island

Project Phase	Impact Categories	Jobs	Earnings (Millions USD)	Output (Millions USD)	Value Added (Millions USD)
Construction	Direct	812	$55.3	$141.9	$70.4
	Indirect	1,186	$81.9	$288.4	$125.4
	Induced	585	$34.1	$94.0	$55.4
	Total	**2,583**	**$171.2**	**$524.3**	**$251.3**
Operations (Annual)	Direct	32	$2.4	$2.4	$2.4
	Indirect	68	$4.9	$17.1	$9.2
	Induced	28	$1.7	$4.8	$2.7
	Total	**128**	**$9.0**	**$24.3**	**$14.3**

Notes: Earnings, Output and Value-Added figures are in millions of 2018 dollars. Construction job figures are in job years, which are full-time equivalent (FTE) jobs multiplied by the number of construction years. Operations jobs are FTEs for a period of one year. The analysis does not include impacts associated with spending of wind farm profits. Totals may not add up due to independent rounding.

The Revolution Wind Rhode Island project will clearly have a positive economic impact and will add a significant number of jobs to the state of Rhode Island. The Revolution Wind Rhode Island project's in-state capital expenditures of approximately $300 million represent approximately 0.5% of Rhode Island's GDP.[2] The local jobs created during the construction phase will make the project one of the state's largest employers. In addition, the Revolution Wind Rhode Island project will have an ongoing significant positive impact for the full 25-year operations period.

[1] Job-years during the construction phase are defined as full-time equivalent (FTE) jobs multiplied by the number of construction years.
[2] Rhode Island's current-dollar Gross Domestic Product (GDP) was $59.5 billion in 2017. (https://apps.bea.gov/regional/bearfacts/pdf.cfm?fips=44000&areatype=STATE&geotype=3).

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2. INTRODUCTION

2.1 Project Definition

The Revolution Wind project is a planned offshore wind farm, to be located over south of the Rhode Island coast in Deepwater Wind's federal lease area OCS-A 0486 (see the North Lease Area in Figure 1). The output produced by approximately 400 MW of the capacity of the Revolution Wind project is expected to be sold to and purchased by ratepayers in the State of Rhode Island (such capacity, the "Revolution Wind Rhode Island" project).

The project will consist of turbines, inter-array cables, an offshore substation, export cable, onshore substation, and associated onshore construction staging and production areas. The wind turbines will be placed on the sea bed in water depths of approximately 30 meters. The turbines are expected to be approximately 55 km from the export cable landfall site.

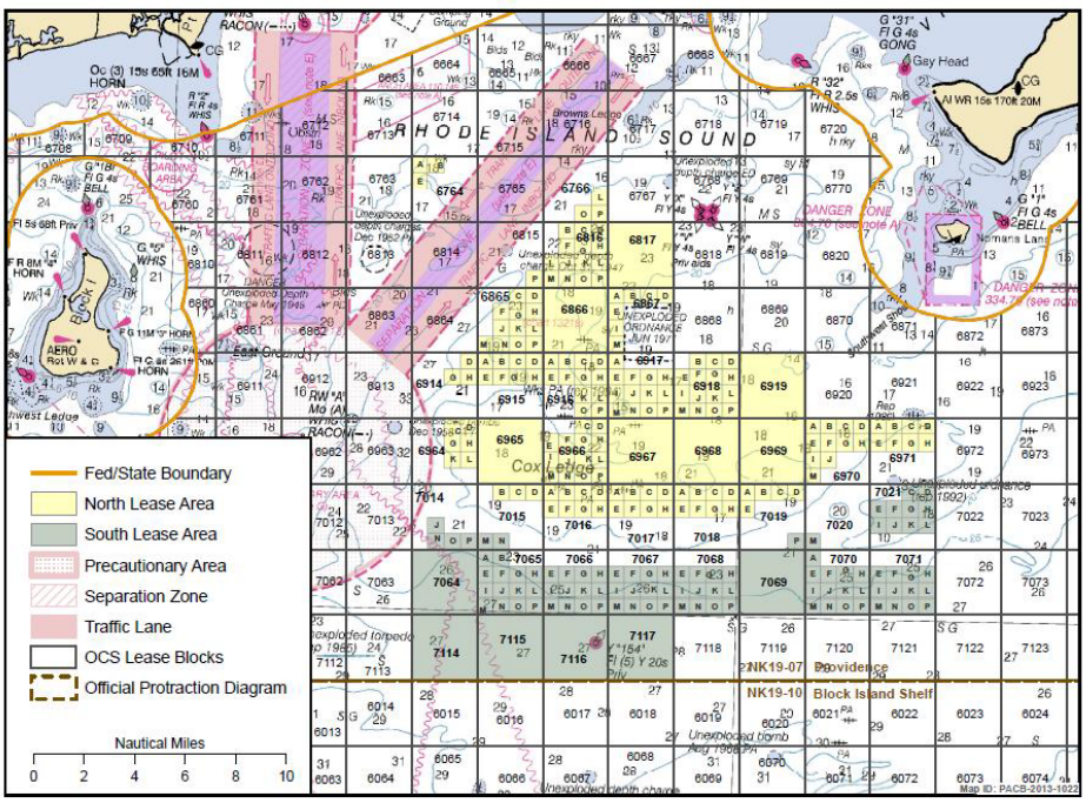

Figure 1. Revolution Wind Project Site

Certain portions of onshore construction is expected to begin in 2021 with offshore construction starting in 2022. The project is scheduled to achieve commercial operations by the end of 2023. The facility is expected to be in operation for at least 25 years from 2024 to 2048.

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The Revolution Wind Rhode Island project has committed to invest at least $40 million in port facility upgrades and other infrastructure in Rhode Island to support the construction and operation of the project. Deepwater plans to perform significant portions of the operations and maintenance of the project from facilities in the State of Rhode Island. Certain steel fabrication and final assembly of the Revolution Wind Rhode Island project's foundations will be performed in Rhode Island. Additionally, the Revolution Wind Rhode Island project is expected to commission the construction of a specialized crew transfer vessel in Rhode Island.

2.2 Analysis Approach

Navigant prepared this evaluation of direct, indirect, and induced jobs and economic value added that will result from the Revolution Wind Rhode Island project, as defined in Section 2.1 above. Direct jobs and economic impact are those resulting from on-site labor and professional services; indirect are a result of local revenues, equipment, and supply chain impacts; and induced are local expenditures from those receiving payments within the first two categories.

To assess the economic value that will result from the development of the Revolution Wind Rhode Island project, Navigant conducted an analysis using the Jobs and Economic Development Impact ("JEDI") Offshore Wind Model. The JEDI Offshore Wind Model is an economic modeling tool developed by the National Renewable Energy Laboratory ("NREL") that allows users to demonstrate the economic impact to a given state or region of the construction and operation of an offshore wind project.

Navigant used the JEDI model[3] to estimate the jobs and economic development benefits that will result from the Revolution Wind Rhode Island project. The primary source for the model inputs was Deepwater, who provided capital and operating budgets including costs, employment, and percent local data that are specific to the Revolution Wind Rhode Island project.[4] Navigant then integrated this data into the JEDI model format. In cases where project specific data was not available, Navigant used the JEDI default values for Rhode Island projects.

3. METHODOLOGY

3.1 JEDI Offshore Wind Model

The JEDI models rely on the widely recognized and well-known input/output (I/O) multiplier data provided by the Minnesota Impact Analysis for Planning (IMPLAN) Group. Offshore wind is the latest addition to this suite, which already includes biofuels, coal, concentrating solar power, natural gas, solar

[3] Note: Navigant used a modified version of JEDI model release OSW1.15.17 which includes impacts for O&M insurance.
[4] Although Navigant did not do a detailed due diligence on the data provided by Deepwater, our independent review of the data indicates that the values are consistent with what we could expect for a project of this magnitude and we did not find any apparent anomalies in the data.

photovoltaics, wind, and marine/hydrokinetic power.[5] Please refer to Appendix B for more information on the JEDI models.

JEDI requires detailed estimates of project expenditures and the share of each individual expenditure line item that is procured locally. These data must be developed for both the construction and operations period of the plant life cycle. As offshore wind is only a nascent industry in the U.S. and only one project has been completed in the U.S. (Deepwater's Block Island Wind Farm), the JEDI Offshore Wind Model relies on projected costs for individual project elements. This analysis evaluates resulting impacts for the construction and operations of the Revolution Wind Rhode Island project.

JEDI requires expenditure data that approximates the expected engineering, material, and office costs as well as labor requirements for proposed infrastructure projects to estimate the economic impact within the Rhode Island economy. JEDI captures all monetary transactions for expenditures and consumption. Inputs to JEDI include projected capital and operational costs and the percentage local assumptions for each line item. In this report, percentage local means the percentage of expenditures that will occur in the State of Rhode Island.

JEDI's outputs include estimates of the effects of a change in one or several economic activities on the regional, state, or local economy. Under the JEDI framework, economic activities include Jobs, Earnings, Output, and Value Added. These terms are defined in Appendix B. The results for Value Added provide the best indications of benefits to the Rhode Island economy.

Table 3-1 shows the categories of jobs and investment impacts that are included in the analysis, along with examples of expenditures in each category.

