Potential Employment Impact from Offshore Wind in the United Stated - The Mid-Atlantic and New England Region

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Executive Summary

This study conducts economic analysis to quantify the potential cumulative regional employment impacts from offshore wind development in the Mid-Atlantic and New England areas, as well as specific employment impacts relating to the Vineyard Wind project. The regional analysis considers multiple scenarios for each state. The scenarios vary in terms of potential offshore wind deployment as well as assumptions about the local workforce and manufacturing content in the supply chain. Using an "input-output" model widely utilized by the offshore wind industry, our analysis finds that 2.06 - 3.17 local job-years per MW (as opposed to permanent jobs) could be created during the construction phase in the region, and 0.18 - 0.26 permanent jobs per MW could be created during the operations and maintenance phase. Our overall results are broadly consistent with the American Wind Energy Association (AWEA) study. However, we generate a much lower number of permanent jobs per unit of capacity during operations and maintenance. This suggests that there may not be significant local employment impacts from offshore wind development in the long-run.

Specific to Vineyard Wind, we estimate 3.92 – 5.71 job-years per MW during construction, while the Vineyard Wind estimate is higher, at 4.30 – 6.16 job-years per MW. During operations and maintenance, we estimate between 0.42 – 0.53 permanent jobs per MW, while the Vineyard Wind estimate is 0.6 – 1.09 permanent jobs per MW. Our results using an alternative "employment factor" model are lower still, with 2.32 job-years per MW during construction and 0.16 permanent jobs per MW during operations & maintenance.

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I. Introduction

Various states over the last few years have proposed offshore wind energy legislation as a future investment in their renewable energy portfolio. At the same time, the Europe-style "green jobs" agenda is being promoted in the U.S. as part of these renewable energy investments.

A variety of official bodies and politicians have been very active in issuing press releases claiming that the investments in offshore wind projects will create hundreds, thousands or millions of green jobs in a wide range of economic sectors, in addition to reducing emissions of carbon dioxide. For example, a recent study by AWEA [1] estimated that developing 30 GW of offshore wind could support up to 83,000 "jobs" by 2030. In addition, an economic impact study for the Vineyard Wind offshore wind facilities in Massachusetts estimated that the construction of 1,600 MW of offshore wind power would generate 3,171 direct employees, 3,618 indirect employees, and 3,063 induced employees [2].

Our first question is: Are these high-quality and long-term jobs that will create the incentive for workforce planning and coordination? Wind energy projects create more jobs during early phases of projects. Unlike traditional power plants, wind farms are built quickly, usually in a year or less, and many construction, installation and manufacturing positions are short term. Until recently, European offshore wind turbine manufacturers led the industry worldwide in terms of technology, market share and quality of turbine [3]. Meanwhile, in the U.S. there are limited locations with adequate components networks for the offshore wind industry. Hundreds of millions of dollars are being spent on foreign-made wind turbines [4,5].

Furthermore, large European vessels will play a significant role in the initial installation of wind turbines off U.S. coastlines, as many foreign companies own lift vessels capable of undertaking much of the heavy work involved in the installation of offshore wind turbines. Wind power developers promise jobs to local Americans, and instead they may be incentivized simply to hire outside skilled workers, and only create a few permanent jobs. The absence of a strong domestic sourcing requirement for offshore wind development limits the positive employment impact in practice, and a significant portion of marginal expenditures is thus actually satisfied by imports, which do not add to GDP.

The second question is: When we look at the big picture, is there any convincing evidence that the wind energy policies being implemented will actually lead to positive net employment? To

put it another way, is the offshore wind industry outperforming other manufacturing industries to the extent it will generate additional employment and stimulate the economy?

Some independent studies, based on the actual experiences gained in Europe and the U.S. with wind energy production, cast serious doubt on the claim that wind-generated electricity results in net job creation, and have shown that the reality is far from what has typically been presented. In fact, many of the jobs created are only supported by the tax incentives for wind projects and lead to a loss in non-tax supported jobs in other sectors.

Denmark, the world's leading wind energy country, is being seen as the good example of job creation. This does not, however, take into account the net employment effect of the governmental wind plant subsidy. The Danish Center for Political Studies released a study [6] of Denmark's wind industry concluding that, "creating additional employment in one sector through subsidies will detract labor from other sectors, resulting in no increase in net employment, but only a shift from the non-subsidized sectors to the subsidized sector." The data shows that, in terms of value added per employee, the wind energy technology sector underperformed by as much as 13% compared with the industrial average. As a consequence, Danish GDP was approximately $270 million lower than it would have been if the wind sector work force was employed elsewhere.

Furthermore, a study based on Spain's experience with wind energy production, concluded that for every new position that depends on energy tax subsidies, at least 2.2 jobs in other industries are eliminated [7]. Spain paid $775,000 for every green job the country created through subsidies since 2000 ($100,000 per year per job). Is that a good use of limited taxpayer funds? Similarly, the Thanet project in England, currently the largest operating offshore wind farm in the world, also received criticism for its lack of significant British job creation [8, 9].

While there is scant empirical data from the U.S. on this point, an independent report conducted by Investigating Reporting Workshop [10] indicated that approximately $2 billion in 2008 federal "stimulus" funds in the U.S. were spent on the onshore wind energy program. However, approximately 80 percent of that amount went to foreign owned companies. In addition, in spite of the massive taxpayer subsidization, the U.S. wind manufacturing sector lost jobs in 2009 because many of the created construction jobs are short term and filled by skilled workers who are brought into the U.S. temporarily. We are currently creating foreign jobs at the expense of American jobs.

II. Objective

The Mid-Atlantic and New England region is home to some of the largest ports and logistics infrastructure in the United States that have the potential to support the offshore wind supply chain. The Bureau of Ocean Energy Management (BOEM) has leased 16 sites in New England and the Mid-Atlantic for offshore wind energy facilities. Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Virginia have established targets to procure a total of 27,812 MW of offshore wind by 2035 [11]. The main purpose of this paper is to analyze the expected economic impacts of these projects mainly in terms of job creation. Following this introduction, this paper will present the most commonly used methods and apply the methods to measure the magnitude of gross employment impacts. Next, the paper will discuss the basic economic principles and mechanisms by which net employment effect is measured. Finally, discussions and conclusions are made to address the issues highlighted in this analysis.

