Economic Impact of Large-Scale Deployment of Offshore Marine and Hydrokinetic Technology in Oregon Coastal Counties

T. Jimenez, S. Tegen, and P. Beiter
National Renewable Energy Laboratory

Produced under direction of the Bureau of Ocean Energy Management by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-12-1867 and Task No. WFQ4.1005.

This report is available from the Bureau of Ocean Energy Management by referencing OCS Study BOEM 2015-018. The report may be downloaded from the BOEM website through the Environmental Studies Program Information System (ESPIS) and may also be accessed on the BOEM Pacific Region website.

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NREL/TP-5000-63506
March 2015
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NOTICE

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Executive Summary

The United States' marine and hydrokinetic (MHK) resources are comprised of river currents, ocean currents, and ocean wave energy. Of the three, ocean wave energy has the greatest resource potential for electricity generation in the nation. Within the continental United States, the West Coast in general, and Oregon in particular, has the most promising wave energy resource. Wave energy resources are transformed into power by using wave energy converters (WECs). MHK power is still in the stage of prototype devices and small demonstration projects[1]; however, this report explores scenarios with high deployment levels of WEC technology to investigate economic impacts for seven coastal counties in Oregon, with the assumptions that technological advancements are made and costs significantly decrease in the future.

To begin understanding the potential economic impacts of large-scale WEC technology, the Bureau of Ocean Energy Management (BOEM) commissioned the National Renewable Energy Laboratory (NREL) to conduct an economic impact analysis of large-scale WEC deployment for Oregon coastal counties. This report follows a previously published report by BOEM and NREL on the jobs and economic impacts of WEC technology for the entire state (Jimenez and Tegen 2015).

As in Jimenez and Tegen (2015), this analysis examined two deployment scenarios in the 2026–2045 timeframe: the first scenario assumed 13,000 megawatts (MW) of WEC technology deployed during the analysis period, and the second assumed 18,000 MW of WEC technology deployed by 2045. Both scenarios require major technology and cost improvements in the WEC devices. The study is on very large-scale deployment so readers can examine and discuss the potential of a successful and very large WEC industry. The 13,000-MW is used as the basis for the county analysis as it is the smaller of the two scenarios. Sensitivity studies examined the effects of a robust in-state WEC supply chain. The region of analysis is comprised of the seven coastal counties in Oregon—Clatsop, Coos, Curry, Douglas, Lane, Lincoln, and Tillamook—so estimates of jobs and other economic impacts are specific to this coastal county area.

The impacts highlighted here can be used in policy and planning decisions and scaled to get a sense of the economic development opportunities associated with other WEC deployment scenarios. In addition, the analysis can be used to inform stakeholders in other states and sub-state regions about the potential economic effects of this scale of WEC technology development. All estimates are based on currently available data, with caveats discussed in Section 2.1. It should be noted that scenarios in this report are hypothetical, and deployments of this magnitude would not realistically happen without advancements and a significant reduction in the cost of energy produced from WEC technology. Important issues like siting and permitting projects are assumed to be resolved, as the focus is on economic impacts. Concerns about project siting would need to be addressed in actual deployment of WEC technology.

[1] According to the December 2013 Ocean Energy Systems Annual Report, the United Kingdom has 3,850 kilowatts of MHK capacity installed (Ocean Energy Systems 2013).

According to the analysis conducted in this study, deploying 13,000 MW of WEC installations in Oregon and assuming a modest in-state supply chain could[2]:

- Support a total of 5,500 operation-phase full-time-equivalent (FTE) jobs[3] by 2045 and 5,500 operation-phase jobs annually in the years following the analysis period for the remaining lifetime of the MHK projects[4]
- Support a total of $1.4 billion in economic activity for Oregon counties during the construction phase
- Support a total of $0.6 billion annually in economic activity by 2045 during operation phases and generate $0.6 billion in annual economic activity in the years following the analysis period for the remaining lifetime of the MHK projects
- Provide $7.4 million in annual lease payments to the State of Oregon[5], with approximately $2.2 million allocated to the counties in which the WECs are located (i.e., the county with the closest coastline to the project).

Figure ES-1 shows the estimated jobs in coastal Oregon counties supported by WEC installations throughout the period of analysis. Each scenario's construction-phase jobs are represented by blue, red, or green bars, and two lines show the FTE jobs estimated during the operation phases. The operation-phase jobs in 2046 indicate the number of jobs in the years following the analysis period for the remaining lifetime of the MHK projects.

The impact of WEC technology is even greater for the entire state (see Figures ES-2 and Figures 3 and 4). This report only discusses the impact of WEC installations to the coastal county economies (see Jimenez and Tegen 2015 for an analysis of state-wide impacts) and does not assess spill-over effects from coastal to the inland counties of Oregon. Compared to a total of 5,500 operation-phase FTE jobs by 2045 in the coastal counties, WEC installations are estimated to support 6,800 operation-phase FTE jobs in the entire state (under the 13,000 MW deployment scenario). Correspondingly, the annual construction-phase FTE jobs supported in the state of Oregon are greater than in the coastal counties alone.

