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Floating Offshore Wind in Oregon: Potential for Jobs and Economic Impacts in Oregon Coastal Counties from Two Future Scenarios

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National Renewable Energy Laboratory

BUREAU OF OCEAN ENERGY MANAGEMENT

This report is available from the Bureau of Ocean Energy Management by referencing OCS Study BOEM 2016-031. The report may be downloaded from BOEM's Recently Completed Environmental Studies - Pacific webpage at http://www.boem.gov/Pacific-Completed-Studies/.

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Strategic Partnership Project Report
NREL/TP-5000-65432
July 2016

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Prepared under Task No. WFHA.1000

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NOTICE

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Executive Summary

Construction of the first offshore wind power plant in the United States began in 2015, off the coast of Rhode Island, using fixed platform structures that are appropriate for shallow seafloors, like those located off of the East Coast and mid-Atlantic. However, floating platforms, which have yet to be deployed commercially, will likely need to anchor to the deeper seafloor if deployed off of the West Coast. Five megawatt-scale floating platform demonstration projects have been deployed around the world.[1]

To better understand the employment and potential economic impacts of large-scale deployment of floating offshore wind technology, the Bureau of Ocean Energy Management (BOEM) commissioned the National Renewable Energy Laboratory (NREL) to conduct this economic impact analysis of large-scale floating offshore wind deployment in Oregon. This analysis examined the impacts to the seven Oregon coastal counties: Clatsop, Tillamook, Lincoln, Lane, Douglas, Coos, and Curry. A map of the counties is shown in Figure ES-1. A separate analysis examined the impacts to the entire state of Oregon. Those results are described in *Floating Offshore Wind in Oregon: Potential for Jobs and Economic Impacts from Two Future Scenarios* (Jimenez et al. 2016a).

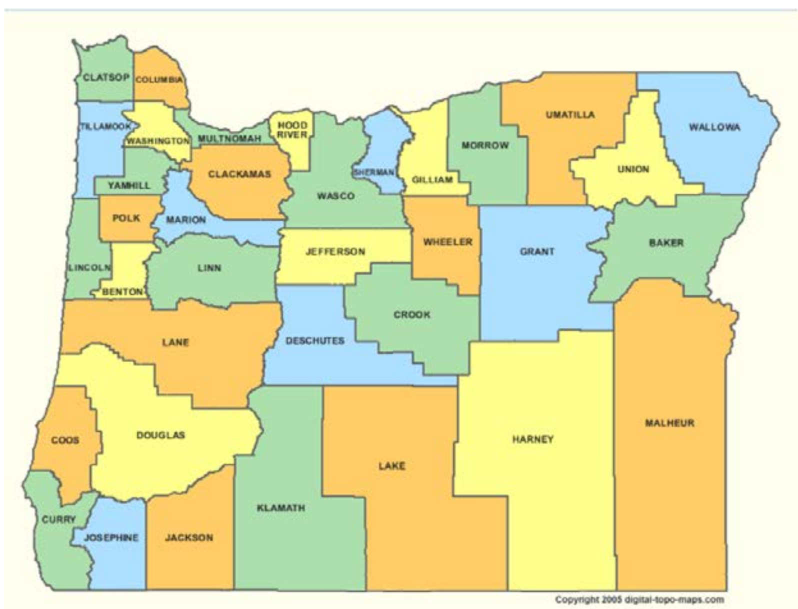

Figure ES-1. Oregon county map

Source: http://www.digital-topo-maps.com/county-map/oregon.shtml

We examined two deployment scenarios in the 2020–2050 period: Scenario A assumes 5,500 megawatts (MW) of offshore wind deployment in Oregon by 2050, and Scenario B assumes 2,900 MW. These levels of deployment could power approximately 1,600,000 homes (Scenario A) or 870,000 homes (Scenario B).

[1] There are four floating platform offshore wind projects that have been installed to date with two more under construction. However none of these projects are generating power at commercial scale. See Appendix A.

Assumptions for this analysis come from projected electricity demand in the Northwest, the estimated offshore wind resource, and discussions with industry, as well as ongoing work at NREL to better characterize the current and future cost breakdowns of floating offshore wind systems. Many of the cost inputs come from NREL's internal Offshore Wind Balance of System (BOS) model. It should be noted that both of these scenarios are hypothetical and are not intended to be forecasts of actual deployment. Figure ES-2 shows the hypothetical deployment scenarios beginning with small-scale demonstration projects in 2020.

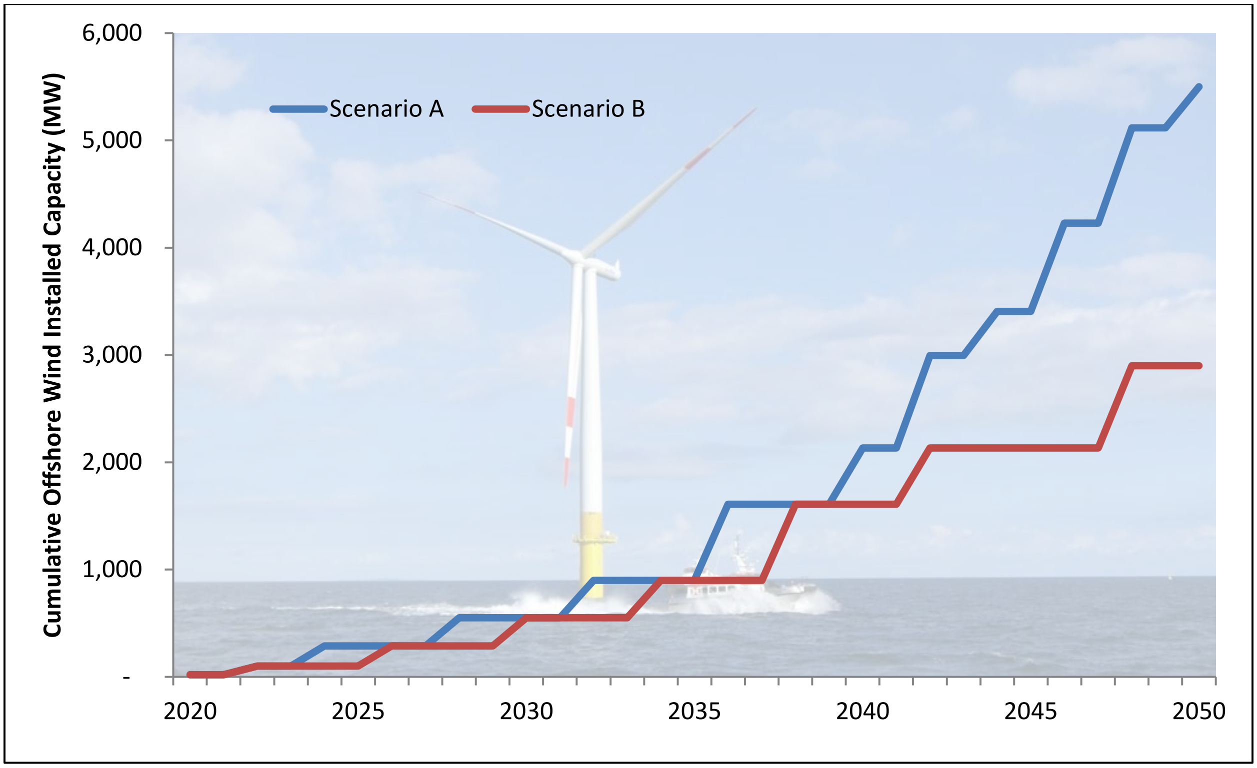

Figure ES-2. Two Oregon offshore wind deployment scenarios modeled between 2020 and 2050

Photo: Siemens Turbine, Baltic Sea, NREL/PIX 26995

The impacts highlighted here can be used in county, state, and regional planning discussions and can be scaled to get a general sense of the economic development opportunities associated with other deployment scenarios. In addition, the analysis can be used to inform stakeholders in other states about the potential economic impacts of this scale of floating offshore wind technology development.[2]

For each of the two scenarios, we examined two sets of values for the local content, defined as locally sourced materials, equipment, labor and services. The two set of local content values are labeled in Figure ES-3 as "High LC" and "Low LC" respectively. Examining higher and lower local content values showed that the estimated economic impacts will vary depending upon the proportion of locally sourced parts, equipment, and labor. According to the analysis, under

[2] NREL has performed similar research analyzing the impact of floating offshore wind deployment for Oregon (state), California, and Hawaii.

Scenario A, deploying 5,500 MW of floating offshore wind in Oregon (showing lower to higher local content assumptions) could:

- Add a total of $1.6 billion–$2.8 billion[3] to the gross domestic product (GDP) of the coastal counties from 2020–2050, in construction-phase activities.[4]
- Support 18,000–33,000 full-time equivalent (FTE)[5] construction-phase job-years between 2020 and 2050 (Figure ES-3).[6] A job-year is one full time job for one year. For example, 1 person working full time for 10 years, or 5 people working full time for 2 years each total 10 job-years. See Figure ES-3.
- Support 14,000–26,000 operations-phase job-years during the analysis period (2020–2050). See Figure ES-4 for annual jobs estimates.
- Support 1,600–3,000 long-term jobs in Oregon coastal counties after the analysis period. These jobs last as long as the offshore wind system is operating.[7]
- Add a total of $1.6 billion–$2.7 billion in GDP to coastal counties from the operations-phase during the analysis period, and $210 million—$320 million annually after the end of the analysis period.