Table 3-1. Categories of Jobs and Investment Impact

Impact Categories	Construction	Operations
Direct	• Project development (engineering, design, permitting, surveys, and other professional services) • Onsite labor including contractors and crews hired to construct the plant	• Onsite labor for operation and maintenance of the plant (plant technicians, operators, management, and administration)
Indirect	• Turbine and supply chain (inter-industry purchases of materials, equipment, manufacturing, and other services)	• Local revenue (sales and property taxes and ROI for local owners) • Supply chain (components, off-site labor)
Induced	• Increased spending of household earnings from project development and on-site labor impacts as well as turbine and supply chain impacts. This includes increased business at local restaurants, hotels, and retail establishments, childcare providers and service providers.	

[5] NREL's JEDI models are publicly available spreadsheet tools that apply state-specific IMPLAN year 2014 multipliers. The JEDI analysis tools were developed by NREL in conjunction with MRG & Associates. For more information on the JEDI tools, see Appendix B or http://www.nrel.gov/analysis/jedi/.

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3.2 Data Collection and Assumptions

Key Inputs

Deepwater provided Navigant with the raw cost, employment, and percent local data for the Revolution Wind Rhode Island project as the primary inputs to the JEDI model. Data was provided in three basic categories: project descriptive data, capital costs, and operations & maintenance (O&M) costs.

Capital expenditures are expected to occur during the period 2021-2023 according to the project schedule. Total capital expenditures are estimated at approximately $1.4 billion in nominal dollars.[6] Operations expenditures are expected to occur during the period 2024-2048. Total annual operations expenditures are estimated at approximately $35 million. Details of capital and operations expenditures are provided in Appendix A.

Other Assumptions

- All operation and maintenance costs are averaged over 25 years of operation.
- Based on Deepwater's provided data, 100% of the operations and maintenance staff are assumed to be local. Wind farm onsite full-time labor includes field technicians, daily operations staff, administration and management.
- Economic impacts during the operations phase represent impacts that result from wind farm O&M. Navigant assumed a breakdown of O&M material and services costs based on JEDI model default inputs.
- O&M Port and O&M Vessel costs totaling $11 million will be paid by Deepwater's turbine supplier and compensated by Deepwater as part of Deepwater's budgeted O&M payments. For purposes of this analysis, these expenditures are considered one-time capital costs during the construction phase. The corresponding annual amount of approximately $749,000 is backed out of the O&M costs reported by Deepwater. The amount of the O&M reduction is based on a 4.6% constant dollar annual discount rate and a net present value of $11 million.[7]
- Wind turbines and related equipment are exempt from sales tax in Rhode Island according to the provisions of RI Title 44 § 44-18-30.[8]
- Wages are based on 2017 data from U.S. Bureau of Labor Statistics for Rhode Island median reported wages for construction and extraction laborers, wind turbine technicians, operating engineers, office administrators, and general managers.[9] [10] All jobs are assumed to have a 37.6% employee payroll overhead cost.

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[6] Note that this capital cost estimate does not include costs associated with financing, insurance, or contingency.
[7] The 4.6% constant dollar discount rate was calculated from a nominal discount rate of 7.2% less 2.5% inflation, with both factors from the Charles River Associates report "The Impact of Block Island Wind Farm Electricity Costs", June 2010, p. 4, footnote 8.
[8] See http://webserver.rilin.state.ri.us/Statutes/TITLE44/44-18/44-18-30.HTM
[9] Note: Due to limited Rhode Island data, wages for construction managers came from Connecticut and wages for wind turbine technicians came from New York.
[10] Data is available for download at: https://data.bls.gov/oes/#/occGeo/One%20occupation%20for%20multiple%20geographical%20areas. Wages are shown in Appendix A.

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4. RESULTS

4.1 Potential Economic Development Benefits

A summary of Revolution Wind's potential overall economic benefits including Value Added, local jobs, Labor Earnings, and Gross Output is shown in Table 4-1. An explanation of the different economic development categories is provided in this section.

Value Added is the best indicator of economic development benefits to the local Rhode Island economy. The sum total of value added of all enterprises and self-employed in a given state comprises that state's GDP. The total Value Added from the Rhode Island Revolution project is $251.3 million during the expected three-year construction phase and $14 million per year (in 2018 dollars) during the operations phase. These values are the sum of earnings from capital and labor or the difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers, proprietary income, other property type income, indirect business taxes, and taxes on production and imports less subsidies.

Job-years are defined as full-time equivalent (FTE) jobs multiplied by the number of construction years. Construction jobs are given as FTE job-years since they are spread over a multi-year construction period. Some construction jobs will last only a portion of a year while others may last the entire expected construction period of three years. Operations jobs are given as annual FTE jobs over the entire operating period. Based on the JEDI analysis, the Revolution Wind Rhode Island project is expected to account for a total of 2,583 job-years in the construction phase and 128 FTE jobs on an annual basis during the operations phase. These additional jobs result from the increased spending from the Revolution Wind project in Rhode Island.

Direct jobs are defined as on-site labor and professional services. The project will result in 812 FTE local direct job-years in the development and construction phase and 32 FTE local direct annual jobs in the operations phase. 812 FTE job-years during the 3-year construction phase is equivalent to 270.7 jobs each lasting 3 years. "Local" is defined by jobs in Rhode Island.

Indirect jobs are driven by the increase in demand for goods and services from direct on-site project spending including business and companies like construction material and component suppliers, analysts and attorneys involved with project feasibility assessments or contract negotiations, equipment or replacement part manufacturers and others. The project will result in 1,186 FTE local indirect job-years in the construction phase and 68 FTE local indirect annual jobs in the operations phase.

Induced jobs are driven by the local expenditures of those receiving payments within the first two job categories or increased household spending by workers. The project will result in 585 FTE local induced job-years in the construction phase and 28 FTE local induced annual jobs in the operations phase.

Labor Earnings encompass the additional earnings (wages and employer paid benefits) associated with the additional local jobs. Labor Earnings total to $171.2 million (in 2018 dollars) in the construction phase and $9 million per year in the operations phase.

Gross Output is the sum value of all goods and services at all stages of production (i.e., as a raw material and as a finished product) resulting from the project. Local Gross Output is estimated as $524.3 million in the construction phase and $24.3 million annually in the operations phase.

Table 4-1. Summary of Jobs and Investment Impacts in Rhode Island

Project Phase	Impact Categories	Jobs	Earnings (Millions USD)	Output (Millions USD)	Value Added (Millions USD)
Construction	Direct	812	$55.3	$141.9	$70.4
	Indirect	1,186	$81.9	$288.4	$125.4
	Induced	585	$34.1	$94.0	$55.4
	Total	**2,583**	**$171.2**	**$524.3**	**$251.3**
Operations (Annual)	Direct	32	$2.4	$2.4	$2.4
	Indirect	68	$4.9	$17.1	$9.2
	Induced	28	$1.7	$4.8	$2.7
	Total	**128**	**$9.0**	**$24.3**	**$14.3**

Notes: Earnings, Output and Value Added figures are in millions of 2018 dollars. Construction job figures are in job years, which are full-time equivalent (FTE) jobs multiplied by the number of construction years. Operations jobs are FTEs for a period of one year. The analysis does not include impacts associated with spending of wind farm profits. Totals may not add up due to independent rounding.

5. DISCUSSION

5.1 Comparison with Previous Analysis

A Preliminary Analysis for the Revolution Wind Rhode Island project was prepared by the Brattle Group on May 29, 2018. A comparison of Navigant's and Brattle's analyses of the economic impacts in terms of jobs and Value Added is shown in Table 5-1.

While Navigant and Brattle used different methodologies and assumptions, our respective analyses resulted in similar estimated ranges of economic value add and job creation. The particular differences in results stem from the use of two different models: Navigant's analysis used NREL's JEDI model and Brattle used the IMPLAN model from IMPLAN Group. Both analyses used the same input cost data and both models use the same IMPLAN multipliers, but they are applied in different ways. Differences in results can also be attributed to the assumptions that were made while integrating the cost data into the model as well as the assumptions outlined in section 3.2. For example, the JEDI model may define the costs included in development services or labor installation differently than the IMPLAN model or which costs are attributed to economic Output vs. Value Added.

As shown in Table 5-2, the estimates of the direct number of jobs impacts are very similar between Navigant's and Brattle's results as is the total Value Added in the construction phase. However, Navigant's analysis resulted in about 25% fewer indirect and induced job-years in the construction phase, but a greater number of annual jobs during the operations phase. In addition, there is a difference in the direct and indirect Value Added in the operations phase. These differences most likely result from variation in the way the cost inputs were aggregated and applied in the models as either direct or indirect impacts.

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Table 5-1. Comparison of Jobs and Economic Value Added

		Navigant 10/1/2018		Brattle 5/29/2018		% Difference (Navigant-Brattle /Brattle)	
Project Phase		**Jobs**	**Value Added**	**Jobs**	**Value Added**	**Jobs**	**Value Added**
Construction	Direct	812	$70.4	841	$62.6	-3%	+12%
	Indirect	1,186	$125.4	1,552	$129.5	-24%	-3%
	Induced	585	$55.4	779	$75.4	-25%	-26%
	Total	**2,583**	**$251.3**	**3,172**	**$267.6**	**-19%**	**-6%**
Operations (Annual)	Direct	32	$2.4	32	14.97	0%	-84%
	Indirect	68	$9.2	48	$5.29	+43%	+74%
	Induced	28	$2.7	24	$2.95	+16%	-10%
	Total	**128**	**$14.3**	**104**	**$23.21**	**+23%**	**+23%**

Notes: Value Added figures are in millions of 2018 dollars. Construction job figures are in job years, which are full-time equivalent (FTE) jobs multiplied by the number of construction years. Operations jobs are FTEs for a period of one year. The analysis does not include impacts associated with spending of wind farm profits. Totals may not add up due to independent rounding.