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[2] Analysis results are provided in real, 2012 inflation-adjusted U.S. dollars.
[3] An FTE job is one full-time job for 1 year. For example, one full-time job for 2 years is two FTE jobs, and two half-time jobs for 1 year is one FTE job.
[4] The jobs remain constant after 2045 because the scenario has reached full deployment.
[5] According to Rebecca O'Neil, a representative from the State of Oregon, lease funds are received by the state and assigned to the Oregon Ocean Science Fund. Then, 30% of the funds are redirected to whichever county's coastline sits ashore to the revenue-bearing project. SB 737 (2013 Regular Session) Section 3 Parts (4) and (5) describe these funding dedications. (https://olis.leg.state.or.us/liz/2013R1/Measures/Text/SB737/Enrolled)

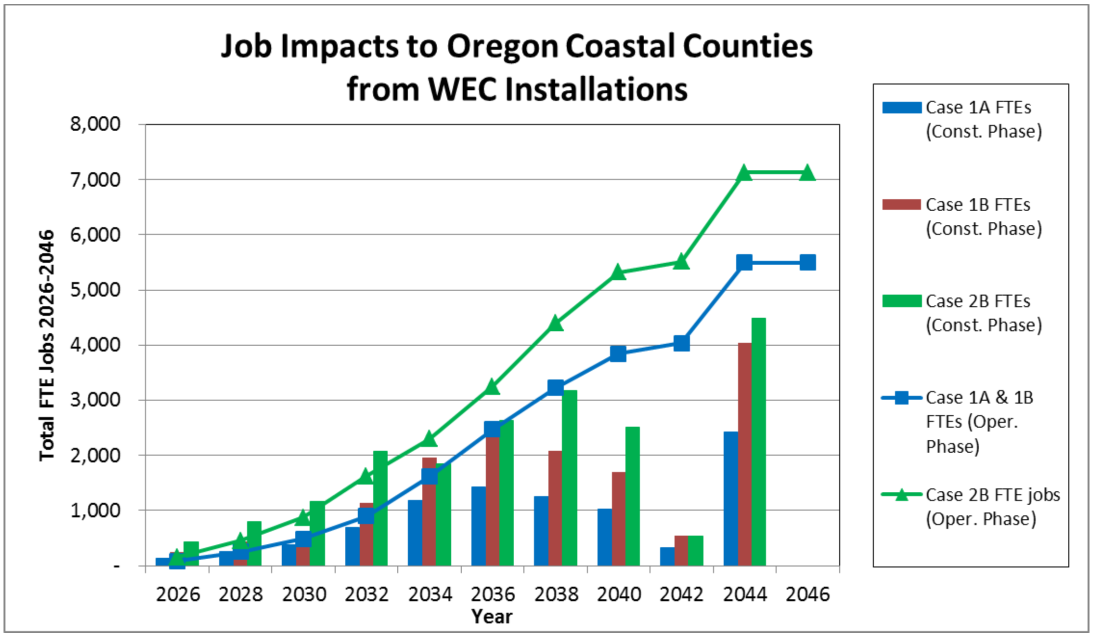

Figure ES-1. Estimated jobs from large-scale WEC deployment in Oregon coastal counties

Another key finding from this work is the sensitivity of the results to the magnitude of the in-state supply chain. Establishing an in-state supply chain that can capture even a modest portion of WEC installations would dramatically increase the economic effects of large-scale WEC deployment within Oregon. Figure ES-2 shows the larger state impacts.[6]

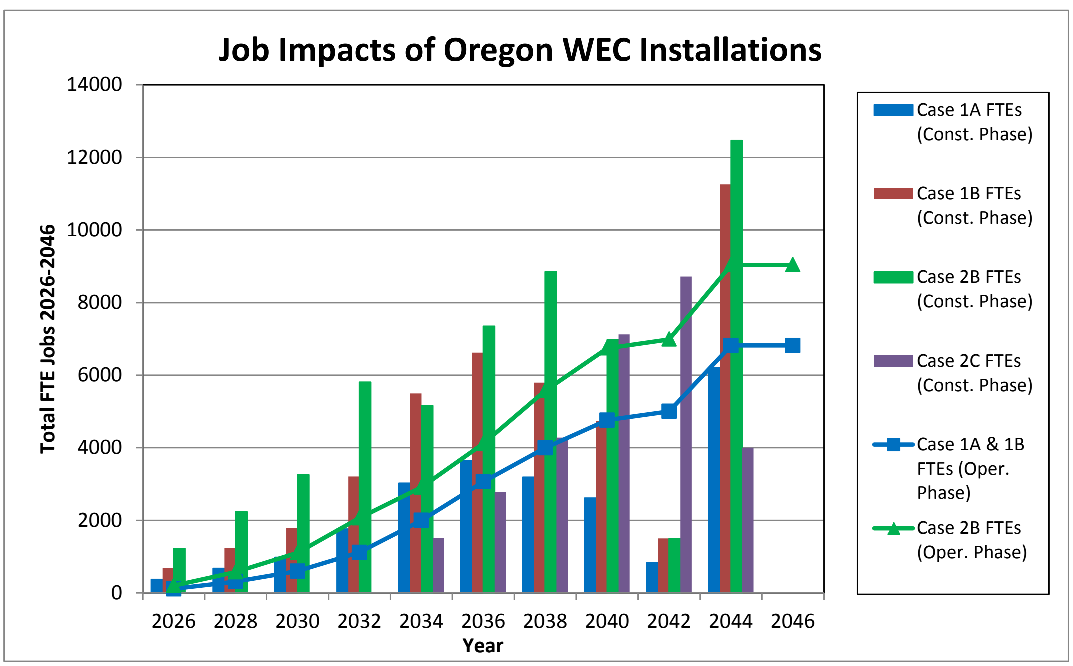

Figure ES-2. Estimated jobs from large-scale WEC deployment in the State of Oregon

[6] The report for the State of Oregon included a case 2C that is not part of this study.

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1 Introduction

Marine and hydrokinetic (MHK) technologies are in the early stages of development and have the potential to become an additional renewable energy option, along with solar and wind power. MHK can be subdivided into two categories: current energy converters (CECs) and wave energy converters (WECs). CECs harness the power of river, tidal, and ocean currents and are similar to wind turbines, whereas WECs harness the energy of ocean surface waves (Thresher 2013). Figure 1-1 shows examples of the different WEC devices currently under development. The wide variety of topologies indicates that WEC technology is still immature. There are currently no commercial-scale, market-ready MHK devices deployed in the United States; however, there are some projects in the demonstration stages, with plans for larger devices. Figure 1-2 shows the U.S. wave energy resource availability.