Figure ES-3 shows the year-by-year construction-phase jobs impacts associated with each local content case. “High LC” represents the high in-state content, and “Low LC” represents low in-state content assumptions. Spikes in construction-phase jobs correspond to installation activity. For reporting and charting purposes, total construction impacts are shown in one year; in reality, construction may take two or more years. The total number of jobs reported in the single year is the same as if it were spread out over multiple years. For example, 5,000 jobs in one year would translate to 2,500 jobs for two years. Figure ES-4 shows the ongoing jobs due to operations and maintenance (O&M) phase activities. Unlike construction-phase jobs, which are short term, these jobs will last for the lifetime of the facility. The total number of operations-phase jobs starts out small, but increases over time as the number of installed offshore wind turbines increases.

One key finding from this work is the sensitivity of the results to the magnitude of the supply chain within the analysis area (in this case the seven coastal counties). The existence of even a modest supply chain within the analysis area dramatically increases the economic impact of offshore wind deployment. Due to the rural nature of the Oregon coastal counties, a significant

[3] All costs are presented in 2014 dollars.

[4] Gross domestic product (GDP) is the sum of: the value of production (i.e., the amount of revenue beyond expenditures paid to other industries), payments to workers, payments to investors, and net tax payments. This is labeled “value added” in the Jobs and Economic Development Impacts (JEDI) models, but is referred to as GDP throughout this report.

[5] An FTE job is considered one person working full time for one year or the equivalent (e.g., 2 people working full time for 6 months each).

[6] The JEDI model reports construction jobs as lasting for one year, whereas in reality, it takes multiple years to construct a wind farm.

[7] Wind energy projects are assumed to last 20-30 years. There are many uncertainties with the new floating offshore wind technology, but in this analysis, the projects installed last through 2050 – through the end of the analysis period. The analysis does not assume repowering of the turbines, which would provide additional economic impacts.

supply chain may not be established within these counties. It is more likely most of the in-state supply chain will be located outside of the coastal counties.

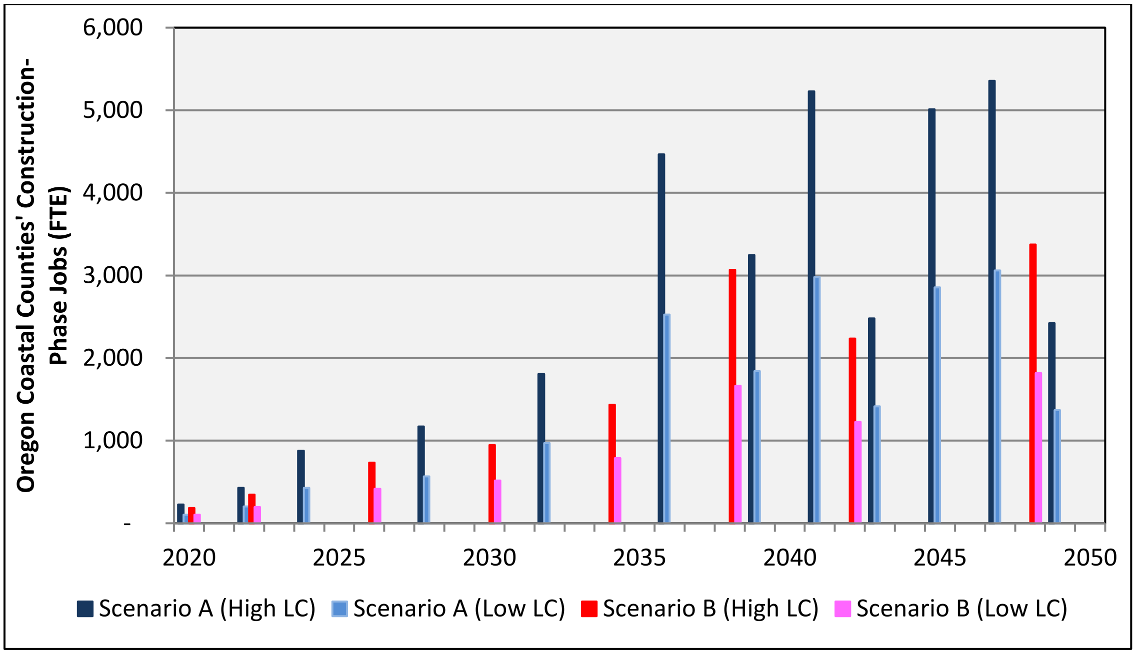

Figure ES-3. Annual Oregon coastal counties' construction-phase jobs supported in Scenario A and Scenario B, showing both high and low local content (LC)

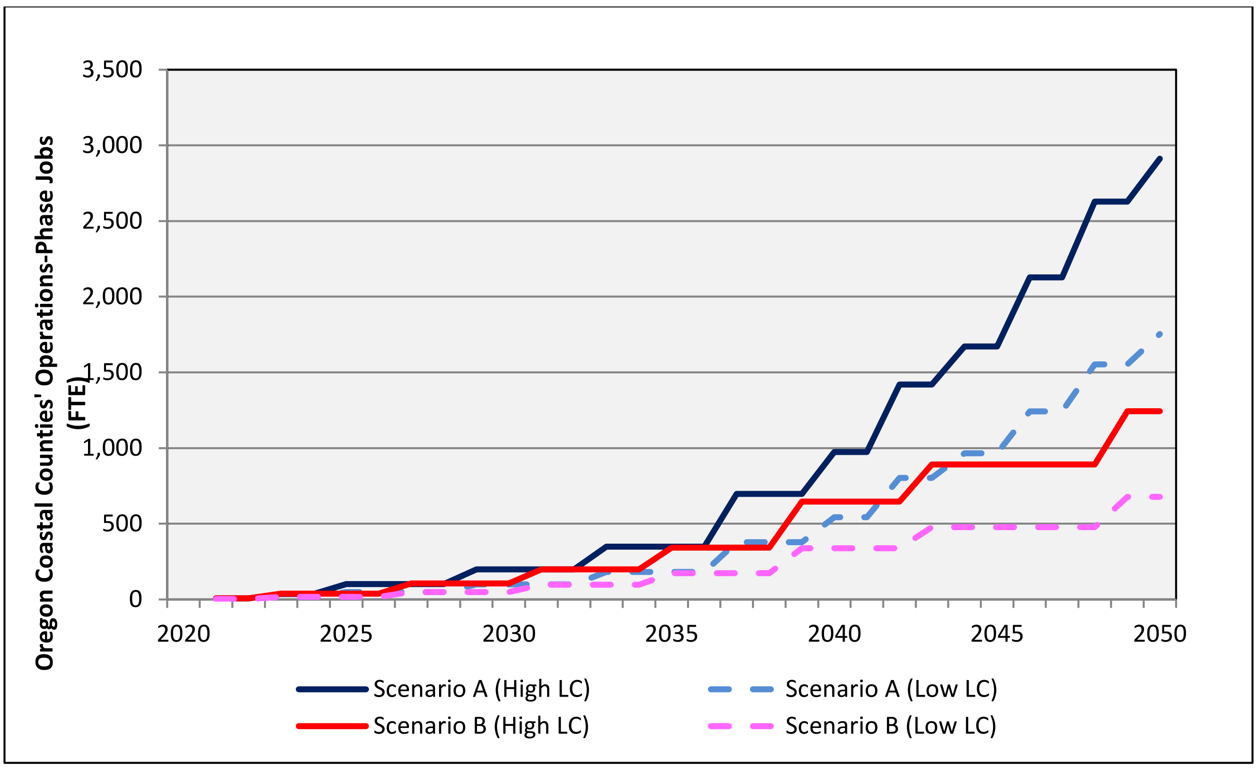

Figure ES-4. Oregon coastal counties' operations-phase jobs (FTE) supported by offshore wind during the analysis period showing ranges from low to high local content (LC)

Table of Contents

Figures and Tables

1 Introduction

Oregon has the technical wind energy resource potential to power approximately 60 gigawatts (GW) off of its coast (Musial and Heimiller, forthcoming).[8] Figure 1-1 shows Oregon's offshore wind resource at a height of 100 meters. The estimate of potential energy production is based on estimates of the potential wind resource and current and projected turbine technologies—not an approximation of what actually will be built. The raw estimate does not factor in important siting restrictions or other potential conflicting uses for the offshore space, such as shipping lanes and environmentally sensitive areas.