5.2 Conclusions

Navigant's analysis showed that for the total capital costs of $1.4 billion, $305 million will be spent in Rhode Island, resulting in 2,583 total job-years and $251.3 million Value Added during the construction phase. During the plant's 25 years of operation, $7.4 million will be spent annually in Rhode Island, resulting in 128 total annual jobs and $14.3 million Value Added per year.[11]

[11] Navigant has provided the above jobs and investment impacts on a best-efforts basis given the data available at the time of this analysis and the assumptions provided by Deepwater.

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APPENDIX A. DETAILED JEDI MODEL INPUTS AND OUTPUTS- *CONFIDENTIAL*

Disclaimer

Certain data contained in the attached document or electronic file have been submitted in confidence and contain trade secrets or proprietary information, and Deepwater Wind requests confidential treatment of such parts of the Proposal as provided in Section 1.7.4 of the 83C RFP. Deepwater Wind requests that the data marked with a double blue underline not be disclosed as such information is confidential and proprietary and exempt from disclosure under the Freedom of Information Act.

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NAVIGANT

Advisory Opinion on the Economic Development Benefits of the Revolution Wind Project

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APPENDIX B. BACKGROUND ON JEDI MODELS

Economic development occurs when a specific area or region of interest secures new sources of investment and when at least a portion of those investments is captured by local businesses and individuals. Economic development analysis seeks to track new investments in a specific location, distinguish different types of expenditures in those regions, and then examine the impact of those investments in the given locality. For those expenditures that are local, the impacts entail the initial investment plus potential downstream effects in the supply chain and in the consumer and retail sectors of the economy. If an expenditure associated with a given project is not captured locally, it is treated as economic leakage and has no economic development value for the region of interest.

Economic development activity is typically estimated using input-output (I/O) models. I/O models apply historical relationships between demand (i.e., specific expenditures within a given sector of the economy) and the resulting economic activity to estimate how new expenditures will affect economic development metrics.

Although some I/O models incorporate dynamic elements, many are static—they measure inter-industry relationships for a given time period—and linear—they assume that any change in demand, regardless of magnitude, has the same proportional result. However, the inter-industry relationships utilized in I/O modeling tend to change only gradually over a long period of time, and I/O modeling is a widely used methodology for measuring economic development activity.

NREL has developed a set of I/O models known as the Jobs and Economic Development Impacts (JEDI) models. The JEDI models are Excel-based models that estimate the economic impacts of constructing and operating power plants, fuel production facilities, and other projects at the local (usually state) level. These models rely on the widely recognized and well known I/O multiplier data provided by the Minnesota IMPLAN Group. Offshore wind is the latest addition to this suite, which already includes biofuels, coal, concentrating solar power, natural gas, solar photovoltaics, wind, and marine/hydrokinetic power.[12] The Offshore Wind JEDI model is specifically tailored to offshore wind facilities and calculates the economic impact to a given region of the construction and operation of an offshore wind project.

B.1 Model Inputs

The JEDI Offshore Wind Model works in a similar way to other models in the JEDI family, allowing the user to specify general characteristics about the wind project such as capacity, number of turbines, distance from shore, water depth, etc., as well as specific cost components that are part of the construction or operations phase of the project.

Calculations can be based either on the entered cost data or on default inputs, which are derived from industry norms. The model asks for several categories of expenditure as well as the percentage of expenditures that will happen locally (in this case meaning in the State of Rhode Island). If project-specific inputs are not available, the model comes with default inputs so a result can be generated with incomplete data.

[12] NREL's JEDI models are publicly available spreadsheet tools that apply state-specific IMPLAN year 2014 multipliers. The JEDI analysis tools were developed by NREL in conjunction with MRG & Associates. For more information on the JEDI tools, see http://www.nrel.gov/analysis/jedi/.

JEDI model defaults are based on interviews with industry experts and project developers.[13] Economic multipliers contained within the model are derived from Minnesota IMPLAN Group's IMPLAN regional input-output software and state data files. The IMPLAN database contains county, state, zip code, and federal economic statistics which are specialized by region, not estimated from national averages and can be used to measure the effect on a regional or local economy of a given change or event in the economy's activity. IMPLAN is based on input-output tables, employment and wage data, data on trade flows, and data on how personal income is spent. Input-output tables are compiled at the national level by the Bureau of Economic Analysis (BEA), an agency within the Department of Commerce. State and county specific input-output tables are derived by adjusting the BEA national tables by adjusting the distribution of production among industries, based on employment data by industry, and deriving imports and exports to and from the state through a combination of the input-output relationships and trade flow data.

B.2 Model Outputs

Based on project-specific inputs from the user, the model estimates job creation, earnings, and output (total economic activity) for a given power generation project. This includes the direct, indirect, and induced economic impacts on the state economy associated with its construction and operation phases. By determining the regional economic impacts and job creation for a proposed power facility, the JEDI Offshore Wind Model can be used to answer questions about the impacts of offshore wind power in a given state, region, or local community.

NREL's JEDI models present outputs for the following economic metrics:

- *Jobs* – Additional jobs resulting from the increased final spending.
- *Earnings* – The additional earnings (wages and employer paid benefits) associated with the additional jobs.
- *Output* – The additional output that drives the increase in jobs. Output is defined more broadly than other metrics of economic activity, including value added or GDP; output is the sum value of all goods and services at all stages of production (i.e., as a raw material and as a finished product).
- *Value Added* – The difference between total gross output and the cost of intermediate inputs. It is the sum total of earnings of capital and labor, comprised of payments made to workers, proprietary income, other property type income, indirect business taxes, and taxes on production and imports less subsidies. The sum total of value added of all enterprises and self-employed in a state comprises that state's GDP.

JEDI models classify results into three categories: direct, indirect, and induced. Direct results are defined as on-site labor and professional services. These are the impacts from dollars spent on labor by companies engaged in development and on-site construction and operation of power generation and transmission. These results do not include materials—only labor. With its exclusive emphasis on labor, JEDI's first tier of impacts is narrower than typical direct economic impacts. Companies or businesses that fall into this category include project developers, environmental and permitting consultants, road builders, concrete-pouring companies, construction companies, tower erection crews, crane operators, and O&M personnel.

[13] Default values are based on analysis of proprietary data provided by NREL, Navigant, Green Giraffe Energy Bankers, Ocean & Coastal Consultants, and the U.S. Department of Labor Bureau of Labor Statistics. In those instances where data from the sources was not an exact match for the system parameters, the best available information was used to derive appropriate values.

Indirect effects are reported in JEDI as local revenues, equipment, and supply chain results. These results are driven by the increase in demand for goods and services from direct on-site project spending. Businesses and companies included in the second tier of economic activity include construction material and component suppliers, analysts and attorneys who assess project feasibility and negotiate contract agreements, banks financing the projects, all equipment manufacturers (i.e., blade manufacturers), and manufacturers of replacement and repair parts.

Induced effects are the third and final category and are driven by the local expenditures of those receiving payments within the first two categories. These are often associated with increased business at local restaurants, entertainment, and retail establishments, as well as child care providers or any other entity affected by the increased economic activity and spending occurring in the first two tiers.

JEDI model results are displayed in two different time periods: construction and operations. Construction period results are inherently short-term. Jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor. (One construction period job equates to one full-time job for one year.) Equipment manufacturing jobs, such as tower manufacturing, are included in construction period jobs as it is ultimately new construction that drives equipment manufacturing. All employment related to the construction of the project is reported in FTE. Operations period results are long-term, for the life of the project, and are reported as annual FTE jobs and economic activity. Operation period impacts continue to accrue throughout the operating life of the facility.

JEDI results are not intended to be a precise forecast; they are an estimate of potential activity resulting from a specific set of projects or scenarios. In addition, JEDI results presuppose that projects are financially viable and can be justified independent of their economic development value. Importantly, results generated by the JEDI models are gross (not net) results. They do not consider potential increases or decreases in electricity rates resulting from investments in new infrastructure, nor do they consider whether the respective projects displace economic activity elsewhere.

EXHIBIT 3

Advisory Opinion on the Environmental and Public Health Benefits of the Revolution Wind Project

Prepared for:

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October 1, 2018

TABLE OF CONTENTS

DISCLAIMER

This report was prepared by Navigant Consulting, Inc. for DWW Rev I, LLC. The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.

1. EXECUTIVE SUMMARY

This advisory opinion was prepared by Navigant Consulting Inc. ("Navigant") at the request of DWW Rev I, LLC ("Deepwater") to assist with the evaluation of environmental and public health impacts that will result from the 400 MW Revolution Wind project serving Rhode Island.

Navigant maintains long-term wholesale power market forecasts for the Independent System Operator of New England (ISO-NE) region, and other regions in the U.S. and Canada, using a variety of energy market modeling tools to project generating capacity retirements and additions, generating unit dispatch, fuel consumption, gas pipeline flows, and commodity prices. The core of this modeling platform is PROMOD IV, a detailed hourly chronological market model[1] that simulates the dispatch and operation of the wholesale electricity market. Navigant runs PROMOD in the full nodal model with full transmission representation. A node refers to any point on a circuit where two or more circuit elements meet.