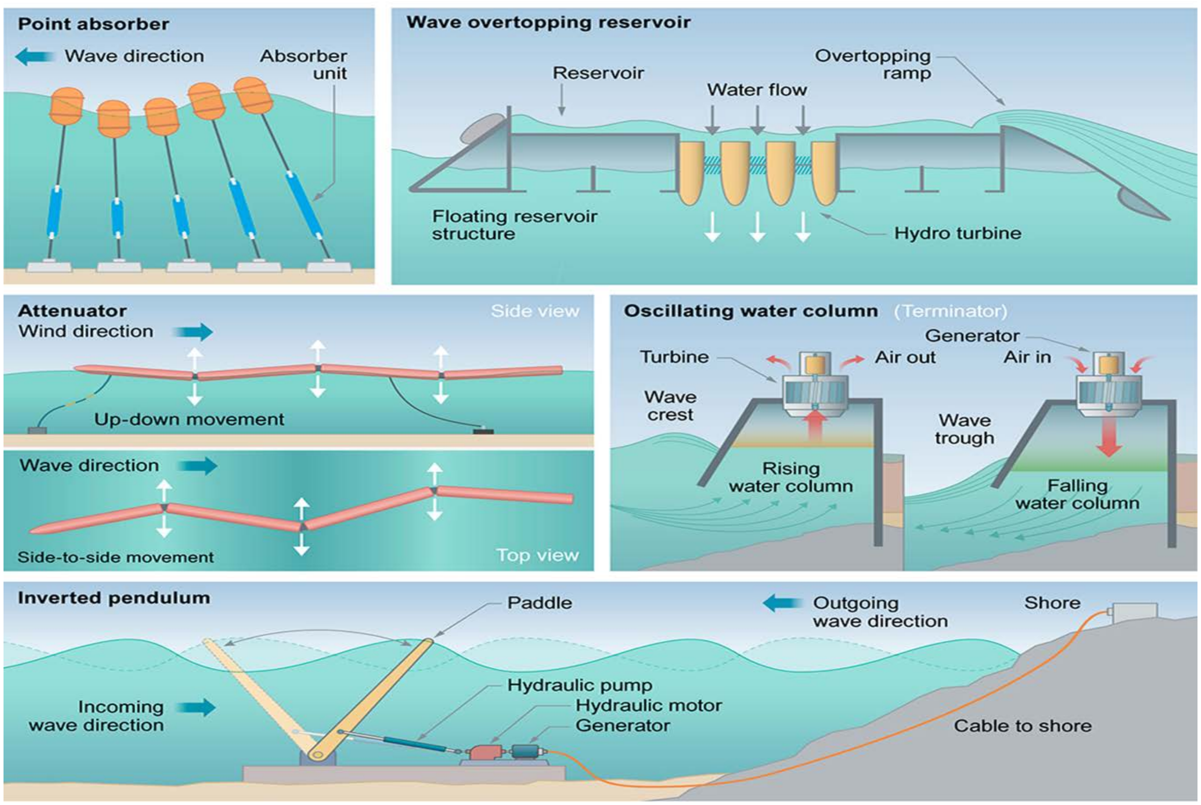

Figure 1-1. Wave energy conversion device topologies
Source: Augustine et al. 2012