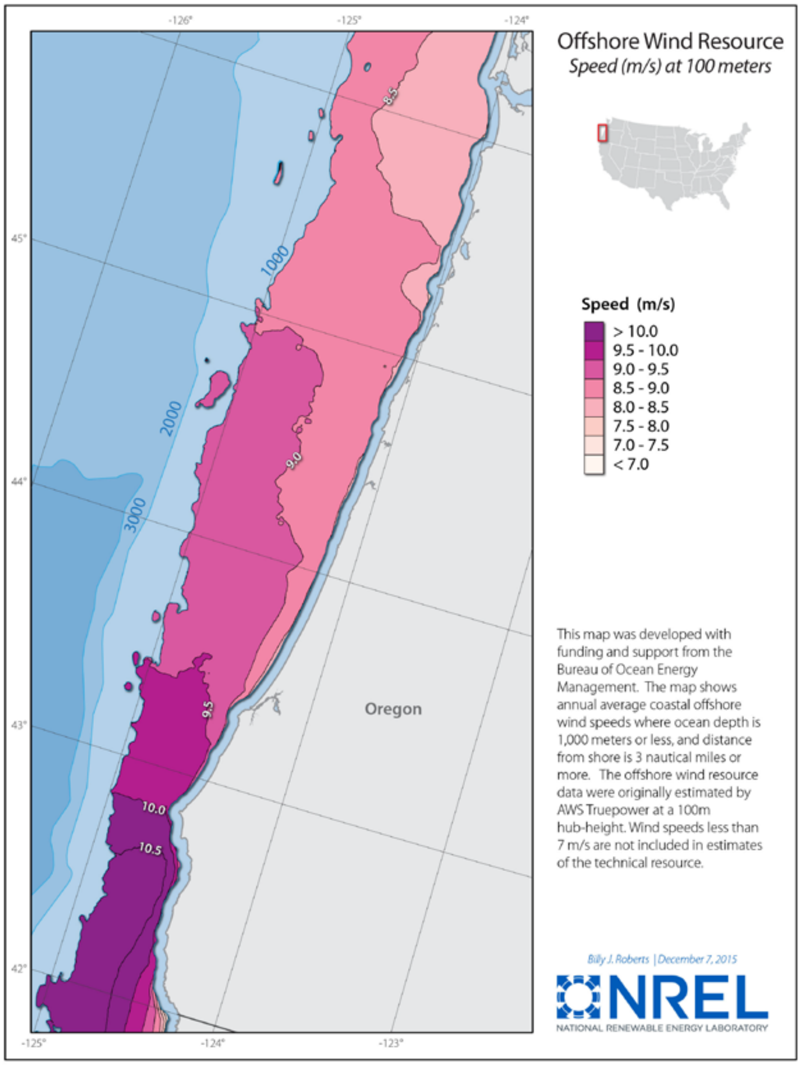

Figure 1-1. Oregon offshore wind resource

Source: NREL

[8] We list technical potential, which is based strictly on resource—not on policy, permitting, or other important considerations. Realistically, not all of this resource will be developed. The technical resource estimate excludes water depth greater than 1,000 meters, wind speeds below 7 meters per second, and conflicting uses (e.g., marine sanctuaries). See Musial and Heimiller, forthcoming.

To better understand the potential economic impacts of large-scale deployment of floating offshore wind technology, the Bureau of Ocean Energy Management (BOEM) commissioned the National Renewable Energy Laboratory (NREL) to conduct this economic impact analysis of large-scale floating offshore wind deployment in the coastal county region of Oregon. The analysis examined two deployment scenarios in the 2020–2050 timeframe: a higher deployment scenario totaling 5.5 GW and a lower deployment scenario at 2.9 GW. It should be noted that both scenarios are hypothetical and are not intended to be forecasts of actual deployment.

The results highlighted in this report can be used in county and regional planning discussions and can be scaled to understand the magnitude of the economic development opportunities associated with various offshore wind deployment scenarios. In addition, the analysis can be used to inform stakeholders in other states about the potential economic impacts of this scale of floating offshore wind technology development. Assumptions for this analysis were developed based on interviews with the offshore wind industry and Oregon offshore development and renewable energy experts, and ongoing work at NREL to characterize the current and future cost breakdowns of floating offshore wind farms. Many of the cost inputs come from NREL's Offshore Wind BOS model. This work builds on similar analyses of the economic potential of offshore wind development on the coasts of California and Hawaii, as well as an analysis of the potential for the state of Oregon (Speer et al. 2016; Jimenez et al. 2016b; Jimenez et al. 2016a).

The potential offshore wind capacity and generation scenarios in this report are based on analysis of the wind resource off the coast of Oregon and the best-fit offshore wind technologies given water depths, wind conditions, and other factors. These estimates are not an approximation of the number of wind projects that will actually be built, nor do they factor in important considerations such as siting restrictions, permitting issues, or environmentally protected or sensitive areas.

In 2016, the Oregon State Legislature passed Senate Bill 1547, titled "Elimination of Coal from Electricity Supply," which revised the state's renewable energy target to 50% by 2040. It also requires that utilities no longer purchase coal starting in 2035. Offshore wind is one renewable energy resource option that could help Oregonians meet their renewable energy target by 2040.

Due to the significant depth of the ocean floor off the coast of Oregon, it is not feasible to use proven fixed-bottom offshore wind platform technologies at most sites. Offshore wind technologies for deep water are still in the development stages and fixed bottom offshore wind structures only work in waters that are less than 60 meters deep. Based on recent studies, fixed bottom offshore wind structures are less economical than floating systems in waters deeper than 60 meters. Compared to Europe, Oregon has a much smaller area of shallow seafloor. While no commercial[9] floating wind farms currently exist, multi-megawatt-scale demonstration projects have been deployed in several countries with generally good success. Figure 1-2 illustrates three generic floating platform technology classes. Of the three floating platform technologies, only spar buoys and semi-submersible platforms have been deployed in the existing demonstration projects; tension-leg platforms have not yet been deployed. Additional information about offshore wind technologies can be found in the Department of Energy's (DOE's) *Offshore Wind*

[9] Several floating offshore wind turbines have been installed to date; however, none of these projects has been deployed at the commercial scale. See Appendix.

Market Report (Smith 2015). The Appendix lists floating offshore wind projects that have been installed or are under construction as of June 2016.

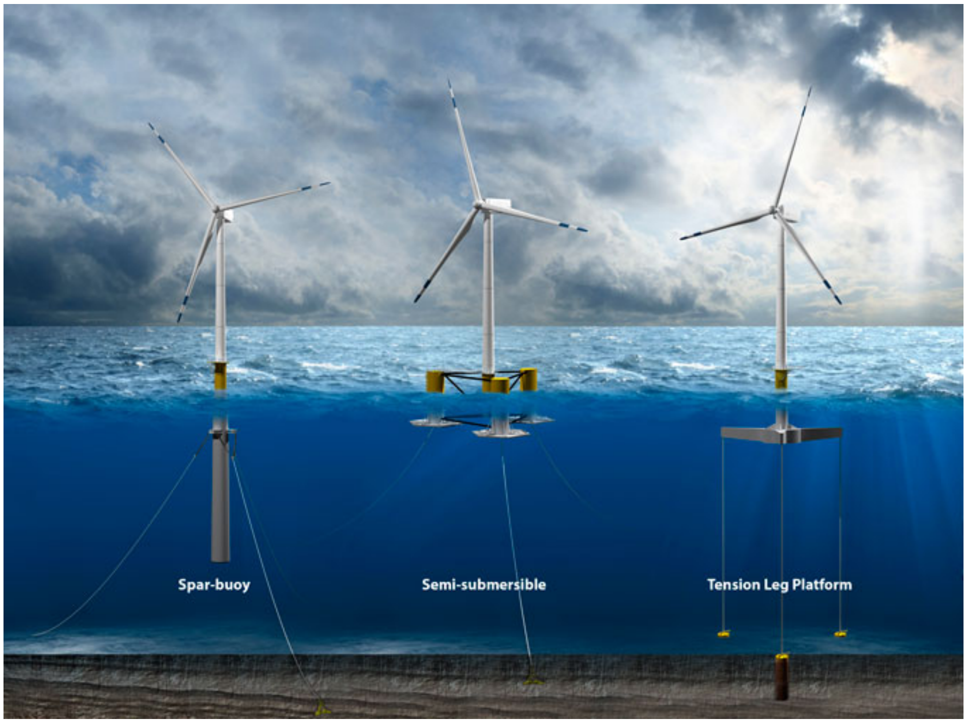

Figure 1-2. Illustration of types of offshore wind turbine platforms

Source: Illustration by Joshua Bauer, NREL

The analysis in this report is similar to the analysis described in *Floating Offshore Wind in Oregon: Potential for Jobs and Economic Impacts from Two Future Scenarios* (Jimenez et al. 2016a), which examined the economic impact from floating offshore wind turbine development on the economy of Oregon as a whole. This report uses the same deployment scenarios, but narrows the focus to examine the effects on Oregon's coastal counties only, rather than for the entire state. The seven coastal counties (from north to south) are Clatsop, Tillamook, Lincoln, Lane, Douglas, Coos, and Curry. Figure ES-1 shows a map of the counties.

Both scenarios indicate that offshore wind could be an important contributor to economic development in Oregon coastal counties, in the near- and long-term, with more significant development occurring in later years. Similarly, substantial local sourcing of materials and labor could greatly increase the gross economic impact of offshore wind energy deployment in the region. This report explains the assumptions and methods used to estimate the potential jobs and gross economic impacts that could result from the two scenarios.

2 Methodology

Gross economic impacts presented in this study were generated using NREL's Offshore Wind Jobs and Economic Development Impact (JEDI) model. JEDI models are commonly used to estimate gross economic impacts from the development and O&M of energy projects (Billman and Keyser 2013; Tegen et al. 2015).

Input-output (I-O) models such as JEDI characterize an economy in terms of inputs purchased and outputs produced by sectors. Sectors include businesses, governments, households, investors, and the rest of the world (through imports and exports). Businesses are modeled as making a set of expenditures for inputs (such as business-to-business services, raw materials, utilities, etc.) and selling an output. All inputs are outputs of another sector. For example, if a generator manufacturer purchases copper wire, this wire is an input to the generator manufacturer and an output from the copper wire manufacturer.

By accounting for all inputs and all outputs within a region, I-O models estimate economic impacts that are supported by expenditures that extend beyond the initial expenditure. For example, if a consumer goes to the grocery store and buys a domestically grown apple, this purchase not only supports a portion of the jobs at the local grocery store, but also jobs within the grocery distribution system, at the orchard where the apple was grown, and throughout the apple grower's supply chain.