III. Job Definition

Job creation studies utilize various metrics for quantifying the magnitude of job creation and disaggregate jobs into different categories and classifications. The impacts of job creation are dependent on how you define a job. A global overview of the job effects of wind-power installations found that the result differs widely by job category [12]. For renewable energy projects, in order to be precise about the employment results, it is important to distinguish between permanent and temporary jobs and whether only direct employment effects are accounted for or whether indirect or induced employment effects are also taken into account.

It is also important to note whether or not the figures being quoted refer to jobs or "job years." The unit of a job-year refers to one year in a job and has become widely used when analyzing job projections for future projects. Particular care should be taken in distinguishing between jobs and job-years. The effect can be to give the impression of a larger number of permanent jobs being created than is the actual case. For example, the AWEA [1] projects 83,000 FTE (full time equivalent) jobs will be created, associated with meeting its goal of 30 GW of offshore wind production by 2030. Although most jobs are projected to be generated from construction, installation and manufacturing which are calculated as "job-years," the 83,000 number tends to be cited instead as "jobs" in the policy arena to support significant public expenditures on renewables.

IV. Methodological Approaches to Employment Quantification

The offshore wind sector includes job profiles from many different economic sectors, such as equipment manufacturing, electricity generation, consulting services, engineering services, finance and insurance, etc. [13] . There are diverse methodologies for the calculation of job creation. The main categories are employment factor approach, input-output (I/O) analysis, and computable general equilibrium (CGE) model. The first two approaches focus on the gross employment relevance of the particular energy sector, and therefore emphasize the positive side of investing in renewables. The last approach involves complicated built-in economic interrelations, which fully takes into account crowding-out effects and potential negative job effects that may occur in alternative employment sectors. It is impossible to comment in any significant way on which model is better, but we can at least notice that there are several ways to look at this question, and that these models produce differing results.

1. Employment factor approach

The easiest and quickest method of assessing direct jobs from offshore wind is the employment factor approach. Employment factors indicate the number of jobs created per megawatt (MW) [3]. Jobs are measured and reported as full-time equivalents (FTEs). One FTE is equivalent to one full-time worker who is employed for one year, and one FTE is thus often equated with a "job year". FTEs generated in the construction phase are job-years, while FTEs generated in the operations phase are permanent jobs. The factors are calculated based on aggregated data on the different phases of the project life cycle, such as manufacturing, construction, installation (MCI), and operations and maintenance (O&M). FTE jobs in the offshore wind sector are estimated by multiplying a project's installed capacity by specified employment factors.

Different employment factors of the same phase of the life cycle relate to regional considerations. If manufacturing takes place in highly industrialized countries or in less developed countries, the labor intensity of the life cycle stage will be influenced. Generally, the lower the cost of labor in a region, the greater the number of workers that will be employed to produce a unit of output. For example, the U.S. has higher labor cost and is assigned lower job creation per unit of generation.

Furthermore, employment factors are adjusted to take account of the reduction in employment per unit of capacity as technologies and production techniques mature. Offshore wind technologies are still in an early stage of development, and therefore reduction in technology

costs and economies of scale are expected to occur in the future, resulting in lower employment factors. The annual decline ratio in job factor was estimated to be 1.5% from 2020 to 2030 in offshore wind industry [14].

Aldieri et al. [12] provided a global overview of number of created jobs per MW of the most widely referenced studies for job growth in the wind industry between 2001 and 2019. The review revealed that, on average, 9.16 jobs will be created per MW during construction, and, on average, 0.29 jobs will be created per MW during O&M. Although there are substantial regional variations, the number of jobs per unit of capacity is considerably lower for O&M than for MCI. O&M generates employment over the lifetime of the projects, while MCI may provide employment for several months to a few years only. O&M employment factors are applied to the total installed capacity, whereas MCI employment factors only refer to newly added capacities. The study concluded that potential for job creation in wind-power installation is comparatively somewhat limited.

For the United States, much of the wind energy infrastructure manufacturing is expected to occur abroad. Accordingly, the application of employment factors must take into account the proportion of manufacturing which occurs locally. For instance, an economic impact study [15] concluded that the abandoned Cape Wind project would have generated 1,000 short-term local jobs during construction and 50 long-term local positions at the Cape Cod-based headquarters to operate and maintain the wind farm.

An Atlantic new energy study [16] found that every megawatt of wind energy capacity installed would create 2.32 job-years in the Mid-Atlantic region during the construction phase, and would create 0.16 permanent jobs in the region during the O&M phase. These include all direct, indirect and induced jobs/job-years. If we apply these percentages to job projections for the mid-Atlantic and New England region for the scenario at 2030, approximately 64,622 job-years would be generated through manufacturing, component supply, wind farm development, construction, transportation, and other services with the planned 27.8 GW of offshore wind deployment, and only 4,335 long-term jobs would be needed for operations and maintenance work at the wind farms, once constructed. If we apply these employment factors for the Vineyard Wind project for the 2030 scenario, approximately 3,712 job-years would be generated during the construction phase with the 1.6 GW of offshore wind capacity, and only 256 long-term jobs would be generated during the O&M phase. Although this extrapolation is subject to differences between time and job categories, the bottom line is that the projection figures could establish a barometer for the employment potential of the targeted offshore wind projects and a benchmark for analysis.

2. Input-output Approach

The offshore wind industry interacts with and has an impact on other economic sectors. The relationship between the different economic sectors can be calculated by using an input-output (I/O) model. Input-output (I/O) analysis provides detailed information on the flows of intermediary goods and services among the sectors of the economy and allows analysts to examine detailed representations of a region's industrial structure. As a result, it is possible to trace how changes in one or more sectors of an economy affects other sectors in the region. The analysis offers an analytical framework for employment creation from wind energy deployment.

This paper uses the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) model to project the employment impacts to the Mid-Atlantic and New England region that can reasonably be supported by offshore wind development through 2025 and 2030. The JEDI model has been broadly utilized in economic modeling, including by AWEA and the Commonwealth of Massachusetts.

More specifically, the JEDI model is a spreadsheet-based tool that applies state-level input - output (I/O) multipliers and consumption patterns based on various databases and similar studies that have been conducted in the U.S. and internationally. Economic multipliers are numeric parameters that indicate the total change in economic activity due to a one-unit direct change and they are derived from state data files. Employment impacts are estimated at the state level to trace the distribution of impacts within the state and local economy and help to inform new policy development to ensure that states and localities are capturing the impacts they desire. The primary economic question addressed here is what are the employment impacts of continued offshore wind deployment in the region.