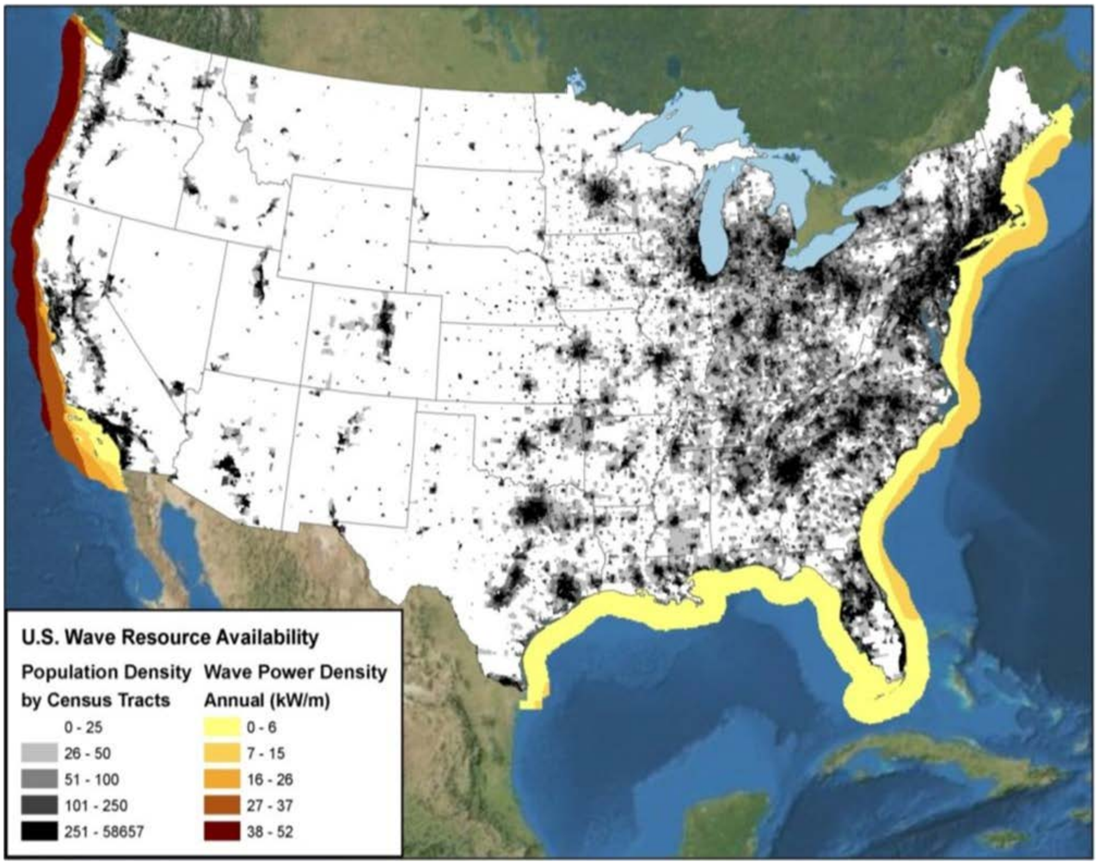

Figure 1-2. Estimated U.S. wave energy resource
Source: Thresher 2013; Resource data from *http://maps.nrel.gov/re_atlas*

At the request of the Bureau of Ocean Energy Management (BOEM), the National Renewable Energy Laboratory (NREL) conducted an analysis of the economic impacts of large-scale (10,000–20,000 megawatts [MW]) MHK (specifically wave energy) deployment off the coast of Oregon. Oregon was selected because of its large wave energy resource and its ongoing efforts to create an Oregon-based wave energy industry. The seven coastal counties studied were Clatsop, Coos, Curry, Douglas, Lane, Lincoln, and Tillamook (see Figure 1-3 for an Oregon county map). Collectively, these counties form what will be referred to as the analysis area. NREL researchers examined two different deployment scenarios using moderate and high WEC deployments between 2026 and 2045. A sensitivity study was also conducted to examine the effects of a regionally-based supply chain for WEC devices and services.

For the purposes of this study, ‘county-level economic impacts’ include jobs, lease revenue, earnings, and overall economic activity from wave energy project development. The described and quantified impacts are gross, not net impacts. In other words, the analysis does not account for potential job losses and reduced economic activity caused by the displacement of other types of electricity-generating facilities and the displacement of other activities (e.g., fishing), nor does it account for potential negative economic impacts to changes in rates or prices.

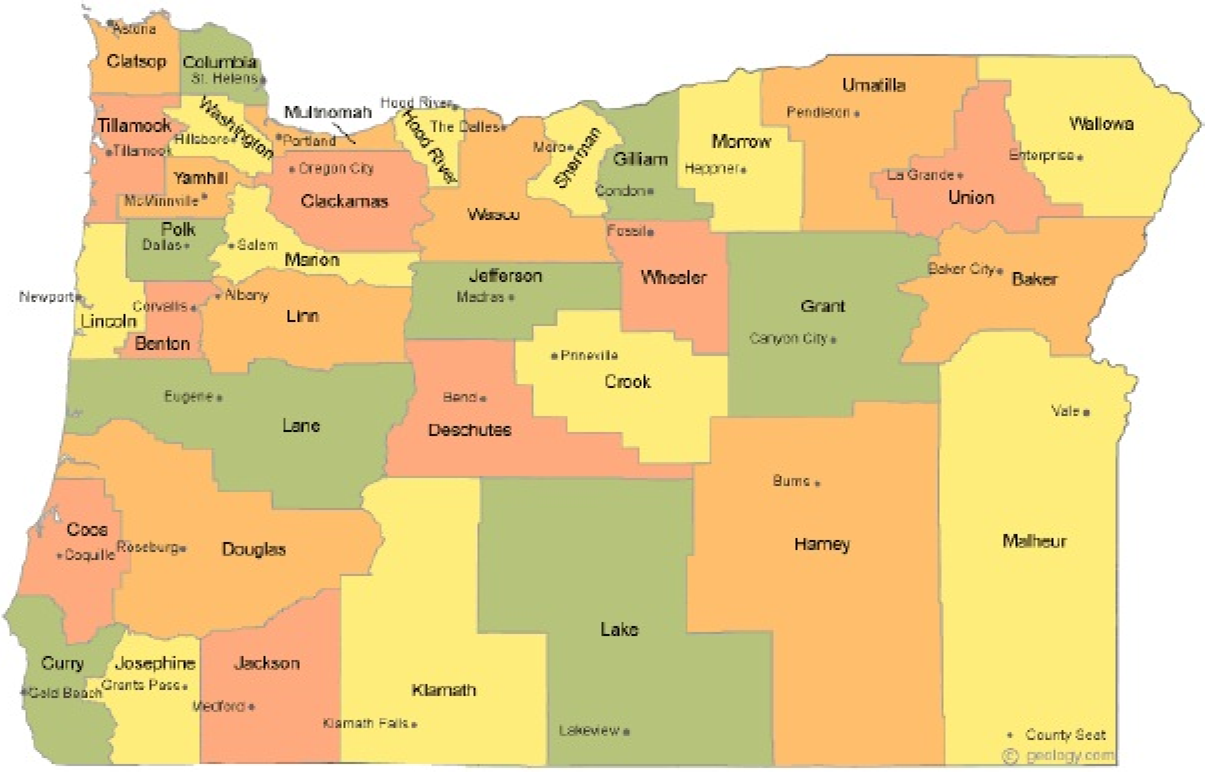

Figure 1-3. Oregon County Map
Source: Geology.com 2015

2 Methodology

2.1 The Jobs and Economic Development Impact Model

For this study, we used the MHK Jobs and Economic Development Impact (JEDI) model, which is one element of a suite of JEDI input-output (I-O) models. JEDI models provide gross estimated economic impacts that are supported by investment in a number of different energy technologies. NREL and MRG & Associates developed the MHK JEDI model to incorporate the unique aspects of MHK development into an economic impact tool that can be accessed and used by the public, at no cost.[7]

I-O models are widely recognized tools that are used to estimate economic impacts associated with expenditures. These models map how sectors in an economy such as businesses, households, workers, capital, and government organizations interact with one another via purchases and sales at a single point in time. Because sectors are related to one another, an increase in demand for one can lead to an increase in demand for another. An increase in demand for a steel plate, for example, results in an increased demand for the iron ore that is sourced within the region of analysis.