Although JEDI models typically contain default data from actual installations, in the case of emerging technologies such as floating platform offshore wind, default data must come from other sources. The version of the Offshore Wind JEDI model used in this analysis contains an integrated version of the NREL BOS model for offshore wind.[10]

Several assumptions in JEDI should be considered when analyzing results:

- JEDI results are gross, not net. This distinction means that impacts not immediately related or associated with the construction and operation of offshore wind facilities are not considered. The impacts that JEDI does not consider include alternate or displaced investments, such as what will occur if, for example, a natural gas power plant is built instead of an offshore wind facility.
- JEDI implicitly assumes fixed prices within any given year. This means that goods and services will always be available and can be purchased at the same price regardless of the quantity purchased.
- JEDI assumes producers continue to use the same sets of inputs in the same proportions and that consumers purchase the same sets of goods and services, also in the same proportions.[11]

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[10] Balance of systems costs include non-hardware costs for wind turbine operation, such as site assessment and permitting.

[11] JEDI models utilize economic multipliers derived from IMPLAN to calculate project impacts. The multipliers are based on industry spending patterns and inter-industry linkages for a particular year, location, and a specific economy (i.e., state, county or region). The JEDI Offshore Wind model utilized in this analysis incorporates industry and consumer spending patterns based on 2012 economic data. IMPLAN, the "IMpacts analysis for PLANing" is a

For the purposes of this analysis, the JEDI model also assumes that projects are sited appropriately and successfully constructed and operated. JEDI estimates do not assume protracted projects, requiring excessive spending on negotiations, extraordinary legal issues, or siting difficulties. This means that offshore wind developers have worked with the appropriate federal and state agencies, local communities, and stakeholder groups to successfully address siting, permitting, and operational concerns in a timely manner.

JEDI analyzes projects based on expenditures made within a region. The model applies these expenditures to industry-specific economic multipliers, based on the structure of the local economy, to calculate gross impacts. Project-specific expenditures for the offshore wind JEDI model (capital expenditures associated with installation activities and other BOS costs) are derived from the NREL offshore BOS model, integrated into the JEDI model.

The BOS model was built using data provided to NREL by DNV GL, which investigated the major contributions to U.S. offshore wind project BOS costs. Model data have been supplemented with additional industry data. Industry data covered the key cost drivers and trends, provided typical values and expected ranges, and included assumptions made based on current technology and best practices. The data reflect active offshore wind projects in Europe, along with modifications based on the offshore and land-based wind industry in the United States.

The BOS model calculates budget-level estimates for:

- Development costs, including those pertaining to project management, engineering, permitting, and site assessment
- Ports and staging costs, e.g., storage rental, crane rental, and port entrance and docking fees
- Support structure costs for primary steel, secondary steel, and transition pieces
- Electrical infrastructure costs for array cables, export cables, and the offshore substation
- Vessels costs, such as for a heavy lift vessel, jack up vessel, or offshore barge
- Decommissioning costs stemming from cable removal and scour removal.

JEDI models report three types of gross economic impacts: onsite, supply chain, and induced (Figure 2-1).

- *Project development and onsite labor* impacts are those that are most closely associated with an offshore wind project. During construction, these are workers who work at the site of the facility or are directly involved with it. During O&M, these are workers who are directly involved with operating and maintaining the wind facility.
- *Turbine and supply chain* impacts are supported by the purchases made by either the operator (during the operations phase) or construction company (during the construction

proprietary software and data tool for conducting input-output economic analysis. IMPLAN is published by MIG, Inc. Further information about IMPLAN can be found at http://www.IMPLAN.com.

phase). These include manufactured components, consulting services, permitting, and provision of other materials.

- *Induced* impacts arise when onsite and supply chain workers spend their earnings within the area of analysis. These often include impacts (fractions of FTE jobs) at retail stores, health care facilities, restaurants, and hotels, among others.

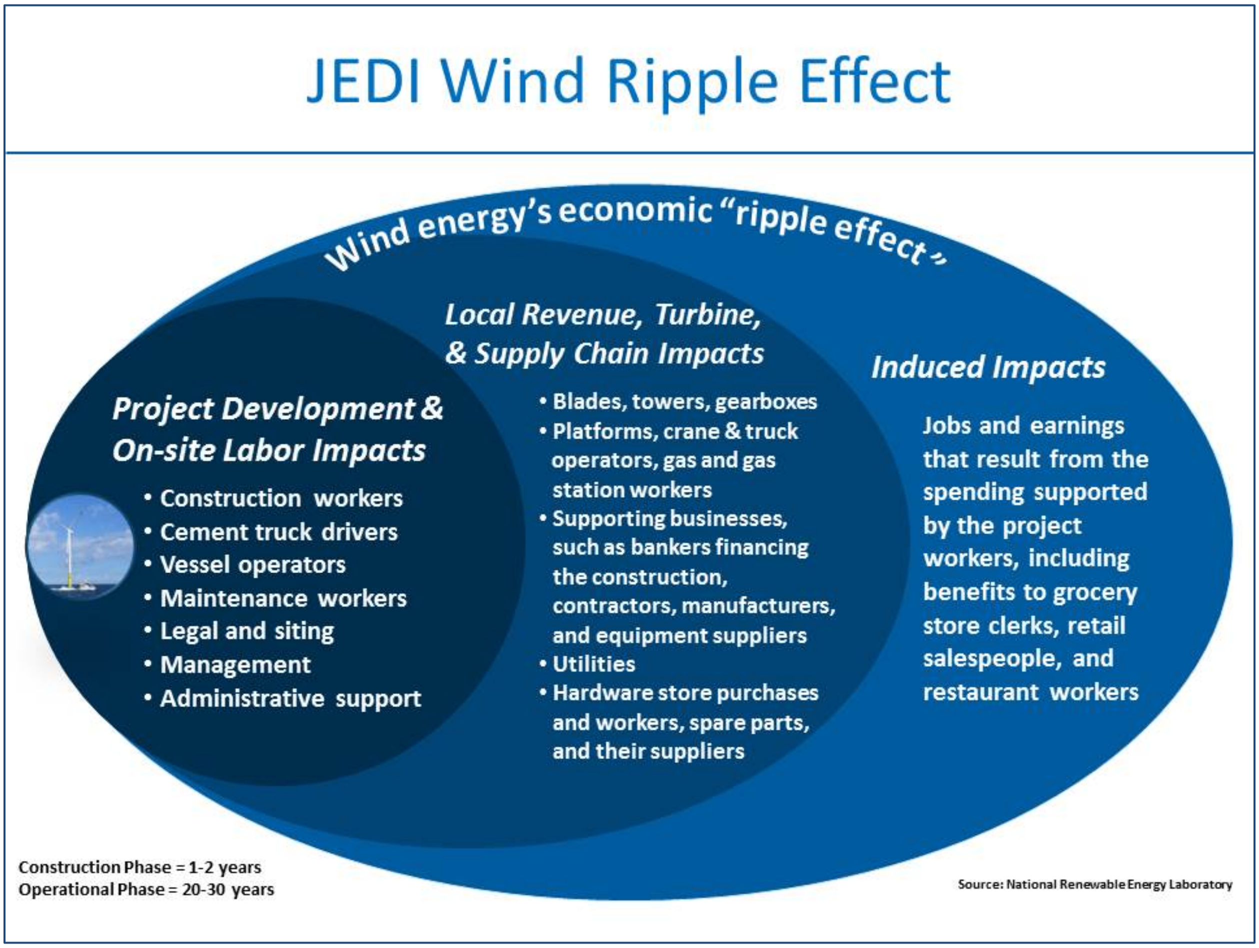

Figure 2-1. JEDI model economic ripple effect: sample jobs in offshore wind

JEDI reports four impact metrics: jobs, earnings, GDP, and output.

- *Jobs* are FTE workers. One FTE is the equivalent of one person working full time (40 hours per week). One person working 20 hours per week is 0.5 FTE. A related term used in this report is the *job-year*. A job-year is one person (working full time) for one year. For example, one person working for 10 years or 5 individuals working for 2 years both total 10 job-years. This is a useful term when describing cumulative or total employment impacts over a multiyear period.
- *Earnings* are wages and salaries as well as supplements, such as health insurance and employer contributions to retirement funds.
- *GDP* is an industry's value of production or, in other words, the amount of revenue beyond expenditures paid to other industries. *GDP* includes payments to workers,

investors, and the government (in the form of taxes). (Note: This is labeled *value added* in the JEDI model, but for the sake of clarity, we use *GDP* throughout this report.)

- *Output* is the sum of overall economic activity (including GDP, plus expenditures on inputs). In other words, it is the market value of the goods and services produced by these Oregon coastal county projects, including taxes.

JEDI reports results within the region of analysis. By default, this could be at a state, county, region, or national level. This study examines the potential impacts within the seven Oregon coastal counties only; reported results do not include impacts that occur outside of this seven county area. The percentage of project expenditures spent within the seven-county area ("local") was based on two sources: interviews with offshore wind technical experts and others familiar with the economy within the state and region and research on the current capacity within the seven-county region to produce the necessary components and other inputs. Once the share of local content is determined, the JEDI model's multipliers are used to derive the local inter-industry linkages and supply chain (i.e., availability of local resources to produce and/or provide the local content - necessary materials, equipment, parts, services, and other goods) and the resulting impacts. For example, $100 may be spent on consulting services within the coastal counties. Yet that local consultant may in turn send $50 of that to another expert in Portland, California or elsewhere outside the local area. The JEDI modeler can specify what portion of that $100 expenditure is made within the seven-county area, but the JEDI model determines how much of that local portion actually remains within the analysis area and benefits the local area.

JEDI reports results for two separate time periods: construction and O&M. Construction period estimates are for the equivalent of one year. Average annual impacts for projects that take more than one year can be derived by dividing the total construction impacts by the number of years it takes to complete. O&M impacts are estimated on an annual basis and are assumed to be supported for the life of the project.