The analysis conducted in preparation of this advisory opinion was based on Navigant's Summer 2018 NEMO Reference Case[2] market forecast for the ISO-NE region. This analysis demonstrates that output delivered to Rhode Island from the Revolution Wind project is expected to displace approximately four percent (4%) of thermal-based generation in Rhode Island and also reduce emissions of CO_2, NOx, and PM_{10} from central station sources in Rhode Island by four percent (4%). Imputed monetary values of these emissions reductions in Rhode Island are presented below in Table 1 and indicate societal benefits ranging from $44 million to $172 million (in 2018 dollars) over the 25-year operating life of the project.

Table 1. Quantity and Value of Emissions Reductions in Rhode Island (2024-2048)

Period	CO_2	NOx	SO_2[3]	PM10[4]	Total
Annual Tons (1,000)	127	0.009	0.000	0.004	n/a
Total Tons, 2024-2048 (1,000)	3,174	0.226	0.000	0.103	n/a
Annual Benefit (mil 2018$) – Low Case	$1.68	$0.02	$0.00	$0.05	$1.75
Annual Benefit (mil 2018$) – High Case	$6.38	$0.11	$0.00	$0.41	$6.90
Total Benefit (mil 2018$) – Low Case	$42.12	$0.44	$0.00	$1.19	$43.75
Total Benefit (mil 2018$) – High Case	$159.42	$2.78	$0.00	$10.18	$172.37

More broadly, Navigant's analysis demonstrates that output delivered to Rhode Island from the Revolution Wind project is expected to displace approximately three percent (3%) of thermal-based generation in in the ISO-NE system and also reduce emissions across New England by approximately three percent (3%). Over eighty percent (80%) of those emissions reductions would occur in the air shed shared by Rhode Island, Connecticut, and Massachusetts. Reductions of smaller levels of SO_2 emissions would also occur. Imputed monetary values of these emissions reductions are presented below in Table 2

[1] ABB's PROMOD IV is commercial software that is widely used in the U.S. by utilities, consultants and ISOs for electricity market modeling.

[2] The Navigant Energy Market Outlook (NEMO) includes long-term forecasts of all regions in North America and is updated twice annually. This analysis for this report was based on the Summer 2018 NEMO Reference Case which was completed in July 2018.

[3] Gas-fired plants in Navigant's models are assumed to have zero kg/MWh. Actual emissions are at around 0.0001 to 0.0002 kg/MWh.

[4] Particulate matter are commonly classified as PM_{10} which are matter that are 10 micrometers or less in diameter, and $PM_{2.5}$ which are matter 2.5 micrometers or less in diameter. EPA survey data indicates that approximately 1,540 tons of PM10 were emitted by generators in New England in 2014 and that 87% of the PM_{10} were contained in the subclass of $PM_{2.5}$.

and indicate societal benefits ranging from $260 million to $1,083 million (in 2018 dollars) over the 25-year operating life of the project.

Table 2. Quantity and Value of Emissions Reductions across ISO-NE (2024-2048)

Period	CO_2	NOx	SO_2	PM_{10}	Total
Annual Tons (1,000)	733	0.236	0.0003	0.037	n/a
Total Tons, 2024-2048 (1,000)	18,320	5.898	0.008	0.917	n/a
Annual Benefit (mil 2018$) – Low Case	$9.51	$0.46	$0.00	$0.42	$10.39
Annual Benefit (mil 2018$) – High Case	$36.81	$2.90	$0.01	$3.62	$43.33
Total Benefit (mil 2018$) – Low Case	$237.84	$11.41	$0.06	$10.54	$259.85
Total Benefit (mil 2018$) – High Case	$920.12	$72.51	$0.13	$90.52	$1,083.27

The methodology for this assessment, including measurement of emissions and the monetary impacts for the high and low ranges, is described in detail below in Section 2. Summary results are presented in Section 4, and data tables as well as descriptions of Navigant's energy modeling platform and tools are presented in Appendix A.

2. INTRODUCTION

The Revolution Wind Rhode Island project is a planned offshore wind farm to be located south of the Rhode Island coast in Deepwater Wind's federal lease area OCS-A 0486 (the North Lease area shown in yellow in Figure 1). The output produced by approximately 400 MW of the capacity of the Revolution Wind project is expected to be sold to and purchased by ratepayers in the State of Rhode Island (such capacity, the "Revolution Wind Rhode Island" project). Offshore construction is expected to start in 2022, and the project is scheduled to achieve commercial operations by December 2023. For this analysis, it was assumed that full commercial operation will begin on January 1, 2024. The facility is expected to be in operation for at least 25 years from 2024 to 2048.

Navigant was commissioned by Deepwater to provide an independent estimate of the reductions in emissions of carbon dioxide (CO_2), nitrous oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM_{10} and/or $PM_{2.5}$) that are expected to result from the deliveries from the Revolution Wind Rhode Island project to ratepayers in Rhode Island, and to comment on the qualitative and monetary benefits of these reductions.

Pollutants emitted by the electric power sector cause damage to human health, including increased morbidity and mortality. Over the course of its operating life, the Revolution Wind Rhode Island project will displace thermal generation which will result in reduced emissions of harmful pollutants, which can be translated to societal benefits. This report also provides commentary on such societal benefits.

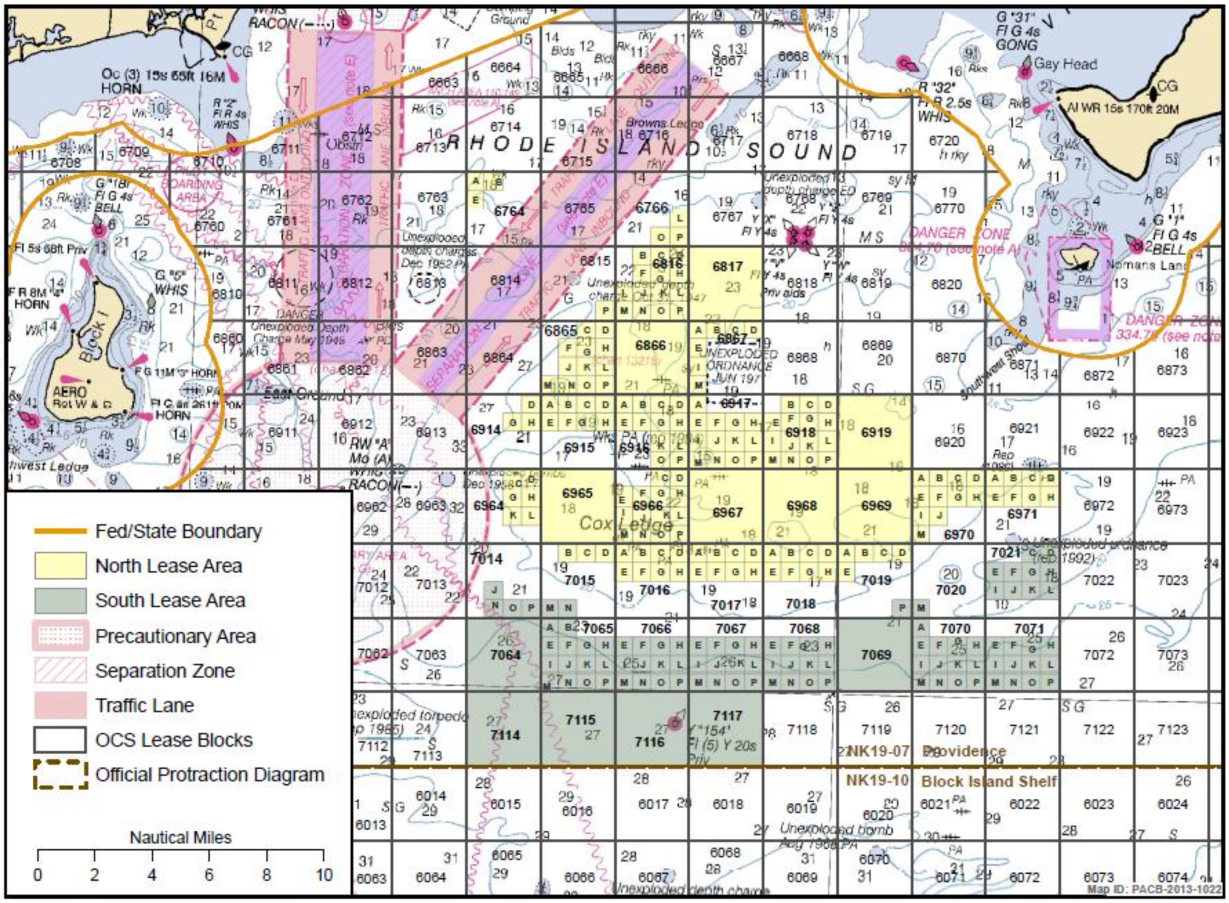


Figure 1. Revolution Wind Project Site

3. METHODOLOGY

Deepwater provided an estimate of hourly wind production from the Revolution Wind Rhode Island project[5], which Navigant used as the basis for this analysis. Navigant employed its current Reference Case forecast[6] under the following assumptions.