JEDI and other I-O models estimate economic impacts that could be supported by changes in demand for goods and services. JEDI estimates these changes with data from the project scenario and the IMPLAN I-O model. [8] The JEDI project scenario is a set of data that describes an energy-generation project in terms of expenditures. Each project contains two sets of line-item expense categories, such as equipment, materials and services, and labor. The first set covers the construction of the project and the second covers the operation and maintenance (O&M) of a project. JEDI models contain limited default cost data, but analysts with knowledge of the project details can edit the inputs to better represent the scenario being analyzed.

The JEDI model requires users to specify the portions of expenditures that are made within the region of analysis, i.e., the "local share." For example, users can specify the fraction of the device purchased from in-region manufacturers. JEDI uses expenditures made within the region of analysis, or "local expenditures," to estimate economic impacts (for example, it uses WEC devices manufactured within the coastal county region); however, it does not estimate economic impacts outside the particular region of analysis (e.g., generators from China).

JEDI reports economic impact estimates for two phases: construction and O&M. Construction-phase results are one-time totals that span the equivalent of 1 year,[9] and O&M phase results are annual and ongoing for the life of the facility.

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[7] The MHK JEDI model can be downloaded at http://www.nrel.gov/analysis/jedi/download.html.
[8] More information about IMPLAN can be found at http://www.implan.com.
[9] If, for example, JEDI reports a construction-phase impact of 50 workers to build a project that takes 2 years to complete, this equates to an average of 25 workers per year (50/2 = 25). If the same project takes 3 years, the average would be 17 (rounded) workers per year.

All impacts are based on expenditures and local content data contained within the project scenario worksheet. JEDI organizes these effects into different categories based on how the user-specified project scenario supports the impact. The workers who install a wave energy project, for example, are on-site. The workers who manufacture the wave energy device are part of the supply chain. Installers and manufacturers earn wages and spend money within the region of analysis, which supports further economic activity (e.g., the construction workers eat lunch at local sandwich shops). The three categories of impacts used by JEDI are[10]:

- **Project development and on-site labor impacts.** This category represents the economic activity that is either directly involved with a project's development and implementation or that occurs on-site. These impacts typically occur in the construction, maintenance, engineering, and port-staging sectors and do not include impacts that arise from expenditures for non-labor inputs used in a project.
- **Plant and supply chain impacts.** This category represents the economic activity that is supported by inputs purchased for a project or business-to-business services. These include locally manufactured inputs, such as the WEC conversion equipment (also referred to as the "device"), and locally procured inputs used to manufacture the device, such as steel and fiberglass. This category also includes services provided by professionals such as analysts and attorneys who assess project feasibility and negotiate contract agreements, banks that finance the projects, and all equipment companies and manufacturers of replacement and repair parts.
- **Induced impacts.** This category represents the impacts of money circulating in an economy. Households spend earnings generated from employment in project development as well as turbine and supply chain activities. A portion of these earnings spent within the region of analysis supports induced impacts, examples of which include: retail sales, child care, leisure, hospitality, and real estate services. (Goldberg and Previsic 2011)

Figure 2-1 shows the three categories of impacts from JEDI.

[10] Typically, I-O models organize impacts into direct, indirect, and induced effects, but JEDI categories are different. Project development and on-site labor impacts include less than typical "direct effects," and supply chain impacts are more broad than the typical "indirect effects." The MHK Wind JEDI User Reference Guide (http://www.nrel.gov/analysis/jedi) provides more information about these differences.

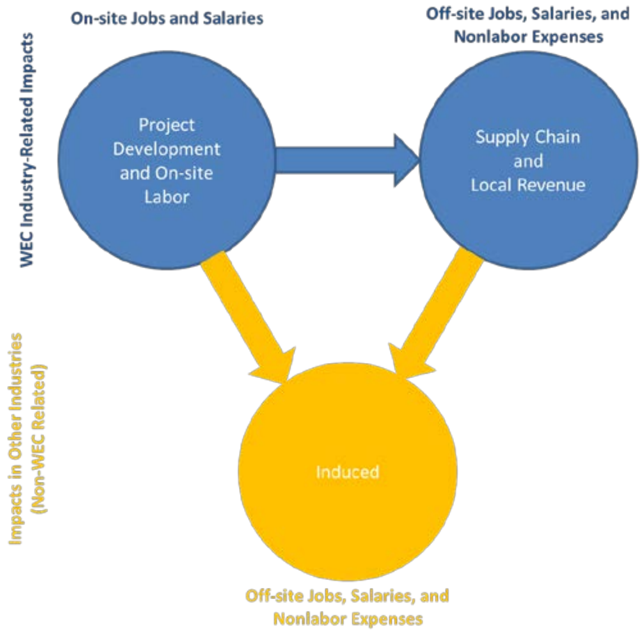

Figure 2-1. JEDI Wind model economic development impact categories

JEDI reports three different metrics for each type of impact: jobs, earnings, and gross output, and utilizes intuitive labels when reporting these metrics, such as "jobs" and "earnings." Each metric, however, has a specific definition that informs how it should be interpreted, as follows.