2.1. Model Inputs

Model assessments of employment creation are necessarily based on various assumptions. Currently, few specifics are known about the development parameters for individual projects because project details are still mostly either unknown or undisclosed. To obtain the best regional assumptions for this report, this report provides four potential offshore wind deployment scenarios in different states of the region. The scenarios vary in terms of assumptions and estimates throughout the different phases that are based on information from an extensive literature review. The other regional and technical parameters are mainly from the "2018 Offshore Wind Technologies Market Report" [17] and NREL's 2019 ATB [18] to conform with

the most recent industry and market developments. When the site-specific information is not available, we use the default values of a reference project that are representative of a general offshore wind project based on real-world projects and historical economic data in the region.

2.1.1. Market and Deployment

There are approximately 28 GW of offshore wind projects that are currently proposed in the mid-Atlantic and New England regions under varying economic schemes [11]. It is not clear how much of the forecasted growth in the region would be met due to financial, technical and regulatory issues. Based on the information of the development timelines for each project, this analysis assumes that the total capacity will reach approximately 13 GW in 2025 and 28 GW in 2030.

2.1.2. Capital Costs

Capital costs are determined by many factors including demand for turbines, maturity of industry, availability of skilled laborers, raw material and commodity prices, fluctuations in exchange rates, etc. Given the limited number of offshore wind projects in the United States and the lack of publicly available data, we used a baseline capital cost from NREL's recent 2018 Cost of Wind Energy Review [19]. Data reported there suggests a representative turbine cost of approximately $1,301/kW with a total installed capital cost of $4,444/kW. Estimates of reported capital cost are converted to 2020 dollars. For each state, adjustments to the baseline were made to account for local differences.

According to the NREL's report [20], capital costs are adjusted to take account of the reduction in costs per unit of capacity, year over year, due to technological advancements, economies of scale, and other factors, such as improvement in manufacturing and deployment efficiency. These estimates establish upper and lower bounds for cost reduction in the studied region. Under the low-growth scenario, a cost reduction of 3.5% every 5 years was applied to the baseline. Under the high-growth scenario, average capital cost of offshore wind is assumed to decrease by 11.2% every 5 years.

2.1.3 Supply Chain Investment

Construction

From an economic point of view probably the most important employment impact of offshore wind development is related to "where": where companies create employment, both direct and indirect in their supply chain, and where they pay taxes. Sourcing components locally can significantly reduce transportation costs and times, while increasing the employment impacts to the local economy. For the purposes of this study, we give assumptions on the portions of expenditures on each item of labor, material, and equipment that are sourced locally. The higher the regional share percentage in a specific item, the more money is being circulated into the regional economy, thereby supporting more regional jobs.

- Turbine supply

Investments in turbine manufacturing and port facilities are expected to bring new jobs to areas where these investments are made. However, nearly 75% of the capital costs spending in the U.S. is for equipment purchased from other countries [22]. Most of the world's major turbine manufacturers are currently based in Europe and China [21]. Manufacturing requires skilled laborers who design and build the components of the wind turbines and towers. Europe accounts for 88% of the global offshore wind installed capacity. Most U.S. offshore developments are importing components or have their sights set on importing turbines and major components from foreign companies [14]. Although additional growth in the local wind energy market could bring turbine manufacturing facilities and additional component suppliers to the region, a stable market has not been created in which to manufacture and sell turbines [13]. Based on these facts, this analysis assumes that in the low-growth scenario, the development of the regional supply chain is minimal and all turbine equipment will likely be sourced from other countries. In the high-growth scenario, manufacturing is expected to grow in the region with new investment in new facilities, and the share of manufacturing expenditures is assumed to be 10% by 2030. The assumptions used in this study are in line with those used in the Massachusetts workforce assessment [2], which were cited in the Vineyard Wind project Impact Statement [23]. As the report indicated, "our economic impact estimates assume that none of the primary components will be sourced in Massachusetts during the first 1,600 MW buildout in the Low scenario and only a small amount of secondary foundation parts will be locally sourced in the High scenario. Capital expenditures that are more likely to be spent in Massachusetts include cables, substations, and labor installation costs related to foundations, substructures, tower erection, grid interconnection, and development services (e.g., engineering, legal, public relations, ports and

staging, marine transportation, etc.).” Appendix A summarizes our regional investment assumptions for the regional scenarios.

- Materials and other equipment

Materials for pilings, moorings and anchoring systems are already produced locally throughout the U.S. Appendix A assumes these materials will be 100% sourced locally. More specialized equipment, like foundations and offshore substations, are likely to come from overseas as that is where most of the expertise is for offshore wind plants, and the local contribution share is expected to vary over time.

- Construction and Installation Labor

According to the Massachusetts workforce assessment, “Large installation vessels will be brought over from Europe for the foreseeable future since they are costly to build and the U.S. pipeline has not developed sufficiently to warrant the construction of a U.S. flagged vessel. While the recent 83C bids indicated that the developers are looking to support the construction of a U.S. flagged vessel, it remains far from certain if and when this will occur.” [2] However, there is still early phase construction work can be done by local contractors, including secondary steel manufacturing, logistics support, heavy equipment supply, and ports and staging grounds, etc. With the development of the projects, more construction and installation companies would presumably relocate to the region or expand their facilities to accommodate the offshore wind industry. However, the local share of construction workers is still low. The supervisory roles will likely be filled by overseas experts during only the early stage of the development, but then evolve. We assume 90 percent local content of management and supervision for the low-growth scenario and 95 percent local content for the high-growth scenario.

- Development services

Many services, like engineering, legal services, and permitting employees are widely available in the region and are all drawn from the local and regional labor market.

Operation & Maintenance

The review of actual experience shows that routine O&M and minor repairs will primarily be provided from the servicing port and surrounding area. This is particularly true for the offshore wind plant technicians, logistical support workers, engineers, and site managers. Monitoring is often done from a central location for all of the turbines and is managed by a few people. However, some maintenance work is filled by subcontractors brought in for short periods. Some

spare parts like corrective maintenance parts are primarily related to the nacelle and drivetrain and need skilled maintenance technicians brought in from outside the region. See Appendix A for more details.

2.2. Estimated job creation

Investments in offshore wind activities will create jobs in component manufacturing, turbine installation, facility operation and maintenance, and induced jobs are created through additional consumer spending from direct and indirect job earnings. The I/O model reports the number of jobs under the low-growth and the high-growth scenario for two phases: Construction and O&M.