- Wind output from the Revolution Wind Rhode Island project was assumed to displace dispatchable generation ("affected generation") such as fossil-based combined cycle, steam turbine, and combustion turbine plants that bid into the day-ahead market. It was assumed to have no effect on power from intermittent renewables (wind, solar), renewables with low marginal cost (hydro), contracted imports from Hydro Quebec, baseload nuclear, or landfill sites under PPAs with host utilities.
- Reductions in generation were assumed to be distributed across the ISO-NE in a manner directionally consistent with anticipated changes in power flows that would result from injection of

[5] Navigant did not perform an independent review nor detailed due diligence of the data provided by Deepwater.

[6] While the NEMO forecasts can be modified to conduct scenario and sensitivity analyses (e.g., for changes in fuel prices, changes in generator capital costs, or changes in public policy), such studies tend to be lengthy and of a large scope and are not suited for all situations. Navigant was not commissioned to and did not conduct a scenario or sensitivity analysis in PROMOD.

power into the grid at points on the Rhode Island coast. Because Navigant was not commissioned to, and did not, develop a new power flow and simulation case, Navigant instead developed specific relative weighting factors for each state based on Navigant's professional judgment.

- Navigant then allocated the generation reductions based on the specific relative weighting factors it developed. Affected generation in Rhode Island were given a weighting of 1.00, affected generation in Connecticut and Massachusetts were given a weighting factor of 0.80, and affected generation in Vermont, New Hampshire, and Maine were given a weighting factor of 0.25. An illustrative example of this is shown in Table 3 below for a case with three regions with different weightings and 1,800 GWh of generation displaced by new offshore wind.

Table 3. Illustrative Calculation of Displaced Generation Distribution

Region	Affected Generation (GWh)	Weight Factor	Implied Share (GWh)	Implied Share (%)	Displaced Generation (GWh)
A	6,000	1.00	6,000	16.67%	300
B	33,750	0.80	27,000	75.00%	1,350
C	12,000	0.25	3,000	8.33%	150
TOTAL	51,750	n/a	n/a	100.00%	1,800

Once the regional distribution was calculated, each region's generation reductions were allocated within the region on a pro rata basis. Continuing with the example, if 90% of affected generation in region A were combined cycle and 10% were from combustion turbines, then we assume that 90% of the 300 GWh displaced generation in region A, or 270 GWh, would come from the combined cycle plants in region A and 10% would come from the combustion turbines.

- CO_2, NOx, and SO_2 reductions were assumed to occur at the average emissions rate by generator/fuel category. For example, if the NEMO forecast projects that, on average, each MWh from a gas-fired combustion turbine produces 1,200 pounds of CO_2, then any displacement of MWh from gas combustion turbines (CTs) would result in 1,200 pounds per MWh. In this manner, the Navigant team was not distinguishing between different gas CTs that are in the system, but was distinguishing between the emissions of gas combined cycle, gas CTs, oil CTs, biomass, coal plants, and so forth.

Unit emissions of PM (in pounds per MWh) were estimated based on plant-level emissions data for 2014 from the U.S. Environmental Protection Agency's National Air Emissions Inventory (NEI) and from 2014 MWh output from SNL[7] from those same plants. Emissions and MWh data by plant were aggregated by generator type and fuel and then used to create unit emissions estimates. PM emissions reductions were then estimated in the same manner as emissions reductions for the other three pollutants. Navigant's modeling horizon is through 2040 so estimates for 2041-2048 were extrapolated from the results for 2024-2040.

Estimates of societal costs were then calculated as the product of emissions reductions (in tons) and social cost ($ per ton) of each pollutant, where social costs were derived from review of secondary sources. A list of data sources used to estimate social costs is shown in Table 4.

[7] SNL is a news and data service by S&P Global Market Intelligence.

Table 4. Social Cost Estimates

Effluent	Sources	Range [6]
CO_2	Navigant RGGI price forecast [1], Interagency Working Group [2]	RGGI price starts at $8.60 in 2024 and rises to $13.91 by 2040; Working Group cost is $49/ton
NOx	National Research Council [3], AEA Technology Report [4]	National Research Council cost is $1,888/ton; AEA cost is $11,994/ton.
SO_2	National Research Council [3], AEA Technology Report [4]	National Research Council cost is $6,844/ton; AEA cost is $15,875/ton
$PM_{10}/PM_{2.5}$	National Research Council [3], UK Department for Environment, Food and Rural Affairs [5]	National Research Council cost is $11,211/ton; UK cost is $96,341/ton

Sources:
[1] Navigant Summer 2018 Reference Case NEMO forecast
[2] Interagency Working Group on the Social Cost of Carbon, United States Government
[3] "Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use", National Research Council of the National Academy of Sciences (2010).
[4] AEA Technology Environment (2005), *Damages Per Tonne Emission of $PM_{2.5}$, NH_3, SO_2, NOx and VOCs From Each EU25 Member State*, Clean Air for Europe (CAFE) Programme, European Commission (www.cafe-cba.org); at www.cafe-cba.org/reports; referenced in Transportation Cost and Benefit Analysis II at http://vtpi.org/tca/tca0510.pdf
[5] DEFR (2015), *Damage Costs by Location and Source, Air Quality Economic Analysis*, UK Department for Environment, Food and Rural Affairs (http://bit.ly/1hur2Ij); at www.gov.uk/government/uploads/system/uploads/attachment_data/file/460398/air-quality-econanalysis-damagecost.pdf; referenced in Transportation Cost and Benefit Analysis II at http://vtpi.org/tca/tca0510.pdf
[6] All conversions to $2017/short ton done by Navigant

4. RESULTS

4.1 Generation Impacts

With the assumption that offshore wind can only displace generation being sold into the ISO on a dispatchable basis, the impacts of the Revolution Wind Rhode Island project result in reductions of gas and biomass generation. Given the expected delivery of 1,632 GWh of offshore wind per year (1,638 GWh in leap years), about 93% of displaced production in New England comes from gas combined cycle, 5% from biomass, and 2% from gas combustion turbines. The distribution in Rhode Island is similar, with 95% from combined cycle and 5% from combustion turbines. Table 5 shows the estimated average annual MWh quantities that are expected to be displaced in Rhode Island by the Revolution Wind Rhode Island plant for various time periods and generation categories.

A plurality of the capacity mix in ISO-New England is made up of natural gas plants (44%), with the remainder coming from hydroelectric and other renewables (16%), nuclear (14%), oil (23%), and coal (3%). In recent years generation from oil and coal have fallen below 1% and generation from gas has risen above 50%. In addition, ISO-NE takes sizable imports of hydroelectric power from Quebec and the ISO-NE states have active load management and energy efficiency programs. Navigant's Reference Case forecast for New England projects that the remaining coal and gas steam plants will be retired by 2026, that Pilgrim nuclear will complete its deactivation by 2019, and that new plant expansion will come from gas combined cycle, gas combustion turbine, wind, and solar. In addition, all 6 states in New England have committed to Renewable Portfolio Standards to ensure that a certain percentage of their electricity comes from renewables. Rhode Island set a standard of 38.5% renewable penetration by 2035, Connecticut set a standard of 48% by 2030, and Massachusetts set a standard of 40% of total energy sales by 2030 with a 1% increase annually thereafter.[8]

Average annual estimates of reductions in affected thermal generation in Rhode Island are presented in Table 5 for 2024 through 2048[9].

Table 5. Quantity of Generation Reductions in Rhode Island (2024-2048)

Period	MWh Displaced	Combined Cycle	Combustion Turbine
Average Annual (2024-2030)	248,275	248,275	-
Average Annual (2031-2035)	308,042	288,794	19,248
Average Annual (2036-2040)	325,798	280,912	44,886
Average Annual (2041-2048)	321,801	277,466	44,335

4.2 Estimated Environmental Reductions

Annual estimates of criterion emissions and reductions in criterion emissions in Rhode Island are presented in Table 6 for 2024 through 2048. For each emission type, the Base column in Table 6 represents the tons of emissions that are expected in Rhode Island without the Revolution Wind plant, and the Impact column represents the tons of emissions that the base case would be reduced (shown as negative numbers to indicate reductions).

[8] Navigant ISO-NE Market Summary and Forecast Report 2018
[9] Navigant's Reference Case extends through 2040. Data for 2041-2048 was estimated by extrapolation of Reference Case data.