- **Jobs** are expressed as full-time equivalent (FTE) jobs. One FTE job is the equivalent of one person working 40 hours per week, year-round. Two people working full-time for 6 months equal one FTE. Two people each working 20 hours/week for 12 months also equal one FTE. An FTE could alternately be referred to as a person-year or job-year. Jobs, as reported by JEDI, are not limited to those who work for an employer—and may include other types of workers, such as sole proprietors (individuals that are self-employed).
- **Earnings** include any type of income generated from work, generally an employee's wage or salary and supplemental costs paid by employers such as health insurance and retirement. They may also include other nonwage compensation for work performed such as proprietor earnings.
- **Total economic activity (gross output)** is the sum of all expenditures. For example, a scenario in which a developer purchases a locally manufactured $500,000 WEC component that utilized $100,000 of locally procured aluminum represents $600,000 ($500,000 direct and $100,000 indirect) in gross output.

As with all economic models, there are caveats and limitations to the use of JEDI. I-O models in general utilize fixed, proportional relationships between sectors in an economy. This means that factors that could change these relationships, such as price changes that lead households to alter consumption patterns, are not considered.

JEDI provides estimates of gross economic impacts based on the user-specified expenditures and economic conditions provided when the I-O data were compiled.[11] Impacts that extend into the future (such as O&M impacts) are assumed to do so if all else is constant. There can be any number of changes in a dynamic economy that JEDI does not consider, so these future results should not be considered as a forecast. They simply reflect how a project might look if it was completed in the current economy under the user-specified cost and local content assumptions.

JEDI results are based on project inputs, and these inputs can change from project to project. These changes in input values are especially true of nascent technologies, or technologies that have not yet been widely deployed in the United States. If an analyst wishes to estimate impacts from a specific project, tailoring inputs to that project should produce more accurate results. JEDI does not evaluate whether or not inputs are reasonable, nor does it determine whether a project is feasible or profitable.

As stated, results from JEDI models are gross, not net. JEDI estimates economic activity that would be supported by demand created by project expenditures. Other changes in an economy will take place that JEDI does not consider, such as price changes, changes in taxes or subsidies, utility rate changes, or changes in property values. JEDI also does not incorporate far-reaching effects such as greenhouse gas emissions or displaced investments, or potential effects of a project such as changes in fishing, recreation, or tourism.

2.2 Research Data and Assumptions and Methodology

This analysis consists of two main parts: 1) the development or selection of MHK deployment scenarios, and 2) our analysis of the economic impacts of those scenarios.

2.2.1 Deployment Scenarios Description

Three cases are presented here that examine two deployment scenarios. We conducted a sensitivity analysis to assess the effects of a larger in-region supply chain. Table 2-1 summarizes the cases analyzed for this effort. Cases 1A and 1B both assume the lower deployment scenario in which West Coast-based WEC installations supply 80 terawatt-hours (TWh) of electricity annually by 2050.[12] Case 1A assumes that none of the WEC devices are sourced by in-state original equipment manufacturers (OEMs), therefore 0% “local share.” Case 1B assumes a 10% local share for the WEC device. Case 2B assumes a higher deployment scenario in which West Coast WEC installations supply 160 TWh of electricity annually by 2050, with a 10% WEC local share. These three cases examine the economic impact to Oregon counties of WEC facilities installed off their coastlines. Each of the scenarios is optimistic and would require technology improvements and cost reductions. Thus, we use the 13,000-MW deployment scenario as the focus for results.

[11] Economic multipliers are from 2012.
[12] This scenario timeframe runs through 2045. However, the model runs that we are basing the scenarios on run through 2050.

Table 2-1. Analysis Cases

Case Label	Deployment Scenario	Notes
1A	Lower deployment level (80-TWh scenario)	0% device local share
1B	Lower deployment level (80-TWh scenario)	10% device local share
2B	Higher deployment level (160-TWh scenario)	10% device local share

The deployment scenarios used in this analysis come from unpublished and hypothetical deployment scenarios for wave energy technology that explore the potential impacts of research and development improvements as well as manufacturing knowledge gains over long time periods (Cohen 2013, Thresher 2014). The hypothetical scenarios forced the deployment of WEC technology according to a specified deployment schedule without regard for its cost. It then estimated the overall capital cost under differing improvement assumptions using the Regional Energy Deployment System (ReEDS) model. ReEDS is a long-term capacity-expansion model for deploying electric-power-generation technologies and transmission infrastructure throughout the contiguous United States.[13] For a given set of economic, policy, and load growth assumptions, ReEDS models the deployment of transmission infrastructure as well as various conventional and renewable energy generation technologies. Within the constraints of the scenario (such as deployment of a certain amount of a specific technology), ReEDS will meet the anticipated load by using the least expensive (on a lifecycle cost basis) combination of transmission and generation. For the purpose of this analysis, we specified the deployment of WEC technology regardless of costs.

ReEDS estimates energy generation deployment by state, thus providing Oregon-specific WEC deployment values. Both deployment scenarios supply significant portions of the energy needs for the West Coast. We selected 2026 to 2045 as our analysis period because it captures the bulk of Oregon-based wave energy installations occurring within the ReEDS scenarios.

These scenarios are hypothetical, and deployments of this magnitude would not realistically happen without advancements in technology and a very significant reduction in the cost of energy for WEC technology.

The scenarios also include cost estimates, both capital and O&M, for the wave energy facilities. Compared to wind or solar energy, wave energy technology is still immature and costly. Current estimated installed capital expenditures (CAPEX) for wave energy plants are more than $8,272/MW. Current operating expenditures (OPEX) are estimated at $400/kilowatt (kW)/year. These values are a composite from several studies (Previsic et al. 2012; Renewable UK 2010; Department of Trade and Industry 2007). Although these costs are high, the current immaturity of wave energy technology makes it likely that significant cost reduction opportunities exist. The hypothetical cases analyzed here would require significant cost reductions over time resulting from technology improvements, acquiring knowledge, and a robust research and development program.