2.2.1. Construction Period

***Direct jobs*:** Much of the work involved in creating an offshore wind farm goes into manufacturing the components, which include rotor blades, structural towers, hubs, transmissions, generators and assorted electronic controls. Construction workers assemble turbines, erect towers, build roads, and lay cable. Following the local contents assumptions, in the low-growth scenario, the offshore wind industry in New England and Mid-Atlantic would support 4,390 job-years during the MCI period by 2025, and 8,169 job-years through 2030. All projected jobs in this study refer to domestic jobs and do not include any foreign jobs. In the high-growth scenario, 6,260 job-years would be created in the MCI of offshore wind turbine by 2025, increasing to 12,595 job-years by 2030.

Indirect jobs: Many turbine components are imported but supply chain support is seeing investment in turbine component manufacture. Indirect jobs measure the secondary impacts set into motion by the materials and services demanded in building and installing the equipment. For example, workers at a manufacturing plant need raw materials and equipment, contractors at a construction site need concrete and heavy equipment, and their work supports additional jobs supplying these needs which include development and planning, engineering, financing, instalment, operation and management, etc. In the low-growth scenario, we estimated 11,989 indirect job-years would be created along the offshore wind supply chain in supporting areas by 2025, and 26,377 job-years by 2030. Indirect jobs in the high scenario are estimated at 18,259 job-years by 2025, and 43,621 job-years by 2030.

Induced jobs: In addition to these direct and indirect jobs, workers spend part of their income in the local economy, purchasing goods and services like groceries and housing, causing another

round of spending in the form of new demands for goods and services produced by regional firms. Under the low-growth scenario, 9,043 local revenue and supply chain job-years are estimated by 2025, and 21,443 job-years by 2030. Under the high-growth scenario, 12,071 induced job-years are estimated by 2025, and 29,922 job-years by 2030.

The sum of all three types of jobs provides an estimate of the total employment impact on the local economy. See **Tables 1-2**.

Table 1. Estimated Numbers of Jobs Supported by Construction - Low Growth Scenario

State	2025					2030				
	Capacity (MW)	Direct (Job-Years)	Indirect (Job-Years)	Induced (Job-Years)	Total (Job-Years)	Capacity (MW)	Direct (Job-Years)	Indirect (Job-Years)	Induced (Job-Years)	Total (Job-Years)
Connecticut	1,000	370	989	763	2,121	2,000	643	1,796	1,436	3,875
Maine	6	159	338	163	660	12	161	344	167	673
Maryland	600	290	685	359	1,334	1,200	453	1,156	597	2,205
Massachusetts	1,600	613	1,502	1,175	3,290	3,200	1,026	2,872	2,372	6,271
New Jersey	3,000	879	2,648	2,523	6,050	7,000	1,902	6,744	7,054	15,700
New York	4,000	1,196	3,312	2,220	6,728	9,000	2,424	8,628	6,081	17,133
Rhode Island	200	197	453	233	883	400	256	628	317	1,202
Virginia	2,500	687	2,061	1,608	4,356	5,000	1,303	4,209	3,419	8,931
Total	**12,906**	**4,390**	**11,989**	**9,043**	**25,422**	**27,812**	**8,169**	**26,377**	**21,443**	**55,989**

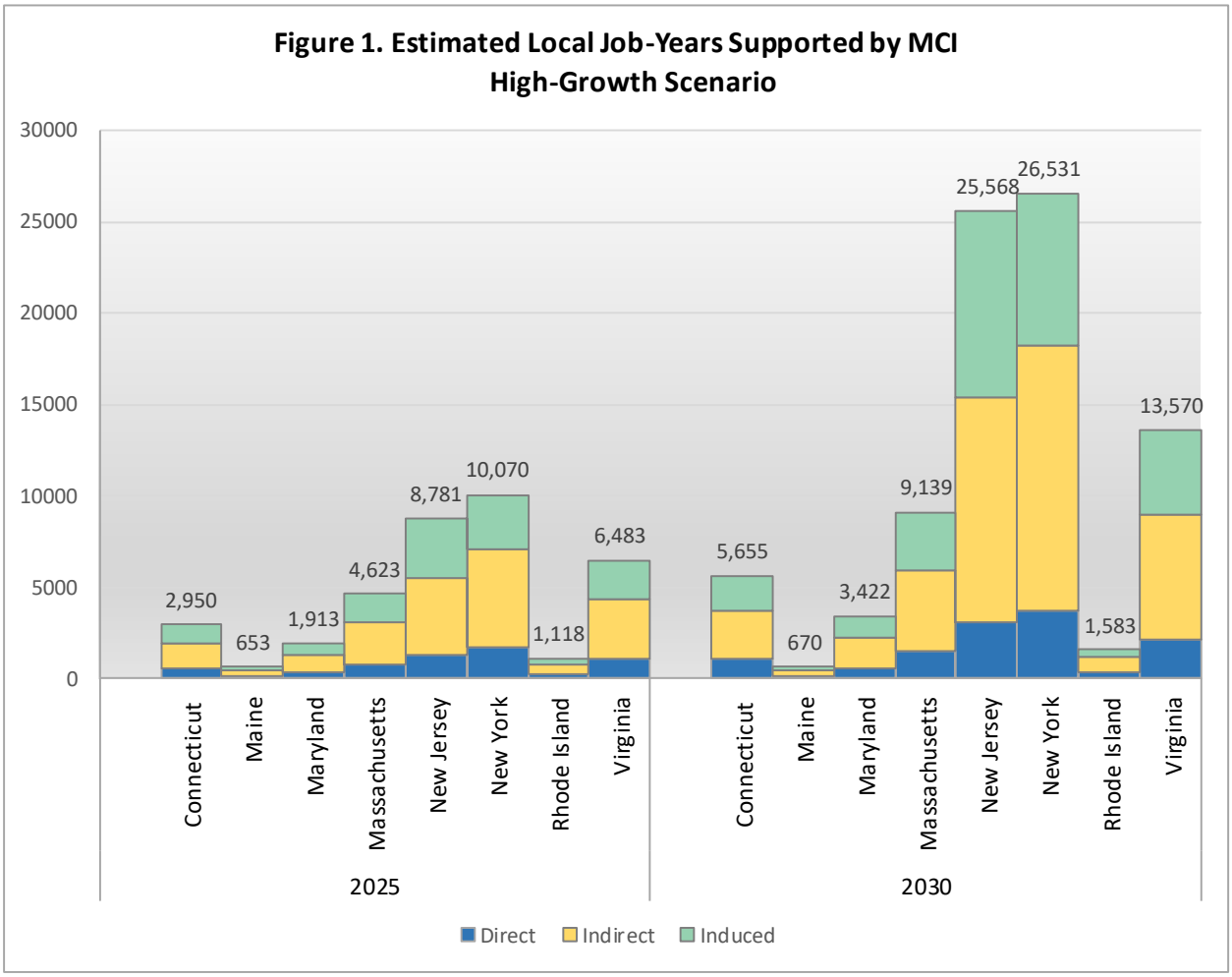
Table 2. Estimated Numbers of Jobs Supported by Construction - High Growth Scenario