As stated, the JEDI model assumes that projects are sited appropriately and successfully constructed and operated (including permitting with federal and state agencies, local communities, and stakeholder groups to alleviate siting and operational concerns). In reality, the deployment process can take years due to siting considerations. For offshore projects, there are many important issues regarding shipping lanes, marine sanctuaries, and other uses of the offshore area, such as for fishing, recreational, and the military.

3 Scenarios

We analyzed two scenarios for the construction and operation of hypothetical offshore wind projects between the years 2020 and 2050. The analysis includes capital and operating cost assumptions, and assumptions about local content.

This analysis contains two wind growth scenarios, the higher growth scenario labeled "Scenario A" and the lower growth scenario labeled "Scenario B." These scenarios were developed based on input from technical experts as well as on capacity expansion and load growth estimates from DOE's *Wind Vision Study* (DOE 2015). For Scenario A, we examine half of the total Oregon deployment modeled in the *Wind Vision,* resulting in cumulative installations of 5.5 GW of offshore wind by 2050. Scenario B follows a slower growth path than Scenario A, resulting in 2.9 GW over the same time frame. Figure 3-1 shows expansion under each scenario.

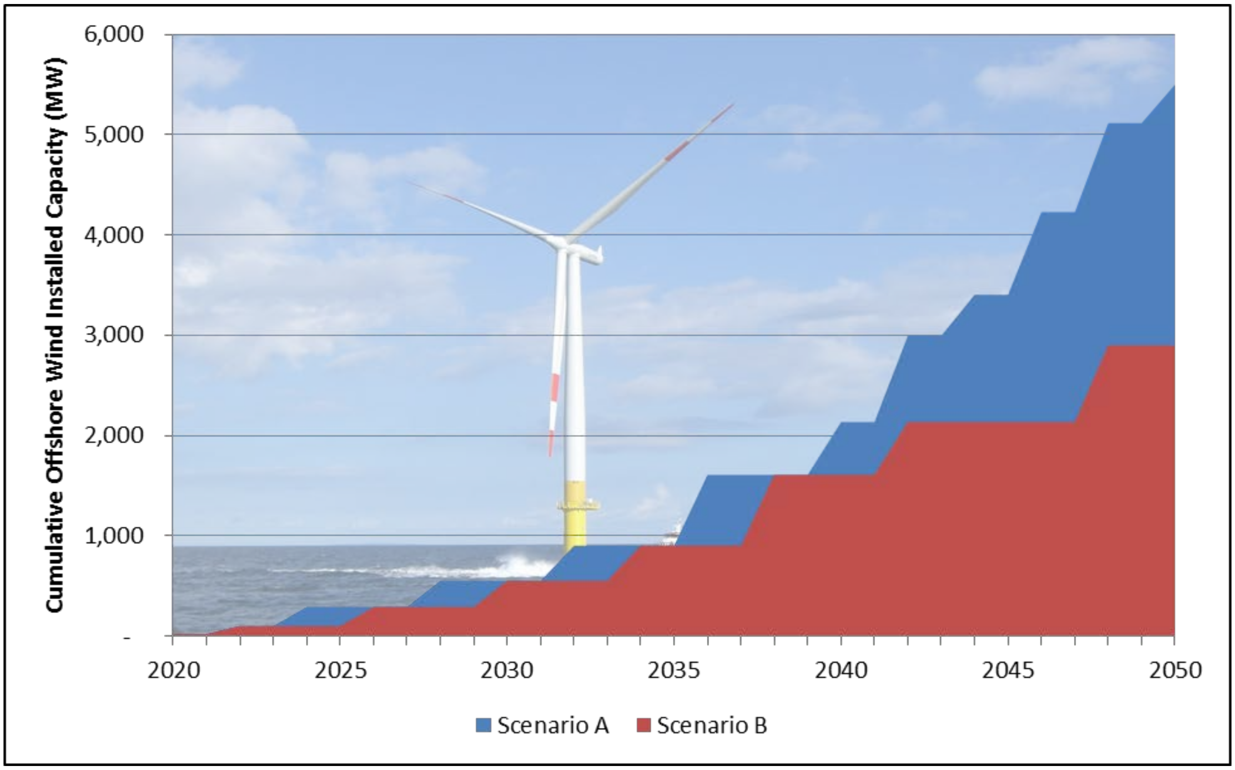

Figure 3-1. Offshore wind deployment for both Oregon growth scenarios

Photo source: NREL/7489066

Both expansion scenarios differ from the *Wind Vision* deployment scenario in that they assume small, initial pilot projects and result in fewer projects deployed by 2050. Oregon offshore wind facilities in the *Wind Vision* were selected based on minimizing energy costs while maintaining a prescribed level of wind-generated electricity and meeting demand for electricity. The offshore wind facilities in the study, therefore, are built in order of their modeled economic viability. Beyond the pilot projects, we assume that facilities of similar sizes to those in the *Wind Vision* study are built, using our own deployment schedules. Resulting capacities (5.5 GW and 2.9 GW) are achieved by decelerating expansion, not by reducing wind facility sizes.

We use averages across potential Oregon offshore wind sites to estimate water depth, distance to the grid, and distance to port. The two potential ports—Astoria and Coos Bay—are approximately 30 kilometers (km) to 150 km from potential sites. Distance to grid is approximately 20 km to 60 km, and water depth ranges from 50 meters (m) to 1,000 m. We model grid distance as 40 km, distance to port as 90 km, and water depth as 525 m.

Both capital expenditures and operational expenditures values are based on recent unpublished work conducted of behalf of BOEM in which we analyzed multiple offshore wind costs and future scenarios. Installations completed through 2026 are assumed to use 8-MW turbines, while installations completed after 2026 are assumed to use 10-MW turbines. Costs do not vary between the scenarios. Both capital costs and O&M costs are assumed to decline over time. For the current analysis, unit ($/MW) turbine costs are assumed to continue declining beyond 2030. In contrast, BOS costs are assumed to remain flat after 2030. BOS costs are calculated using the BOS model. Inputs to this model include turbine rated power, distance to port, and distance to the grid. Cost assumptions are summarized in Table 3-1. Due to its small size, the 20-MW project installed in 2020 has a noticeably higher unit capital cost than the succeeding projects.

Table 3-1. Analysis Cost Assumptions

Year	Installations (Scen A) (MW)	Installations (Scen B) (MW)	Turbine Cost ($/kW)	Total CAPEX (Scen A) ($/kW)	Total CAPEX (Scen B) ($/kW)	Total Annual OPEX ($/kW)
2020	20	20	$1,732	$11,282	$11,282	$137
2021	0	0	$1,723			$131
2022	80	80	$1,713	$5,873	$5,873	$126
2023	0	0	$1,703			$120
2024	189	0	$1,693	$5,067		$115
2025	0	0	$1,683			$110
2026	0	189	$1,674		$5,047	$105
2027	0	0	$1,664			$101
2028	262	0	$1,655	$4,619		$96
2029	0	0	$1,645			$92
2030	0	262	$1,636		$4,600	$88
2031	0	0	$1,626			$88
2032	349	0	$1,617	$4,596		$88
2033	0	0	$1,608			$88
2034	0	349	$1,599		$4,577	$88
2035	0	0	$1,590			$88
2036	708	0	$1,580	$4,559		$88
2037	0	0	$1,571			$88
2038	0	708	$1,562		$4,540	$88
2039	526	0	$1,554	$4,454		$88
2040	0	0	$1,545			$88
2041	861	0	$1,536	$4,490		$88
2042	0	526	$1,527		$4,426	$88
2043	409	0	$1,519	$4,366		$88
2044	0	0	$1,510			$88
2045	823	0	$1,501	$4,458		$88
2046	0	0	$1,493			$88
2047	888	0	$1,484	$4,425		$88
2048	0	765	$1,476		$4,516	$88
2049	384	0	$1,468	$4,382		$88
2050	0	0	$1,459			$88

Local content is specified based on input from experts with knowledge of both offshore wind and the Oregon economy, as well as evaluations of existing economic activity and capacity within the seven-county region. These differ in each scenario because we assume more rapid expansion would incentivize greater levels of supply chain growth.

It is unlikely that all local content would remain constant for the entire period of analysis. For certain items, local content would likely start out very low and increase over time as new industries develop or locate to the local area. For each deployment scenario we examined two sets of values for local content, labeled “High LC” and “Low LC” respectively. Note that the set of values differ between the deployment scenarios. In other words, the High LC values are different between scenario A and scenario B.

These local content assumptions are summarized in Table 3-2 for construction and Table 3-3 for O&M. In both tables, if there is one value for an item, that value is constant for the whole analysis period. If two values are given, the first value is the 2020 local share; the second value is the local share from 2035–2050. Figure 3-2 shows the growth in overall local content for both construction and O&M from the initial values in 2020 to the final values in 2035 and after.