[13] http://www.nrel.gov/analysis/reeds/description.html

Table 2-2 shows the annual wave energy deployment in Oregon counties, as well as CAPEX and OPEX, for both scenarios. The 80-TWh scenarios (Cases 1A and 1B) show roughly 13,000 MW of wave energy deployment off the coast of Oregon by 2045, whereas Case 2B, the 160-TWh scenario, predicts WEC installations of over 18,000 MW. Note that the higher scenario does not represent twice the deployment (in Oregon) of the lower scenario. Because of Oregon's sizable wave energy resource, the state could reach significant levels of deployment, if technology advancements and cost reductions occurred. Of course, there are many siting considerations such as environmental, logistical, and public acceptance concerns that would need to be handled appropriately (e.g., development in certain waters could be restricted due to critical species habitat so developers must work with applicable state and federal agencies). As the overall West Coast deployment scenario increases in Case 2B, Oregon's best wave energy areas are saturated, and more development starts to occur in lower wave energy resource areas.

Both deployment scenarios envision sharp drops in both CAPEX and OPEX from the present baseline values of $8,272/kW and $400/kW/year. As stated, they also assume appropriate siting protocols. In the 80-TWh scenarios, Case 1A and Case 1B, CAPEX and OPEX drop to $1,098/kW and $53/kW/year in inflation-adjusted 2012 dollars, by the end of the analysis period. For the Case 2B 160-TWh scenario, the respective costs at the end of the analysis period are $966/kW and $47/kW/year—a very significant decrease. The cost reductions assumed here are ambitious and would take substantial technological improvements, but were modeled to show impacts during a timeframe in which WECs are assumed to have large cost reductions and few siting restrictions.

Table 2-2. Oregon Counties' Wave Energy Deployment Scenarios (2012 Dollars)

80 TWh Scenario					160 TWh Scenario			
Year	Installed (MW)	Installed Cost ($/kW)	Investment ($MM)		Year	Installed (MW)	Installed Cost ($/kW)	Investment ($MM)
2016	5	$8,272	$41.36		2016	11	$8,272	$90.99
2018	6	$8,272	$50		2018	11	$8,272	$91
2020	12	$4,963	$60		2020	23	$4,963	$114
2022	24	$4,960	$119		2022	47	$4,464	$210
2024	48	$3,122	$150		2024	97	$2,810	$273
2026	99	$2,809	$278		2026	197	$2,528	$498
2028	199	$2,528	$503		2028	398	$2,277	$906
2030	397	$1,824	$724		2030	790	$1,663	$1,314
2032	775	$1,669	$1,293		2032	1,570	$1,490	$2,339
2034	1,475	$1,502	$2,215		2034	1,540	$1,349	$2,077
2036	1,945	$1,370	$2,665		2036	2,405	$1,228	$2,953
2038	1,836	$1,269	$2,330		2038	3,117	$1,141	$3,556
2040	1,613	$1,182	$1,907		2040	2,647	$1,059	$2,803
2042	530	$1,140	$604		2042	593	$1,015	$602
2044	4,117	$1,098	$4,520		2044	5,024	$996	$5,004
Cumulative	**13,081**				**Cumulative**	**18,470**		

2.2.2 Methodology

Our research on expenditures and cost breakdowns consisted of a literature review (Carbon Trust 2011; Previsic et al. 2012). We conducted interviews with internal experts and MHK stakeholders to provide depth and validation of the analysis. Data obtained from interviews included construction costs, O&M costs, percentage of goods and services acquired in-state, job generation during the construction phase, job generation during the operation phase, land-lease payments, tax information, payroll parameters, and the cost breakdown of different installation and operation categories.

Using the information derived from the sources noted above, we developed specific assumptions including construction cost breakdown (Table 2-3), operating cost breakdown (Table 2-4), local (in-state) share for both CAPEX and OPEX, and other relevant parameters (Table 2-5), which were used as inputs in the JEDI model.

Table 2-3. Construction Cost Assumptions

Construction	% of Total Cost	Local Share
Equipment and Materials		
Device	69.2%	0%/10%
Underwater Electrical Collector System	7.8%	0%
Underwater Transmission Cable	1.3%	0%
Cable Landing and Grid Interconnection	1.9%	0%
Balance of Plant	4.1%	40%
Equipment and Materials Subtotal	*84.3%*	
Installation/Labor		
Mooring and Device Installation	6.8%	50%
Underwater Cable Installation	5.5%	0%
Cable Landing and Grid Connection	1.4%	80%
Installation/Labor Subtotal	*13.7%*	
Permitting		
Permitting	2.0%	35%
Permitting Subtotal	*2.0%*	
Sales Tax (Materials and Equipment Purchases)		
Sales Tax (Materials and Equipment Purchases)	0.0%	100%
Sales Tax Subtotal	*0.0%*	
Total	**100.0%**	

Tables 2-3, 2-4, and 2-5 show the assumptions behind the analysis. Local share refers to the percentage of resources (e.g., labor, materials, supplies, and equipment) purchased or acquired within the Oregon county region. Two values of the local share are given for the "device." The lower 0% value assumes no continued special effort to develop an Oregon-county-based WEC industry. The higher 10% value assumes a concerted effort to develop a large Oregon-county-based WEC industry and that the majority of the nonelectrical equipment is sourced by Oregon county-based OEMs. A large underwater electrical component industry already exists outside of Oregon, so the local share for these items is anticipated to be low. In addition, underwater cable installation uses specialized vessels that are not based in Oregon, resulting in the low value for the local share of the labor for the underwater cable installation.[14] Equipment costs represent about 84% of the total project cost, labor represents 14%, and permitting represents 2%.

Figure 2-2 shows the average capital expenditure breakdown assumptions used as inputs for this study.