State	2025					2030				
	Capacity (MW)	Direct (Job-Years)	Indirect (Job-Years)	Induced (Job-Years)	Total (Job-Years)	Capacity (MW)	Direct (Job-Years)	Indirect (Job-Years)	Induced (Job-Years)	Total (Job-Years)
Connecticut	1,000	534	1,430	986	2,950	2,000	1,050	2,715	1,890	5,655
Maine	6	172	312	169	653	12	175	322	174	670
Maryland	600	373	916	624	1,913	1,200	609	1,664	1,150	3,422
Massachusetts	1,600	825	2,244	1,553	4,623	3,200	1,503	4,459	3,178	9,139
New Jersey	3,000	1,316	4,184	3,281	8,781	7,000	3,102	12,290	10,176	25,568
New York	4,000	1,727	5,336	3,007	10,070	9,000	3,703	14,515	8,313	26,531
Rhode Island	200	250	576	292	1,118	400	339	834	411	1,583
Virginia	2,500	1,064	3,261	2,158	6,483	5,000	2,115	6,823	4,631	13,570
Total	**12,906**	**6,260**	**18,259**	**12,071**	**36,591**	**27,812**	**12,595**	**43,621**	**29,922**	**86,138**

The analysis suggests that the offshore wind industry would support a total of 55,989 - 86,138 job-years during construction from 2020 to 2030. Every megawatt of offshore wind capacity installed is estimated to support 3.17 year-long manufacturing jobs under the high-growth scenario (and 2.06 job-years under the low-growth scenario). The high-growth estimate is consistent with the 3.19 job-years found by the Renewable Energy Policy Project [24].

Offshore wind industry is claimed to support a large amount of jobs during early phases of projects. High-skilled workers play a significant role during the construction of the wind plant, including welders, electricians, crane operators, steel workers, pile drivers, painters, longshoremen, machine operators, etc. However, most high-skilled workers in the U.S. projects will be imported from developed countries and thereby limit the positive impacts in the U.S. Most job-years supported during the constructing phase are actually in supply chain and induced impacts (See **Figure 1**). In the high-growth scenario, direct manufacturing jobs will only account

for 15 percent of the total job-years, while indirect and induced jobs will account for 51 percent and 34 percent of the total job-years, respectively. The strong growth in the offshore segment does not fully translate into more domestic jobs.



2.2.2. Operations and Maintenance Period

Offshore wind farms need staff to operate and regularly service the turbines throughout the lifetime of the power plant, which is typically around 30 years. These needs create long-term, full-time employment. In other words, jobs supported during this phase are typically more permanent opportunities. In the low-growth scenario, operating and maintenance needs would support approximately 2,484 onsite permanent jobs in the local economy by 2025, and 5,003 permanent jobs by 2030. In the high-growth scenario, commissioned offshore wind projects will support 3,533 jobs by 2025, and 6,994 jobs by 2030 respectively. The model outputs for jobs supported during the O&M period are given in **Tables**

3-4. Every megawatt of offshore wind capacity is estimated to support 0.25 permanent jobs during O&M under the high-growth scenario. The finding is in line with the literature on O&M job creation [12].