Table 3-1. Local (Oregon Coastal Counties) Content Assumptions – Construction

If there is one value for an item, that value is constant for the whole analysis period. If two values are given, the first value is the 2020 local share; the second value is the local share starting in 2035. LC = "Local Content"

	Counties Share – Scen. A		**Counties Share – Scen. B**	
	High LC	**Low LC**	**High LC**	**Low LC**
Construction Expenditure Items				
Turbine Equipment				
Nacelle/Drivetrain	0%	0%	0%	0%
Blades	0%	0%	0%	0%
Towers	0%→20%	0%	0%→5%	0%
Ground Transportation (to project staging area/port by vessel)	15%→35%	0%	5%→15%	0%
Warranty Cost	0%	0%	0%	0%
Materials and Other Equipment				
Basic Construction (concrete, rebar, gravel, mooring lines, etc.)	40%→45%	30%→35%	40%	30%
Foundation (including anchors/alternatives for fixed bottom types only)	15%→25%	0%→10%	10%→20%	0%→5%
Substructure	0%→10%	0%→10%	0%→5%	0%→5%
Project Collection System	0%	0%	0%	0%
HV Cable (project site to point of grid interconnection)	0%	0%	0%	0%
Onshore substation (formerly converter station)	0%	0%	0%	0%
Offshore substation (formerly substation)	0%	0%	0%	0%
Labor Installation				
Foundation	20%→30%	4%→40%	10%→20%	4%→12%
Substructure	0%→20%	4%→40%	0%→5%	4%→12%
Erection/Installation	45%→90%	4%→40%	5%→15%	4%→12%
Project Collection	5%→45%	4%→40%	5%→15%	4%→12%
Grid Interconnection (including substation)	45%→70%	4%→40%	20%→45%	4%→12%
Management/Supervision	10%→30%	0%→10%	5%→15%	0%→5%
Insurance During Construction				
CAR/Third Party liability/business interruption, etc.	0%	0%	0%	0%

	Counties Share – Scen. A		Counties Share – Scen. B	
	High LC	**Low LC**	**High LC**	**Low LC**
Construction Expenditure Items				
Development Services/Other				
Engineering	0%➔20%	1%➔10%	0%➔10%	1%➔5%
Legal Services	5%➔15%	1%➔10%	5%➔10%	1%➔5%
Public Relations	15%➔30%	10%➔15%	15%➔25%	10%
Ports and Staging	50%➔70%	8%➔60%	10%➔15%	8%➔10%
Site Certificate/Permitting	25%➔50%	5%➔20%	25%➔35%	5%➔15%
Air Transportation (personnel or materials)	0%	0%	0%	0%
Marine Transportation (personnel or materials)	25%➔60%	10%➔40%	20%➔40%	10%➔15%
Erection/Installation (equipment services)	10%➔60%	8%➔54%	10%➔50%	8%➔45%
Decommissioning Bonding	0%	0%	0%	0%
Construction Financing (AFUDC)				
Interest During Construction	0%	0%	0%	0%
Due Diligence Costs	0%	5%	0%	5%
Bank Fees	0%	0%	0%	0%
Other Miscellaneous	5%➔20%	5%➔25%	5%➔10%	5%➔10%

Table 3-2. Local (Oregon Coastal Counties) Content Assumptions – O&M

If there is one value for an item, that value is constant for the whole analysis period. If two values are given, the first value is the 2020 local share; the second value is the local share from 2035–2050. LC = "Local Content"

	Counties Share – Scen. A		**Counties Share – Scen. B**	
	High LC	**Low LC**	**High LC**	**Low LC**
Annual Operating and Maintenance Costs				
Labor				
Technician Salaries	30%➔90%	60%➔90%	30%➔60%	45%➔90%
Monitoring & Daily Operation Staff and Other Craft Labor	75%➔90%	45%➔70%	50%	45%
Administrative	50%	80%	50%	80%
Management/Supervision	10%➔50%	8%➔80%	10%➔45%	8%➔72%
Materials and Services				
Water Transport	20%➔60%	20%➔75%	20%➔40%	20%➔50%
Site Facilities	60%	40%	60%	40%
Machinery and Equipment	15%➔20%	0%➔5%	10%➔15%	0%➔2%
Subcontractors	10%➔20%	1%➔20%	1%➔15%	1%➔8%
Corrective Maintenance Parts	25%➔70%	1%➔5%	20%➔45%	1%➔2%

Figure 3-2 shows the growth in overall local content for both construction and O&M from the initial values in 2020 to the final values in 2035. As shown in Figure 3-2, overall, maximum construction local content ranges from 10%–16% in Scenario A (dark blue bar) and 6%–11% in Scenario B (orange bar). Maximum O&M local content is 32%–60% in Scenario A (dark blue line) and 25%–43% in Scenario B (orange line). Because the seven-county area is mostly rural, the analysis assumes that much of the material and labor for the projects will come from outside the analysis area, i.e. from other parts of Oregon (e.g., the Portland area) or from out of state.

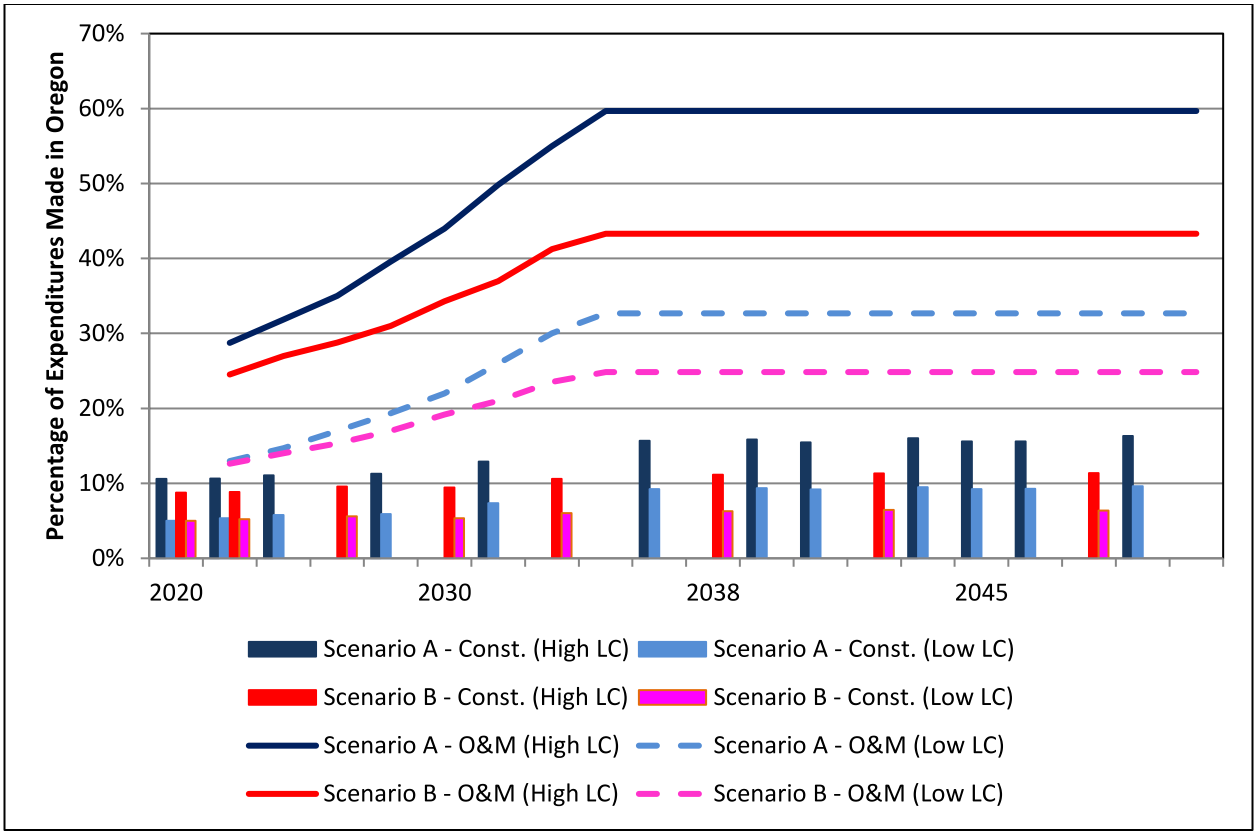

Figure 3-2. Scenarios with high and low percentages of local content from Oregon coastal counties over time

There are many uncertainties about local content, especially for specialized offshore wind components. Components are often too large to be moved great distances on land and staging facilities must be located at a port. The port itself often must undergo infrastructure improvements to handle the size and weight of offshore components (Tetra Tech 2010; Navigant 2014; Cotrell et al. 2014). Similarly, vessels capable of installing offshore wind facilities would either need to be built or mobilized to the Oregon area. Vessels and crews may temporarily relocate to Oregon coastal counties, but would not be considered local because they are permanently based elsewhere.

At least two states—Massachusetts and Rhode Island—have used public funding to analyze opportunities to upgrade existing ports or to build new ports with the capacity to handle large offshore wind components.[12] This type of analysis demonstrates how local demand for components could have significant economic implications because offshore wind companies could be incentivized to locate near the ports.

[12] Port improvements can involve physical repairs and upgrades to infrastructure, including piers, decks, cranes, terminals, and railways. For more information on recent improvements to a Rhode Island port, see: http://www.ri.gov/press/view/10777. A full analysis of opportunities to improve ports and infrastructure to support offshore wind in Massachusetts can be found here: http://www.epa.gov/region1/superfund/sites/newbedford/518618.pdf.

Manufacturing is another sector in which economic activity can occur as a result of offshore wind deployment. Due to the generally rural character of the coastal counties, this analysis assumes that only a small proportion of the project's equipment is manufactured within the counties themselves. It is assumed that the majority of the in-state supply chain will be located outside of the seven-county area. Figure 3-3 shows a map of the United States counties and the concentration of jobs in manufacturing of durable goods (e.g., machinery, not bread). The darker colors indicate higher levels of manufacturing jobs. It shows that most of the Oregon coastal counties do not have a high number of manufacturing workers, relative to the other counties. For this reason, the local content estimates (meaning labor, parts, and equipment that come from Oregon coastal counties) are set to assume that most of the parts and equipment come from outside the seven-county region.