Table 6. Summary of Emissions Impacts of the Most Common Pollutants in Rhode Island

	CO_2 (1000 tons)		NOx (tons)		SO_2[10] (tons)		PM_{10} (tons)	
Year	Base	Impact	Base	Impact	Base	Impact	Base	Impact
2024	2,229	-77	201	-16.3	0	0	57	-1.9
2025	2,027	-71	171	-18.6	0	0	52	-1.8
2026	1,864	-63	160	-11.7	0	0	47	-1.6
2027	3,241	-130	235	-11.4	0	0	90	-3.6
2028	3,135	-130	227	-11.5	0	0	87	-3.6
2029	3,192	-127	234	-11.3	0	0	88	-3.5
2030	3,212	-130	231	-11.9	0	0	88	-3.6
2031	2,995	-122	212	-11.4	0	0	82	-3.4
2032	3,001	-122	212	-11.6	0	0	83	-3.4
2033	3,133	-126	221	-11.5	0	0	97	-3.9
2034	3,210	-130	228	-11.5	0	0	107	-4.2
2035	3,470	-137	243	-11.4	0	0	127	-4.8
2036	3,424	-139	239	-11.9	0	0	124	-4.7
2037	3,339	-134	234	-11.5	0	0	120	-4.5
2038	3,452	-136	240	-11.3	0	0	125	-4.7
2039	3,454	-138	244	-11.5	0	0	124	-4.7
2040	3,329	-137	233	-11.9	0	0	118	-4.6
2041	3,340	-138	233	-11.9	0	0	122	-4.7
2042	3,352	-139	233	-11.9	0	0	126	-4.8
2043	3,364	-139	234	-11.9	0	0	129	-4.9
2044	3,376	-140	234	-11.9	0	0	133	-5.0
2045	3,388	-141	234	-12.0	0	0	137	-5.1
2046	3,400	-142	234	-12.0	0	0	141	-5.3
2047	3,413	-142	234	-12.0	0	0	145	-5.4
2048	3,425	-143	234	-12.0	0	0	150	-5.5
2024-48	78,767	-3,174	5,637	-304	0	0	2,700	-103

4.3 Estimated Financial Benefits

Table 7 shows a summary of emissions reductions that are expected to result from the Revolution Wind Rhode Island plant over its 25-year operating life, exclusively within the State of Rhode Island. Table 7 also shows the range of imputed monetary values of these emissions reductions for each pollutant in constant 2018 dollars and also in nominal dollars, again only in the State of Rhode Island. Annual societal benefits within Rhode Island range from $1.7 million to $6.9 million per year in 2018 dollars or $2.8 million to $10.9 million per year in nominal dollars. Total societal benefits in Rhode Island range from $44 million to $172 million in 2018 dollars or $71 million to $273 million in nominal dollars.

[10] Gas-fired plants in Navigant's models are assumed to have zero kg/MWh SO_2. Actual SO_2 emissions are at around 0.0001 to 0.0002 kg/MWh.

Table 7. Quantity and Value of Emissions Reductions in Rhode Island (2024-2048)

Period	CO_2	NOx	SO_2	PM_{10}[11]	Total
Annual Tons	126,967	9.0	0	4.1	n/a
Total Tons	3,174,163	226	0	103	n/a
Annual Benefit (1,000 2018$) – Low Case	$1,685	$17	$0	$47	$1,750
Annual Benefit (1,000 2018$) – High Case	$6,377	$111	$0	$407	$6,895
Total Benefit (1,000 2018$) – Low Case	$42,121	$438	$0	$1,184	$43,742
Total Benefit (1,000 2018$) – High Case	$159,422	$2,779	$0	$10,175	$172,375
Annual Benefit (1,000 nominal $) – Low Case	$2,741	$28	$0	$76	$2,845
Annual Benefit (1,000 nominal $) – High Case	$10,098	$175	$0	$657	$10,929
Total Benefit (1,000 nominal $) – Low Case	$68,537	$689	$0	$1,910	$71,136
Total Benefit (1,000 nominal $) – High Case	$252,445	$4,376	$0	$16,413	$273,233

More broadly, Table 8 shows a summary of emissions reductions and the range of imputed monetary values of these emissions reductions across New England. As with Table 7, Table 8 is in constant 2017 dollars and also in nominal dollars for each pollutant. Annual societal benefits across New England range from $10 million to $43 million per year in 2018 dollars or $16 million to $67 million per year in nominal dollars. Total societal benefits across New England range from $260 million to $1,083 million in 2018 dollars or $415 million to $1,682 million in nominal dollars.

Table 8. Quantity and Value of Emissions Reductions across New England (2024-2048)

Period	CO_2	NOx	SO_2	PM_{10}	Total
Annual Tons	733	0.236	0.0003	0.037	n/a
Total Tons	18,320	5.898	0.008	0.917	n/a
Annual Benefit (1,000 2018$) – Low Case	$9,514	$456	$2	$421	$10,393
Annual Benefit (1,000 2018$) – High Case	$36,805	$2,900	$5	$3,620	$43,331
Total Benefit (1,000 2018$) – Low Case	$237,840	$11,413	$57	$10,533	$259,843
Total Benefit (1,000 2018$) – High Case	$920,120	$72,505	$132	$90,516	$1,083,274
Annual Benefit (1,000 nominal $) – Low Case	$15,210	$710	$3	$659	$16,582
Annual Benefit (1,000 nominal $) – High Case	$57,088	$4,511	$6	$5,664	$67,268
Total Benefit (1,000 nominal $) – Low Case	$380,260	$17,750	$67	$16,476	$414,554
Total Benefit (1,000 nominal $) – High Case	$1,427,203	$112,763	$156	$141,590	$1,681,712

[11] Particulate matter are commonly classified as PM_{10} which are matter that are 10 micrometers or less in diameter, and PM2.5 which are matter 2.5 micrometers or less in diameter. EPA survey data indicates that approximately 1,540 tons of PM_{10} were emitted by generators in New England in 2014 and that 87% of the PM_{10} were contained in the subclass of $PM_{2.5}$.

4.4 Estimated Public Health Benefits

The Revolution Wind Rhode Island project will displace thermal generation which will result in reduced emissions of harmful pollutants. Table 9 summarizes the impacts on human health that have been linked to common pollutants from power plants.

Table 9. Summary of Human Health Impacts of the Most Common Pollutants

Emission	Impact
NO_x	• Chronic Obstructive Pulmonary Disease (COPD) • Ischaemic Heart Disease (IHD)
SO_2	• Asthma • Cardiac
O_3	• Chronic asthma • Acute-exposure mortality • Respiratory problems • Acute asthma attacks
$PM_{2.5}$	• Premature death • Nonfatal heart attacks • Hospital admissions • ER visits for asthma, acute bronchitis, upper and lower respiratory symptoms
PM_{10}	• Chronic bronchitis

Source: Oak Ridge National Laboratory, "Environmental Quality and the U.S. Power Sector: Air Quality, Water Quality, Land Use and Environmental Justice", January 2017.

Health impacts of air pollution include reduced organ functionality; increased asthma attacks; doctor visits, school and work absences; emergency room visits, hospital admission and heart attacks; and premature death. Emissions of *coarse* particulate matter (PM_{10})[12] cause chronic obstructive pulmonary disease, asthma, and hospital respiratory and cardio-vascular admissions but have not been associated with increased mortality. However, *fine* particles ($PM_{2.5}$)[13] are more harmful because they translocate from the lungs to blood and accumulate in other parts of the body, increasing short- and long-term mortality and morbidity.

Human exposure to ground-level ozone (O_3) reduces lung function, generates inflammation of the airways, and causes symptoms such as chest pain, coughing, wheezing and shortness of breath, even for people with no pre-existing respiratory ailments.

[12] PM_{10} is course particulate matter that is between 10 and 2.5 μm in diameter.
[13] $PM_{2.5}$ is fine particulate matter that is less than 2.5 μm in diameter.

5. DISCUSSION

5.1 Comparison with Other Analysis

A memorandum on the subject of "Energy Market and Emissions Reduction Benefits of the Revolution Wind Project" was prepared by the Brattle Group on December 19, 2017.[14] This memorandum provided estimates of total emissions reductions in ISO-New England which can be compared to the estimates provided by Navigant in Table 2 above. A comparison of results of Navigant's and Brattle's analyses of the ISO-NE emissions reduction benefits is shown in Table 10.

Table 10. Comparison of Navigant and Brattle Results

	Navigant 10/1/2018		Brattle 12/19/2017	
	Avoided ISO-NE Emissions (tons)	Avoided ISO-NE Emissions Value (2018 K$)	Avoided ISO-NE Emissions (metric tonnes)	Avoided ISO-NE Emissions Value (2018 K$)
Annual CO_2	733,000	$9,512 to $36,808	648,878	$32,809
Annual NOx	236	$460 to $2,900	42	$90
Annual SO_2	0.3	$0 to $10	44	$338
Annual $PM_{2.5}$	37	$420 to $3,618	245	$3,100
Total		**$10,670 to $43,327**		**$36,338**

While Navigant and Brattle used different methodologies and assumptions, our respective analysis produced results within a similar range. The particular differences between the Navigant and Brattle results stem from two notable differences in assumptions. The first is that Brattle appeared to assume that the entire effect of Revolution Wind would be borne by combined cycle plants, as was shown in Brattle's May 2018 memo at Table 2. The second is that Brattle's assumptions for effluent concentrations for SO_2 and PM are greater than those assumed by Navigant.

Comparison of Brattle's CO_2 and NOx impacts show strong similarity to Navigant's impacts if the analysis is based on 100% combined cycle, with Brattle assuming 398 kg/MWh for CO_2 and 0.026 kg/MWh for NOx, and Navigant assuming 389 kg/MWh for CO_2 and 0.034 kg/MWh for NOx.

Navigant's analysis shows the majority of displacement coming from combined cycle (93-94%), but Navigant also has 5% coming from wood waste biomass and 1-2% from gas CTs, both of which have higher emissions concentrations. Wood waste biomass is estimated as 774 kg/MWh for CO_2 and 0.872 kg/MWh for NOx, and Gas CT is estimated as 490 kg/MWh for CO_2 and 0.094 kg/MWh for NOx. The much higher NOx component for biomass coupled with displacement of biomass in Connecticut leads to higher NOx reductions in our analysis.