Table 3. Estimated Numbers of Jobs Supported by O&M - Low Growth Scenario

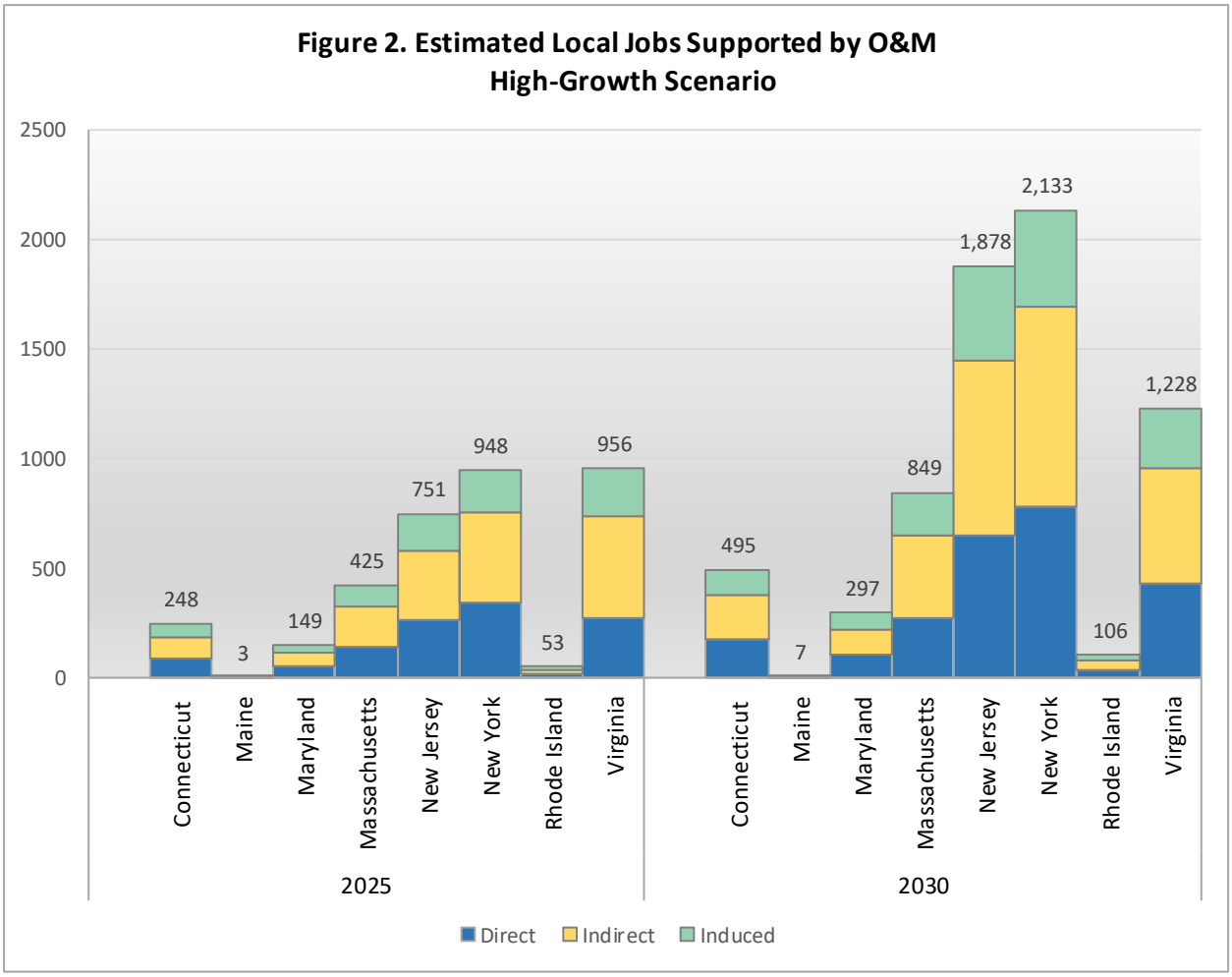
State	2025					2030				
	Capacity (MW)	Direct (Jobs)	Indirect (Jobs)	Induced (Jobs)	Total (Jobs)	Capacity (MW)	Direct (Jobs)	Indirect (Jobs)	Induced (Jobs)	Total (Jobs)
Connecticut	1,000	56	91	46	192	2,000	111	181	92	384
Maine	6	1	2	1	4	12	1	4	1	6
Maryland	600	33	58	24	115	1,200	67	115	47	229
Massachusetts	1,600	89	166	77	332	3,200	178	333	154	665
New Jersey	3,000	167	283	135	585	7,000	389	661	316	1,366
New York	4,000	222	362	152	736	9,000	500	816	341	1,656
Rhode Island	200	11	22	9	42	400	22	43	18	83
Virginia	2,500	139	233	106	478	5,000	218	261	134	614
Total	**12,906**	**717**	**1,217**	**550**	**2,484**	**27,812**	**1,485**	**2,415**	**1,104**	**5,003**

Table 4. Estimated Numbers of Jobs Supported by O&M - High Growth Scenario

State	2025					2030				
	Capacity (MW)	Direct (Jobs)	Indirect (Jobs)	Induced (Jobs)	Total (Jobs)	Capacity (MW)	Direct (Jobs)	Indirect (Jobs)	Induced (Jobs)	Total (Jobs)
Connecticut	1,000	87	102	59	248	2,000	175	203	118	495
Maine	6	1	2	1	3	12	1	4	2	7
Maryland	600	52	61	35	149	1,200	105	122	71	297
Massachusetts	1,600	140	187	98	425	3,200	280	374	195	849
New Jersey	3,000	262	320	170	751	7,000	655	799	424	1,878
New York	4,000	349	406	193	948	9,000	786	913	435	2,133
Rhode Island	200	17	24	11	53	400	35	49	23	106
Virginia	2,500	278	466	213	956	5,000	437	522	268	1,228
Total	**12,906**	**1,187**	**1,567**	**779**	**3,533**	**27,812**	**2,473**	**2,986**	**1,535**	**6,994**

Similarly to the construction phase, most of the jobs supported are expected to be indirect and induced jobs, while the relative percentage of direct onsite jobs is somewhat higher than the construction phase. See **Figure 2**. The O&M phase is much less labor-intensive than the construction phase. Our results indicate that the ratio of temporary construction jobs to permanent O&M jobs is very high, which is about 12:1 under the high scenario. In order to be precise about the employment results, it is important to distinguish between short-term and long-term employment effects, and it is not appropriate to measure MCI employment effect on a total jobs basis.

According to the economic principles, temporary employment has a negative impact on productivity growth and does not benefit long-term technological change for the local economy. Due to the limited permanent jobs, there may not be meaningful local employment impacts from the offshore wind projects in the long-run.



2.3 Comparison of Results of AWEA report, BOEM draft and this Study

The AWEA report [1] used the NREL's I/O model to estimate the potential employment impact of offshore wind development off the East Coast of the United Stated through 2030. Our study estimates the employment impact using the same I/O model and the Employment Factor method, respectively.

The estimates in **Tables 5-6** compare the domestic job-years during the construction phase and jobs during the O&M phase produced by the AWEA's report and our study. The I/O results indicate that our study generates higher job-years per MW during construction. According to the Bureau of Labor Statistics, approximately 60 percent of jobs in the wind power industry are indirect and induced jobs, which include port and staging, logistics, transportation, part-related services, developers and development services, contracting and engineering services, etc.[13]. In our analysis, we assumed these materials and services are nearly 100% sourced locally because

they are widely available in the region based on the publicly available information of the state supporting infrastructure availability. However, much of the information underlying the specific offshore wind projects is confidential and cannot be peer reviewed. If the AWEA analysis used lower local content assumptions for these materials and serveries based on its more direct knowledge of project parameters that we don't have, it is likely that the AWEA's model would produce more conservative results in terms of construction jobs than our analysis.

Meanwhile, we generate much lower jobs per MW during O&M. As O&M jobs may last throughout the lifetime of the wind plant and are more likely to be filled by local workers, O&M jobs represent the greatest potential for long-term local employment.

Further, our estimates of job-years/jobs from the Employment Factor analysis are more conservative than our I/O estimates. As was mentioned in the Employment Factor section, the employment factors used in this study were derived from a national survey of companies involved in the manufacturing of wind turbines [24]. Surveys are a relatively straightforward method and have the advantage of creating a high degree of accuracy because the data comes from people with inside knowledge of the project. This suggests the true effect of permanent employment resulting from offshore wind development was overestimated in the AWEA's report.