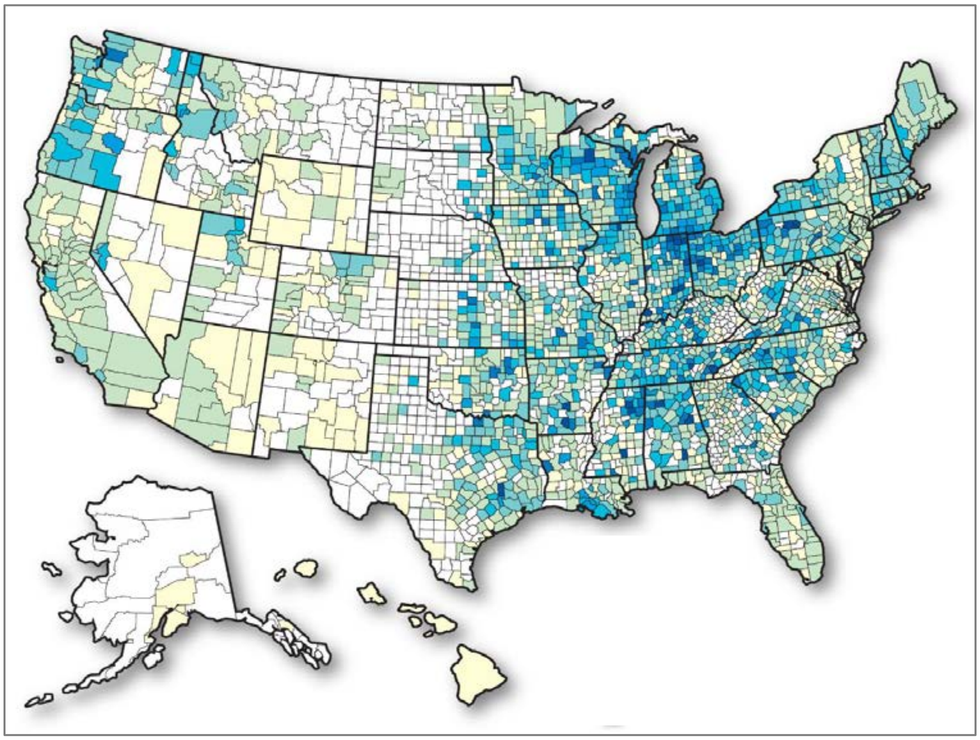

Figure 3-3. Map of concentration of manufacturing jobs by county (durable goods)

Source: NREL with county manufacturing data from the Bureau of Labor Statistics (2014)

4 Results

4.1 Construction Phase

Model estimates show that large-scale deployment of offshore floating wind turbines, even with modest local content, results in significant construction-phase impacts. Scenario A, with the larger buildout and the higher local content, supports a total of 18,000–33,000 construction-phase job-years. Scenario B supports a total of 12,000–14,000 construction-phase job-years. Figure 4-1 shows the construction-phase jobs by year during the analysis period. Each modeled job shown in Figure 4-1 lasts the equivalent of one year. Under our assumptions, it will take years for the offshore manufacturing, project development, and other service markets to develop, thus, the majority of the jobs are supported toward the latter half of the scenarios, as indicated in Table 4-1.

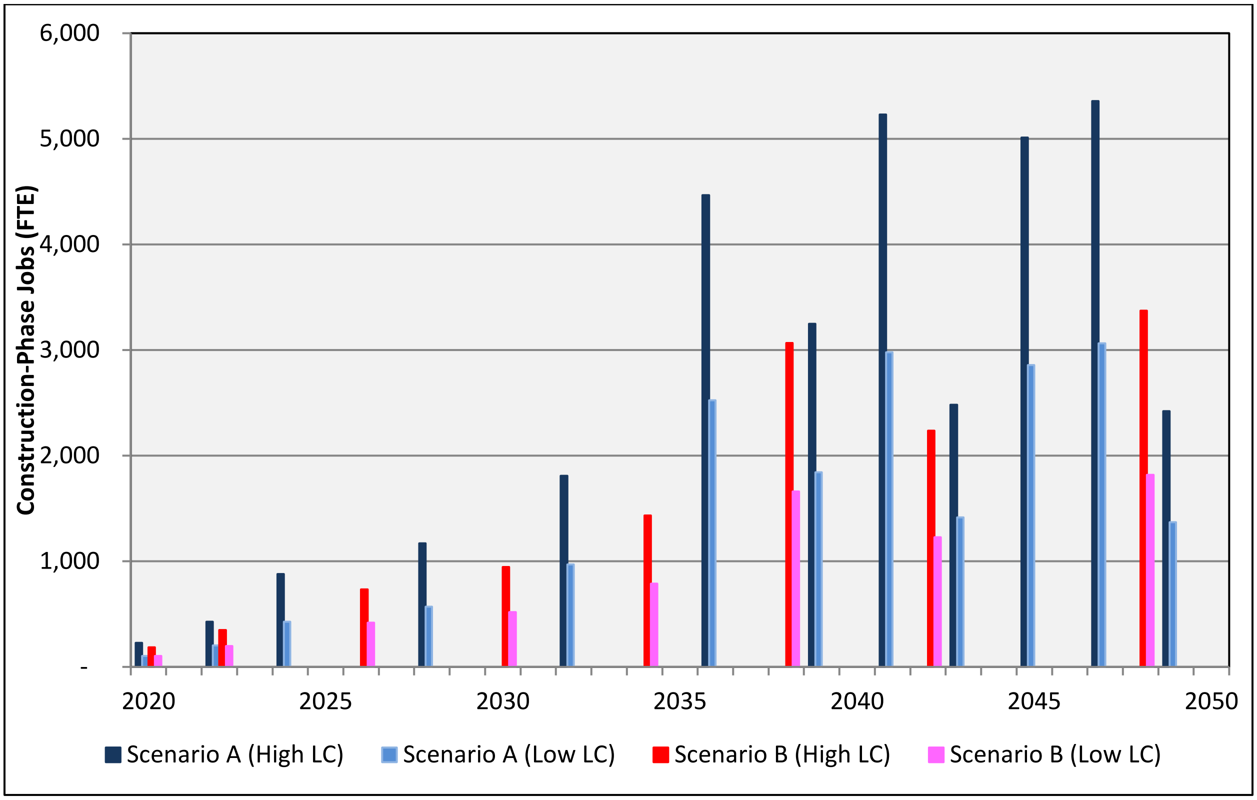

Figure 4-1. Annual construction-phase jobs supported in Scenario A and Scenario B

Most jobs and other impacts occur in the last half of the analysis period. Table 4-1 provides a more detailed breakdown of average annual jobs and other economic impacts during each of the three decades of the analysis period. By the last decade (2040–2050), average annual employment in the Oregon coastal counties supported by the construction of offshore wind ranges from 290 jobs (Scenario A) to 60 jobs (Scenario B).

Table 4-1. Average Annual Construction-Phase Impacts by Decade

		2020–2030		2030–2040		2040–2050	
	Scenario	**A**	**B**	**A**	**B**	**A**	**B**
Jobs	Onsite	20–50	20–30	90–160	40–80	180–330	40–80
	Supply Chain	70–140	60–120	280–500	160–290	620–1,100	170–300
	Induced	30–60	30–50	120–210	70–120	260–450	70–120
	Total	**120–250**	**110–200**	**490–870**	**270–500**	**1,100–1,900**	**280–510**
Earnings ($ Millions, 2014)	Onsite	$3–$6	$3–$5	$11–$20	$6–$10	$24–$39	$6–$11
	Supply Chain	$3–$6	$1–$5	$14–$24	$8–$14	$30–$52	$8–$15
	Induced	$1–$2	$1–$2	$4–$8	$2–$4	$9–$16	$2–$4
	Total	**$7–$15**	**$7–$12**	**$29–$51**	**$16–$29**	**$64–$108**	**$16–$30**
Output ($ Millions, 2014)	Onsite	$4–$9	$4–$6	$15–$26	$7–$14	$31–$39	$7–$13
	Supply Chain	$17–$31	$16–$28	$67–$115	$40–$70	$149–$252	$41–$72
	Induced	$3–$7	$3–$6	$14–$24	$8–$14	$30–$52	$8–$14
	Total	**$24–$47**	**$23–$40**	**$96–$165**	**$97**	**$209–$357**	**$56–$100**
GDP ($ Millions, 2014)	Onsite	$3–$7	$3–$5	$12–$22	$6–$11	$26–$43	$6–$11
	Supply Chain	$6–$10	$5–$9	$23–$38	$13–$23	$50–$84	$14–$24
	Induced	$2–$4	$2–$3	$8–$14	$4–$8	$18–$31	$5–$8
	Total	**$11–$22**	**$10–$18**	**$43–$74**	**$24–$43**	**$94–$158**	**$24–$44**

Average earnings for these jobs vary depending on their relationship to the project. As shown in Table 4-2, onsite workers earn an average of approximately $125,000 annually, while supply chain workers earn an average of approximately $48,000 (in 2014 dollars). As stated previously, earnings include wages and benefits. Induced jobs, which are concentrated in lower paying industries such as retail, earn an average of approximately $36,000 annually. Changes in these averages between scenarios reflect different pools of workers and different types of economic activity occurring within the seven-county area.

Table 4-2. Average Annual Earnings for Construction Phase Workers ($ 2014)

	Scenario A	Scenario B
Onsite	$125,000	$130,000
Supply Chain	$48,000	$48,000
Induced	$36,000	$36,000
Overall	$60,000	$60,000

Beyond jobs and earnings, by the last decade of the analysis (2040–2050) offshore wind construction-phase activity increases the annual seven-county regional GDP by an average of $90 million–$160 million per year in Scenario A and $24 million–$44 million per year in Scenario B.

Recalling the definition of GDP in these scenarios: JEDI estimates the contribution of the offshore wind value chain (for these projects) to GDP. This is the value of production, or the amount of revenue beyond expenditures paid to other industries. It includes payments to workers and investors and net tax payments.