[14] A further refinement of the CO_2 emissions reduction benefits was provided in a memorandum on the subject of "Preliminary Analysis for Deepwater Wind's 400 MW Revolution Wind Farm" by the Brattle Group on May 9, 2018.

The are some additional differences between the Brattle and Navigant analyses. One area is SO_2 emissions, which are very low in combined cycle plants. As a general course, Navigant assumed zero kg/MWh SO_2 from gas even though the measured levels are somewhere around 0.001 to 0.002 kg/MWh. Brattle assumes 0.027 kg/MWh, which would only make sense if they adopted an average SO_2 concentration for all thermal generation from some historical test period and then applied it to combined cycle plants.

The same happens for PM. The EPA data shows concentration factors ranging from 0.011 kg/MWh for combined cycle plants to 0.176 kg/MWh for oil combustion turbines and ICs, and the Navigant analysis averages about 0.024 kg/MWh. Brattle assumes 0.15 kg/MWh for PM.

5.2 Conclusion

The Revolution Wind Rhode Island project will result in reduced emissions with total societal benefits in the state Rhode Island of $71 million to $273 million in nominal dollars over the 25-year life of the project. On an annual basis, societal benefits will be in the range of $2.8 to $10.9 million in nominal dollars. These benefits will be the result of reduced CO_2, NOx, SO_2, and particulate emissions from displaced thermal (primarily combined cycle gas) power plants in Rhode Island. The majority (92% to 96%) of the benefits will be the result of reduced CO_2 emissions.

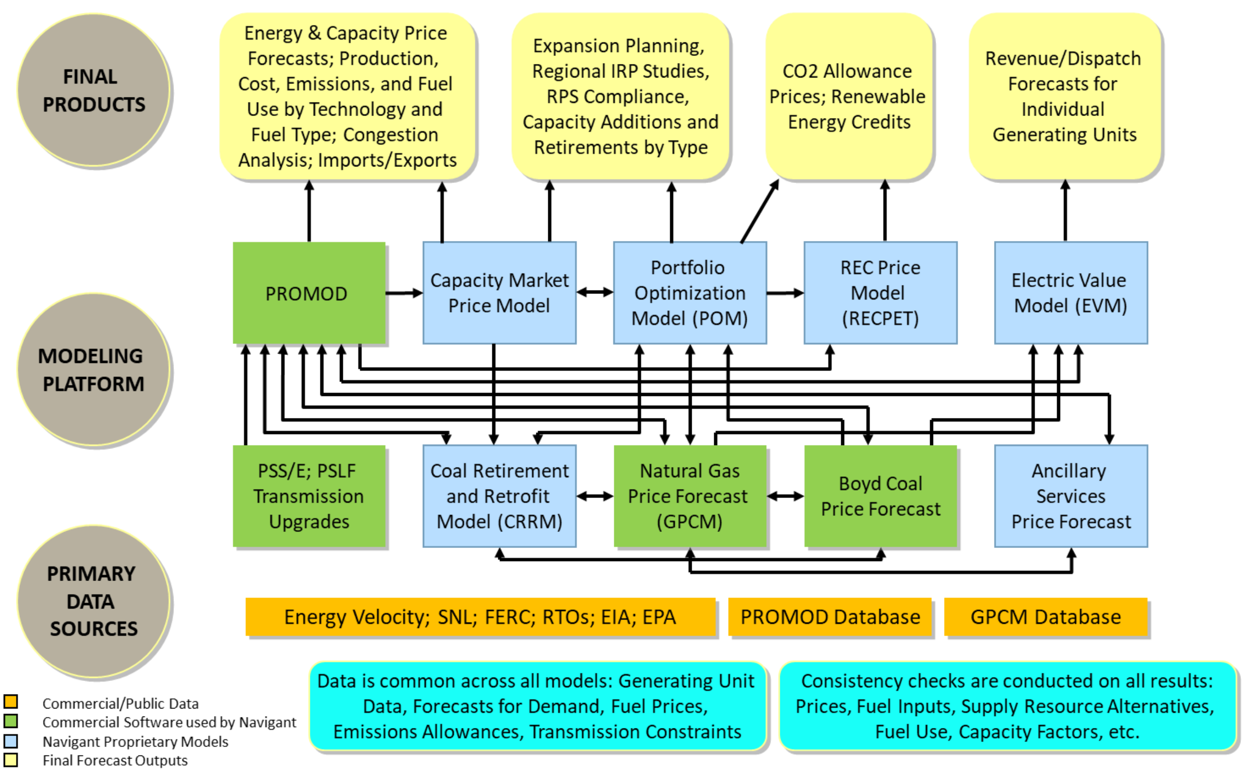
The vast majority of the emissions impacts are in the three southern states of Rhode Island, Connecticut, and Massachusetts. The composition and locations of generation in the ISO-NE supply base are such that 89% of the CO_2 reductions, 83% of the NOx reductions, and 81% of the PM_{10} reductions occur at plants in the three southern states. This finding is relevant to the study as the close proximity and relatively small geographic sizes of the states implies a common airshed. The lone exception is SO_2 emissions reductions which are concentrated primarily in New Hampshire. However, the benefits of SO_2 reductions largely disappear after 2025 when most coal capacity in New England is assumed to have retired.

APPENDIX A. BACKGROUND ON DATA SOURCES

Energy Market Analysis

Navigant employs a variety of commercial and proprietary energy market modeling tools to project generating capacity retirements and additions, generating unit dispatch, fuel consumption, gas pipeline flows, and commodity prices in organized (ISO-NE, NYISO, PJM, IESO, Midwest ISO, SPP, ERCOT, CAISO, and Alberta Electric System Operator [AESO]) and traditional markets (southeastern U.S., southwest U.S., Rocky Mountain, Basin, Pacific Northwest, British Columbia, Saskatchewan, Manitoba, Quebec, and remaining eastern Canada). A schematic of these tools is shown below, followed by a description of each tool.

Figure 2. Navigant Energy Market Modeling Tool Set



PROMOD and supporting models

PROMOD

For fundamental energy price market forecasting, Navigant uses PROMOD IV, a detailed hourly chronological market model[15] that simulates the dispatch and operation of the wholesale electricity market. PROMOD is a least-cost optimization model that simulates the hourly operation of the energy market, while observing generator operating limitations and transmission constraints. PROMOD can be run as a zonal or nodal model, although Navigant normally runs it in the full nodal model with full transmission representation.

Separate models are used for Eastern Interconnection (EI), ERCOT, and Western Electricity Coordinating Council (WECC.) ERCOT is represented as four separate control areas, the EI is represented as 147 separate control areas, and WECC is represented as 105 separate control areas. In addition, due to its large size, the EI model is maintained with three "centered" versions, with each containing a full depiction of the high-level bulk transmission system and interface limits as well as additional regional detail to more fully incorporate intra-regional and local transmission constraints. For example, the Midwest-centered version of our EI PROMOD contains the full bulk transmission configuration as well as significant added detail about transmission constraints in MISO, SPP, and areas of PJM, IESO, and SERC that border MISO and SPP. PROMOD contains multiple balancing and operating (control) areas in each Interconnection.

The PROMOD database for base-year and forecasted generation assets, fuel prices, and emissions allowance prices in all regions is maintained and updated by Navigant on a semiannual basis in spring and autumn, and demand forecasts are updated annually depending on release dates of demand forecasts. Navigant updates power flows and event files in PROMOD on a scheduled basis, using the most recently available FERC 715 power flows.

Generation updates
Navigant continually monitors and researches generation retirements, announced additions, and plant parameters using public databases and news services in order to maintain current information and to identify and correct for gaps and/or errors which may be imbedded in the vendor's "off-the-shelf" PROMOD database. Forecasts of future generation additions are developed in Navigant's Portfolio Optimization Model (POM) as part of our semi-annual Reference Case forecast updates. Forecasts of future generation additions for ERCOT are screened further using multiple iterations of PROMOD with a proprietary Return on Equity (ROE) analysis to confirm that new additions meet commercial and financial thresholds for new investment.

Emissions price updates
Mid-term regional prices for CO_2 are modeled and/or adopted from publicly available information on Regional Greenhouse Gas Initiatives (RGGIs) for New England, New York, and participating mid-Atlantic states, California (California Air Resources Board [CARB] rules pursuant to Assembly Bill [AB] 32), Ontario, Quebec, Manitoba, Alberta, and British Columbia. Long-term CO_2 emission prices for scenarios that include a Federal U.S. CO_2/GHG policy are modeled within POM (see below) as the shadow price on mandated CO_2 limits per the EPA's final Clean Power Plan. Navigant's reference cases assume the CPP is eliminated, but Navigant can prepare alternate cases on a consulting basis in which the CPP

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[15] ABB's PROMOD IV is commercial software that is widely used in the U.S. by utilities, consultants and ISOs for electricity market modeling.

withstands litigation and is implemented on the timeline laid out in the final rule, with interim targets starting in 2022. The rule leaves compliance regimes up to the states, indicating that there could be differences among states and/or regional trading of CO_2 credits. The final rule included model language to set up trading among states that adopt that model language, making it easier for states to coordinate on compliance. Modeling and discussions within the industry indicate that mass-based trading regimes are likely. Navigant currently assumes that there would be regional markets on the interconnection level, with the more stringent RGGI and CARB markets continuing under current rules without trading with the larger CPP CO_2 markets. Therefore, in 2022 and beyond we model the following carbon markets: RGGI, rest of EI, ERCOT, CARB, and rest of WECC. By using POM for this modeling, we ensure agreement among our supply and demand assumptions and our CO_2 emission price assumptions.