Table 5. Local Job-Years During Construction for Mid-Atlantic and New England by 2030

	Job Type	AWEA (O/I)		This Study (O/I)		This Study (Employment Factor)
		Low Scenario	High Scenario	Low Scenario	High Scenario	
Construction	Direct	3,583	8,367	8,169	12,595	N/A
	Indirect	14,548	29,186	26,377	43,621	N/A
	Induced	10,517	21,377	21,443	29,922	N/A
	Total Job-Years	**28,648**	**58,930**	**55,989**	**86,138**	**64,524**
	Job-Years/MW	**0.95**	**1.96**	**2.06**	**3.17**	**2.32**

Table 6. Local Jobs During O&M for for Mid-Atlantic and New England by 2030

	Job Type	AWEA (O/I)		This Study (O/I)		This Study (Employment Factor)
		Low Scenario	High Scenario	Low Scenario	High Scenario	
Operations & Maintenance	Direct	2,869	4,304	1,458	2,473	N/A
	Indirect	8,282	10,565	2,415	2,986	N/A
	Induced	5,638	8,713	1,104	1,531	N/A
	Total Jobs	**16,834**	**23,582**	**5,003**	**6,994**	**4,450**
	Jobs/MW	**0.56**	**0.79**	**0.18**	**0.26**	**0.16**

The project-specific Environmental Impact Statement [23], which was developed by the Bureau of Ocean Energy Management (BOEM) to assess the potential environment and economic impacts from the construction of 1,600 MW of offshore wind power off Martha's Vineyard, Massachusetts, does not contain sufficient analysis regarding cumulative jobs creation. The employment estimates in the Statement were sourced from the analysis in a Massachusetts workforce assessment [2], which was also generated from the NREL's I/O model.

Our study used the same approach to recreate the employment estimates. Due to the uncertainly in the portion of labor that will be sourced domestically, and the availability of US-flag vessels that can perform the required tasks, our analysis of these projects used the similar local content assumptions in the Massachusetts workforce assessment in which there are no strong requirements to build and hire domestically. **Tables 7-8** display the comparisons of the results. Our estimates of both construction job-years and O&M jobs from the I/O model are lower than the BOEM's estimates. The Employment factor analysis found even fewer job-years/jobs that will be realized.

Table 7. Local Job-Years During Construction for Massachusetts by 2030

	Job Type	BOEM (O/I)		This Study (O/I)		This Study (Employment Factor)
		Low Scenario	High Scenario	Low Scenario	High Scenario	
Construction	Direct	2,279	3,171	1,026	1,503	N/A
	Indirect	2,315	3,618	2,872	4,459	N/A
	Induced	2,284	3,063	2,372	3,178	N/A
	Total Job-Years	**6,878**	**9,852**	**6,271**	**9,139**	**3,712**
	Job-Years/MW	**4.30**	**6.16**	**3.92**	**5.71**	**2.32**

Table 8. Local Jobs During O&M for Massachusetts by 2030

	Job Type	BOEM (O/I)		This Study (O/I)		This Study (Employment Factor)
		Low Scenario	High Scenario	Low Scenario	High Scenario	
Operations & Maintenance	Direct	140	256	178	280	N/A
	Indirect	581	1,053	333	374	N/A
	Induced	242	439	154	195	N/A
	Total Jobs	**964**	**1,748**	**665**	**849**	**256**
	Jobs/MW	**0.60**	**1.09**	**0.42**	**0.53**	**0.16**

V. Limitations of the Study and Future Research

Job creation is an important issue for policy-makers since employment is a key factor for the economy. The positive effects on the environment and job stimulation in the wind industry were often stressed as 'win-win' solutions in the public debate. There is a common belief that through increased aggregate demand, employment is likely to be stimulated. However, it is not a sound principle for environmental regulations from an economist's perspective. Employment is determined by the supply of labor in the long run, and supply-side hurdles can be related to the high capital, operating, and financing costs of offshore wind projects.

Although the NERL's JEDI model is very adaptable and commonly used in many studies, it has some limits as do those for job assertions. JEDI results are not intended to be a precise forecast; the estimates are based on approximations of the relationship between an industry expenditure and its associated economic output [25]. In addition, JEDI captures employment impacts in a long supply chain and a wide range of indirect and induced impacts. Estimated employment impacts will likely be high due to the larger economy from which to draw for project-level resources, as well as the larger multipliers that reflect slower rates of economic leakage from the local economy as a whole. Importantly, the input-output analysis only accounts for gross employment impacts that result from new investment in offshore wind plants and does not consider implications to the broader economy in terms of displacement of alternative generation sources, impacts to electricity rates, or impacts from incentive schemes that may support offshore wind development. The question of whether the deployment of offshore wind energy is beneficial from an economy-wide perspective should be assessed within a framework that captures the economy-wide employment effects in terms of net employment. In particular, economy-wide price, income and substitution effects are taken into account. These may affect the consumption of households or the production of intermediate products and services, as well as the competitiveness of entire industries, which arises due to altered energy prices. Net employment may be negative depending on which repercussions are taken into account.

According to the available evidence in Italy on green jobs [26], the same amount of capital that creates one job in the wind sector would create 6.9 or 4.8 jobs if invested in other industries or the economy in general, respectively. The key reason for this is that the cost of electricity produced by wind is higher than the conventional sources, which tends to drive the electricity-intensive companies and industries away and leads to businesses cutting back. It is no surprise, therefore, that green investments would generate fewer jobs than investments in other industrial sectors of the economy.

As mentioned in the Introduction section, the Danish wind industry is often cited as a success story for the U.S. to replicate in quick pursuit of "green jobs". However, in Denmark the dead weight loss from offshore wind energy taxation is estimated at around 20% [27]. These taxes were designed to support the development of renewable energy, but the tax distortion increased the costs of tax financed public projects by at least 20%, which was a pure loss to society. Furthermore, the Denmark offshore wind industry is a strong export industry. It seems unlikely the U.S. would be able to replicate the large share of exports of wind turbine technology, based on its existing capacity and larger overall economy. The Danish experience also suggests that the strong U.S. offshore wind growth likely would not benefit the overall economy. It would entail substantial costs to the industry and taxpayer, and only to a lesser degree benefit a small part of the economy, namely wind turbine owners, wind shareholders and those employed in the sector.

Further research on employment impacts is particularly required to take into account economy-wide price, income and substitution effects. Comprehensive economic models (e.g. computable equilibrium models) can be used to capture all employment impacts including those which occur beyond the offshore wind industry and portray the economy-wide employment effects in terms of net employment for the region. Adopting a longer-term view to assessment will allow for these impacts to be captured, and for a refined understanding of the net employment impacts associated with U.S. offshore wind development.