4.1.1 Job Years

A job-year is equivalent to one person (working full time) for one year. One person working for 10 years is expressed as 10 job-years; 5 individuals working for 2 years is also 10 job-years. Another way to look at this is to add up all of the same-colored bars shown in Figure 4-1. Model estimates show that large-scale deployment of offshore floating wind turbines, even with modest local content, results in significant construction-phase impacts. Scenario A, with the larger buildout and the higher local content, supports a total of 45,000– 66,000 construction-phase job-years. Scenario B supports a total of 13,000–21,000 construction-phase job-years.

4.2 Operations and Maintenance Phase:

As shown in Figure 4-2, by 2050 the total number of ongoing O&M-related jobs supported is 1,800–2,900 for Scenario A and 680–1,100 for Scenario B.

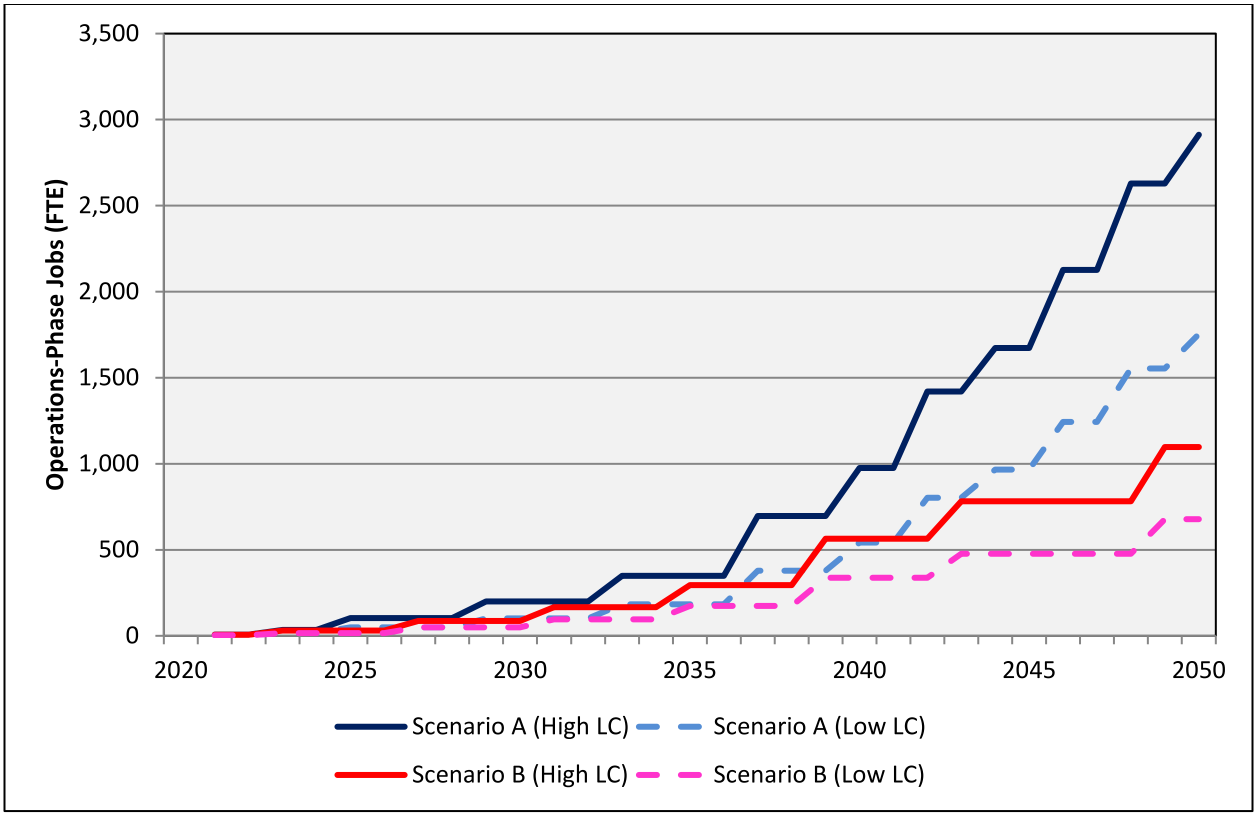

Figure 4-2. Operations-phase jobs (FTE) supported by offshore wind during the analysis period, in the Oregon coastal counties

After the analysis period, operations, maintenance, and other operations-phase employment (including environmental monitoring, legal work, etc.) supports an estimated $220 million–$310 million annually in the seven-county GDP in Scenario A or $80 million–$110 million in Scenario B. Table 4-3 shows these impacts in three different years: 2030, 2040, and 2050.

Table 4-3. O&M Impacts for Selected Years

		2030		2040		2050	
	Scenario	**A**	**B**	**A**	**B**	**A**	**B**
Jobs	Onsite	16–22	8–11	90–130	70–90	250–350	130–170
	Supply Chain	53–130	26–57	270–620	160–350	850–1,800	310–670
	Induced	25–51	12–22	150–260	88–150	550–860	190–300
	Total	**100–200**	**48–87**	**540–980**	**340–560**	**1,800–2,900**	**680–1,100**
Earnings ($ Millions, 2011)	Onsite	$2–$2	$1–$1	$11–$15	$8–$10	$30–$42	$15–$20
	Supply Chain	$3–$7	$1–$3	$16–$34	$9–$19	$50–$98	$18–$36
	Induced	$1–$2	$0–$1	$5–$9	$3–$5	$19–$30	$7–$10
	Total	**$6–$11**	**$3–$5**	**$36–$54**	**$23–$32**	**$110–$160**	**$45–$61**
Output ($ Millions, 2011)	Onsite	$2–$2	$1–$1	$11–$15	$8–$10	$30–$42	$15–$20
	Supply Chain	$11–$27	$5–$11	$66–$140	$36–$74	$250–$450	$80–$150
	Induced	$3–$6	$1–$2	$16–$29	$9–$16	$58–$93	$20–$33
	Total	**$16–$34**	**$7–$14**	**$96–$180**	**$56–$98**	**$350–$570**	**$120–$200**
GDP ($ Millions, 2011)	Onsite	$2–$2	$1–$1	$11–$15	$8–$10	$30–$42	$15–$20
	Supply Chain	$6–$13	$3–$5	$35–$65	$20–$36	$130–$210	$43–$73
	Induced	$2–$3	$1–$1	$10–$17	$6–$10	$36–$56	$12–$20
	Total	**$10–$18**	**$5–$8**	**$59–$93**	**$36–$53**	**$210–$300**	**$76–$110**

The average earnings of workers supported by operations-phase activities vary only slightly between the two scenarios. Onsite workers earn an average of approximately $120,000 annually, supply chain workers earn an average of approximately $60,000 annually, and induced workers earn an average of approximately $36,000 annually. Combined, average worker earnings are slightly over $60,000 in wages, salaries, and employer-provided benefits (Table 4-4).

Table 4-4. Average Annual Earnings for O&M Phase Workers ($ 2012)

	Scenario A	**Scenario B**
Onsite	$122,000	$121,000
Supply Chain	$60,000	$57,000
Induced	$36,000	$36,000
Overall Average	$63,000	$63,000

The construction of offshore wind projects in Oregon would induce additional impacts that are not represented in this analysis, especially those in other counties, states, or countries. For example, other markets may supply goods and services, such as specialized crane parts or bearings, for projects located in Oregon. Similarly, JEDI does not account for the impacts on consumers that may occur, such as changes in utility or tax rates, or the price of goods and services.

5 Conclusion

Offshore wind can contribute to economic development within the Oregon coastal counties in the near future, and more substantially in the long term, especially if equipment and labor are sourced from within the seven-county area. According to the analysis, over the 2020–2050 analysis period, Oregon floating offshore wind facilities could support 32,000–59,000 job-years and add $3.2 billion–$5.5 billion to the regional GDP (Scenario A) Under this same deployment scenario, post analysis-period impacts include support of 1,600–3,000 ongoing O&M jobs and $210 million–$320 million in additional annual regional GDP.

The analysis found that higher levels of local spending by developers and operators within Oregon, and the coastal counties in particular, could support even greater gross economic impacts. If offshore wind and other related manufacturing increases in Oregon coastal counties the area could experience a significantly increase in jobs and other economic development impacts. These impacts would increase substantially if Oregon-coast-based suppliers also export goods and services out of state. Improvements in technologies, manufacturing processes, and O&M practices, as well as policy changes and growth in domestic and international markets, among other factors, could have a significant impact on the development of offshore wind projects in the seven-county region of Oregon.

Regardless of the offshore wind technology utilized, or in-region content, offshore wind development represents a significant opportunity to expand economic development and employment from offshore wind in the Oregon coastal counties, assuming projects are sited appropriately and operate as expected. At the same time, developing offshore wind will help Oregon meet its renewable energy goals.

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Appendix. Floating Offshore Wind Projects Installed or Under Construction

Table A-1. Floating Offshore Wind Projects

Project	Status	Turbine Capacity (MW)	Project Capacity (MW)	Water Depth (m)	Country	Foundation Type	Year Online
Hywind Demo	Installed	2.3	2.3	220	Norway	Spar	2009
WindFloat Atlantic I	Installed	2	2	50	Portugal	Semi-submersible	2011
Kabashima/Goto	Installed	2	2	91	Japan	Spar	2013
Fukushima Forward I	Installed	2	2	120	Japan	Semi-submersible	2013
Fukushima Forward II	Under Construction	7 & 5	12	120	Japan	1 Semi-submersible; 1 Spar	Expected 2016
Hywind Scotland Pilot Park	Under Construction	6	30	120	United Kingdom	Spar	Expected 2017