Prices for SO_2 and NO_x emissions are based recent and modeled allowance prices under the Cross State Air Pollution Rule (CSAPR).

Demand forecast updates

Navigant uses publicly available finalized planning reports from ISOs and RTOs and forecast data sets from ABB to update annual peak and energy demand forecasts. ISO/RTO data sets are drawn for ISO-NE, NYISO, PJM, IESO, and ERCOT, and are input to POM and our version of PROMOD annually in late winter or early spring. Demand forecasts for other regions are drawn from ABB releases and are based on that vendor's blend of FERC 714 data and ISO/RTO or NERC regional reports. We typically update Midwest ISO, SPP, CAISO and other non-market areas such as SERC, Florida Reliability Coordinating Council (FRCC), and the remainder of WECC during the latter half of the year.

Transmission updates

Due to the extensive research required for synchronizing FERC 715 power flows with other elements of PROMOD, updates are conducted on staggered basis. Updates for the Eastern Interconnection were conducted in winter-spring 2016 for ISO-NE and PJM and updates for MISO and NYISO were completed for Navigant's Summer 2017 Reference Case release. Updates for ERCOT and WECC were completed in Winter 2016/2017 and Summer 2015, respectively, using powerflow data sets obtained from the ERCOT and WECC websites. Our next update for WECC powerflows is scheduled to be included in our Winter 2017/18 Reference Case. These transmission representations include all known significant and likely transmission upgrades as planned by ISO/RTO and other balancing area planners through 2023-2025, the time horizons of the transmission expansion plans. Navigant uses PSS/E and PSLF for transmission analyses. These are transmission planning software licensed from Siemens PTI and GE, respectively. Both programs include power flow, optimal power flow, balanced and unbalanced fault analysis, dynamic simulations, extended term dynamic simulations, open access and pricing, transfer limit analysis, and network reduction. In addition, Siemens PTI's MUST is used to determine transmission transfer capability (FCITC, ATC, TTC) by simulating network conditions with equipment outages under different loading conditions.

POM

Navigant's proprietary POM is a capacity expansion model that emphasizes impacts of environmental policies and focuses on thermal and renewable generation, while being suitable for risk analysis. It is linked with Navigant's PROMOD input data set and incorporates the same generation base, demand forecasts, fuel prices, other operating costs, and plant parameters which are utilized in PROMOD. POM's algorithmic structure and solution methods are also compatible with Navigant's models for forecasting fuel prices, capacity market prices, and emissions prices. POM is a linear optimization program that dynamically solves for the multi-decade planning horizon simultaneously to simulate economic investment decisions and power plant dispatch on a zonal basis subject to capital costs, reserve margin planning requirements, renewable portfolio standards, fuel costs, fixed and variable O&M costs, emissions allowance costs, and zonal transmission interface limits. It includes a multi-regional representation of the North American electrical system with constraints on inter-zonal transmission and adopts a load duration curve representation to speed computational times. POM has every individual generating unit specified in PROMOD and allows for state-by-state reporting of generation data. Optionally POM can perform multivariate optimization, which considers other value propositions than just cost minimization, such as sustainability, technological innovation, or spurring economic development. This makes it especially suitable for modeling future renewable generation expansion. Navigant has frequently used POM in consulting engagements over the last several years.

Coal Retirement Model

Navigant's proprietary Coal Retirement Forecast model rapidly estimates the total coal-fired capacity in danger of retirement due to EPA regulations, determines which states require the greatest emissions reductions to be compliant with existing and/or proposed air pollution regulations,[16] and identifies the specific units and plants most at risk of retirement. The tool reviews the historical emissions of all existing coal units, the existing emissions equipment, and unit allocations for NO_x and SO_x emissions in order to determine which units are economic to retrofit with pollution control technology and which should be retired. The retirement or retrofit decision is based on the long-term financial viability of coal units and the cost of replacing them with other generating technologies. The Coal Retirement Forecast model summarizes the coal retirements and retrofits by state, ISO, and NERC region, and reports the retirements and retrofits as announced or economically driven. The tool will also estimate how far in or out of the money each unit is due to environmental requirements and market conditions, and the emissions equipment required to be compliant with EPA regulations.

PSS/E, PSLF, and MUST

PSS/E and PSLF are transmission planning software licensed from Siemens PTI and GE, respectively. Both programs include power flow, optimal power flow, balanced and unbalanced fault analysis, dynamic simulations, extended term dynamic simulations, open access and pricing, transfer limit analysis, and network reduction. Siemens PTI's MUST is used to determine transmission transfer capability (FCITC, ATC, TTC) by simulating network conditions with equipment outages under different loading conditions.

GPCM Gas Price and J.T. Boyd Coal Price Model

GPCM (formerly, the Gas Pipeline Competition Model) is a linear-programming model of the North American natural gas market that captures the complex interactions among gas producers, pipelines, storage facilities, gas marketers, and consumers.[17] Based on a pipeline specific model of the industry, GPCM contains more than 90 delivery points, 200 existing and proposed pipelines, 400 storage areas, 85 production areas, 15 LNG import/export terminals, and nearly 500 demand centers. Navigant applies its own analysis to provide macroeconomic outlook and natural gas supply and demand data for the model, including infrastructure additions and configurations, and its own supply and demand elasticity assumptions. Forecasts are based upon the breadth of Navigant's view, insight, and detailed knowledge of the U.S. and Canadian natural gas markets. Adjustments are made to the model to reflect accurate infrastructure operating capability as well as the rapidly changing market environment regarding economic growth rates, energy prices, gas production growth levels, sectoral demand and natural gas

[16] The Coal Retirement Forecast model was initially developed to represent likely coal retirements under MATS and was modified and expanded to incorporate the now-defunct Cross-State Air Pollution Rule (CSAPR).
[17] See http://www.rbac.com/ProductsServices/GPCMGasModel/tabid/80/Default.aspx for further detail.

pipeline, storage and LNG terminal system additions and expansions. GPCM is co-optimized with POM to develop equilibrium solutions for gas prices, gas use, gas-fired generation capacity (MW) and energy (megawatt-hour [MWh]) by POM/GPCM region. To capture current expectations for the gas market, this long-term monthly forecast is combined with near-term NYMEX average forward prices for the first two years of the forecast. Navigant has used GPCM in numerous engagements over the last six years including work for the LNG export sector, in which Navigant has developed a leading market position having supported six LNG export projects filing for permits to export LNG to non-Free Trade Agreement countries to the U.S. Department of Energy.

Navigant currently obtains the delivered coal price forecast from J.T. Boyd. Boyd provides forecasts of delivered coal prices and emissions inputs that are coded for direct use in POM and Navigant's version of PROMOD. Plant-specific inputs and projected costs are provided for the following factors: (i) forecasts of annual coal prices by coal supply region and coal type, (ii) revised coal commodity price forecasts using Navigant inputs on natural gas prices (Henry Hub basis) and coal-fired power plant retirements, (iii) coal selection by plant and unit, and (iv) coal transportation costs.

Capacity Market Price Model

Navigant's proprietary Capacity Price Forecast model estimates clearing prices in the PJM, ISO-NE, and NYISO capacity markets. It has also been adapted to model clearing prices in the new Midwest ISO capacity market and is being extended to fully model the new locational structure of the market. The model is tailored to the different market rules in each of these ISOs including resource eligibility, locational prices, and auction structure. It can be used to both forecast expected revenue from entering the capacity markets as well as for scenario analysis of uncertainties (both market parameters and regulatory) that may impact the revenue forecasts.

The model is fully consistent with the assumptions and outputs of Navigant's PROMOD/POM modeling. The basic structure is to determine the intersection of supply and demand for capacity in each locational subzone of the markets subject to import constraints from other subzones. The model estimates the capacity demand curve in each ISO following the ISO's administrative rules combined with a forecast of net CONE that uses PROMOD output. The capacity supply curve is estimated by calculating the "missing money" for each unit in the PROMOD database and setting the unit bid to the amount needed to be made whole. Imports from other regions and EE/DR resources are also considered.

A streamlined version of the model is also used by Navigant to forecast proxy capacity prices for non-market areas.

REC Price Model

Navigant prepares forecasts of REC prices using its REC Price Notional Estimator Tool (RECPET-notional©). Theoretically, the long-run price of a REC (i.e., at market equilibrium) represents the incremental revenue required by renewable resources to provide targeted returns over the life of the project. RECPET-notional© measures this as the differential between the weighted average levelized cost of renewable energy and the prevailing price of power. Navigant will model a proxy renewable resource (e.g., wind farm or typical state renewable resource) at increments of five years to extrapolate a REC price curve, which reflects both the underlying wholesale power forecast as well as project declining (or increasing) cost to construct the renewable resource as well as higher costs of capital. REC prices would be applicable only in those areas that have state-mandated Renewable Portfolio Standards (RPS). Currently there are twenty-nine states, Washington D.C. and three territories with an RPS.

<u>**CERTIFICATION**</u>

I hereby certify that on April 5, 2019, I sent a copy of the within to all parties set forth on the attached Service List by electronic mail and copies to Luly Massaro, Commission Clerk, by electronic mail and by hand delivery.

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