VI. Conclusion

Although offshore wind projects have a potentially beneficial role to play as part of U.S. energy portfolio, a careful investigation of the employment impact shows a surprisingly low number of positions at the more permanent level of actual operation and maintenance of the offshore wind electricity. In addition, the bulk of the jobs will be created overseas rather than here at home, and total domestic employment in manufacturing and construction is small when compared with employment in the manufacture of conventional equipment for power generation. There are no sound economic arguments to support an assertion that offshore wind investments will increase the total level of employment in the longer run when we hold macroeconomic conditions constant. The claim that the huge investments on offshore wind would provide significant job and economic benefits in the U.S. has been grossly inflated.

References

1. American Wind Energy Association (AWEA). “U.S. Offshore Wind Power Economic Impact Assessment”. 2020.

2. Vigeant, P., Donovan, A., et al. “2018 Massachusetts Offshore Wind Workforce Assessment”. Massachusetts Clean Energy Center. 2018.

3. The International Renewable Energy Agency (IRENA). “Offshore wind investment, policies and job creation - Review of key findings for G7 ministerial meetings”. Canada. 2018.

4. Karl, J. “New Wind Farms in the U.S. Do Not Bring Jobs”. ABC News. 2010.

5. Herrnstadt, O. “Green jobs, with strings attached”. Economic Policy Institute. 2009.

6. Danish Center for Political Studies (CEPOS). 2009.

7. Calzada, G. “Study of the effects on employment of public aid to renewable energy sources,” Universidad Rey Juan Carlos, March 2009

8. MacAlister, Terry. "British firms miss out as world's biggest offshore windfarm opens off UK coast". The Guardian. London. 23 September 2010.

9. Black, R. "UK 'needs domestic wind energy industry'". BBC News. 27 September 2010.

10. Choma, R. “Most Wind Grants Go To Overseas Firms.” Investigative Reporting Workshop of the American University School of Communication, February 8, 2010. Available at https://iberdrolawatch.org/2013/05/01/most-wind-grants-go-to-overseas-firms/

11. AWEA. “U.S. Offshore Wind Industry STATUS UPDATE”. June 2020.

12. Aldieri, L., Grafström J., et al. “Wind Power and Job Creation”. Sustainability. 2020.

13. Hamilton, J. and Liming, D. “Careers in Wind Energy”. Bureau of Labor Statistics. 2010.

14. Rutovitz, J., Atherton, A. “Energy Sector Jobs to 2030: A Global Analysis”. Institute for Sustainable Futures. 2009.

15. Todd J., Chen, J. et al. “Analysis of the Offshore Wind Energy Industry”. International Economic Development Council. 2013.

16. Algoso, D., Rusch, E. “Job Growth from Renewable Energy Development in the Mid-Atlantic”. NJPIRG Law and Policy Center. 2014.

17. Musial, W., Beiter P., et al. “2018 Offshore Wind Technologies Market Report”. National Renewable Energy Laboratory. 2018.

18. National Renewable Energy Laboratory (NREL). Annual Technology Baseline. 2019

19. Stehly, T., and Beiter, P. “2018 Cost of Wind Energy Review”. National Renewable Energy Laboratory. 2018.

20. Tegen, S., Keyser, D., at al. “Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios.” National Renewable Energy Laboratory. 2015.

21. European Wind Energy Association (EWEA). Wind at Work-Wind energy and job creation in the EU. 2009.

22. Richard C. “Vestas leads the pack with squeezed market share”. Wind Power. 2020.

23. U.S. Department of the Interior, Bureau of Ocean Energy Management. “Vineyard Wind Offshore Wind Energy Project Draft Environmental Impact Statement”. 2018.

24. Renewable Energy Policy Project (REPP). “Renewable Portfolio Standard (RPS) Map”. 2004.

25. National Renewable Energy Laboratory. “Limitations of JEDI Models.” Accessed July 2020: http://www.nrel.gov/analysis/jedi/limitations.html.

26. Leoni., B. “Are Green Jobs Real Jobs? The Case of Italy” Luciano Lavecchia Carlo Stagnaro. 2010.

27. Center for Politiske Studier. “Wind Energy. The Case of Denmark”. 2009.

Appendix A: Local Content Sourcing Assumptions for Offershore Wind Project

Project Costs	Low Growth Scenario	High Growth Scenario
	(%)	(%)
Construction Costs		
Turbine Equipment		
Nacelle/Drivetrain	0%	10%
Blades	0%	10%
Towers	0%	10%
Ground Transportation (to project staging area/port)	0%	10%
Warranty Cost	0%	10%
Materials and Other Equipment		
Piling, anchors, mooring	100%	100%
Foundation (including anchors or alternatives for fixed bottom t	5%	10%
Substructure	5%	10%
Project Collection System	0%	10%
HV Cable (project site to point of grid interconnection)	0%	10%
Onshore substation (formerly converter station)	5%	10%
Offshore substation (formerly substation)	5%	10%
Labor Installation		
Foundation	5%	15%
Substructure	5%	15%
Erection/Installation	5%	15%
Project Collection	5%	15%
Grid Interconnection (including substation)	5%	15%
Management/Supervision	90%	95%
Insurance During Construction		
CAR/Third Party liability/business interuption, etc.	0%	0%
Development Services/Other		
Engineering	80%	100%
Legal Services	100%	100%
Public Relations	100%	100%
Ports and Staging	100%	100%
Site Certificate/Permitting	100%	100%
Air Transportation (personnel or materials)	100%	100%
Marine Transportation (personnel or materials)	100%	100%
Erection/Installation (equipment services)	10%	50%
Decomissioning Bonding	0%	0%
Construction Financing (AFUDC)		
Interest During Construction	0%	0%
Due Diligence Costs	0%	15%
Reserve Accounts (MRA/DSRA)	0%	0%
Bank Fees	0%	0%
Construction Financing Total		
Other Miscellaneous	0%	0%
Sales Tax (Material and Equipment Purchases)	100%	100%
Annual Operating and Maintenance Costs		
Operational Costs		
Labor		
Technician Salaries	95%	100%
Monitoring & Daily Operation Staff and Other Craft Labor	95%	100%
Administrative	95%	100%
Management/Supervision	0%	100%
Materials and Services		
Water Transport	95%	100%
Site Facilities	95%	100%
Machinery and Equipment	95%	100%
Subcontractors	95%	100%
Corrective Maintenance Parts	0%	0%

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