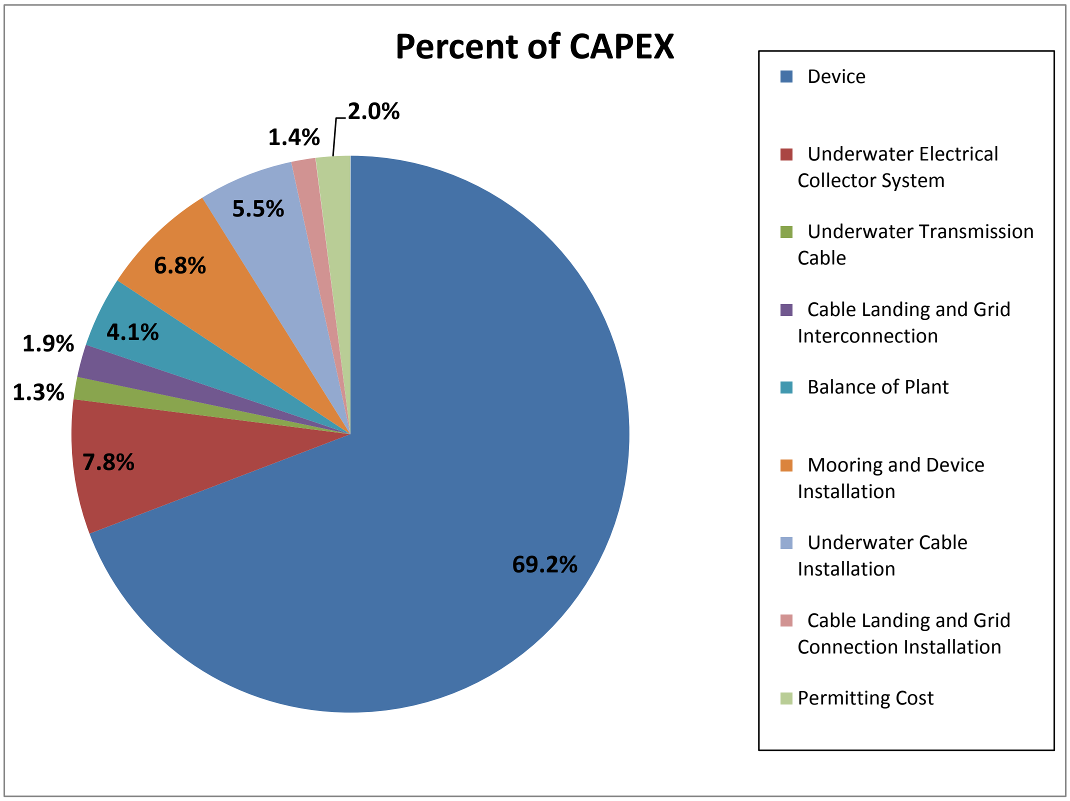

Figure 2-2. Construction cost breakdown assumptions

Table 2-4 shows the operating expenditure breakdown assumptions. Operating costs are assumed to be 4.8% of the capital cost and are comprised of just over 20% labor and fewer than 80% for materials and services. For both of these items, the local share is anticipated to be relatively high. We anticipate that most O&M workers will either already live in-state or settle within the state to conduct their jobs.

[14] If such vessels were to port in Oregon, there could be a greater economic impact than that reported in this analysis.

Table 2-4. Operating Cost Assumptions

Wind Plant Annual O&M Costs	% of Total Cost	Local Share
Labor		
Labor	21.1%	60%
Labor Subtotal	*21.1%*	
Materials and Services		
Materials and Services	78.9%	35%
Materials and Services Subtotal	78.9%	
Sales Tax (Materials and Equipment Purchases)[15]		
Sales Tax	0.0%	100%
Sales Tax Subtotal	*0.0%*	
Total O&M Cost	**100.0%**	

Table 2-5 shows the additional parameters considered in the analysis. Because of the large capital investment required, the analysis assumes that 100% of the investment for the WEC facilities comes from out of state (i.e., the local share is zero.) Deployment on the scale assumed for this analysis would require a total investment of $10–$20 billion.

As a result of assuming a zero local share for the investment, the only value in this section affecting the results is the lease rate. For lease purposes, the offshore facilities will fall into one of three zones:

1. Facilities located within 3 miles of the shoreline. These facilities are located in state waters and will be subject to lease rates determined by the State of Oregon.
2. Facilities located in federal waters that are greater than 3 miles from shore. These facilities must receive a lease from BOEM. For projects located 3–6 miles offshore, the state is entitled to 27% of the lease revenue.[16] Oregon counties receive approximately 30% of state revenues for those revenue-bearing projects that sit ashore their coastline.[16]
3. Facilities located beyond 6 miles from shore. These facilities do not need to provide the state with lease revenue.

Facilities located in federal waters may also be subject to Federal Energy Regulatory Commission fees; however, the state share of these fees is zero (Bowler 2014), and thus has no economic impact on Oregon.

It is anticipated that most installations will be conducted in water with depths of 50 meters (m)–100 m. For Oregon, this depth of water is generally located 3–6 miles offshore. Therefore, it is reasonable to assume that the majority of the installations will be positioned within this zone.

[15] The State of Oregon does not collect sales tax.

[16] Information on county, state, and federal leases and permitting is from the Oregon Wave Energy Trust and the State of Oregon. See Oregon SB 737 (2013 Regular Session) Section 3, Parts (4) and (5) for a description.

The BOEM lease rate used in the analysis is based on a precedent from four offshore leases for planned wind plants to be located in federal waters (BOEM 2010, 2013a, 2013b, and 2013c). For these projects, the initial operation phase lease rate is 2% of product of the facility's energy production and the average regional wholesale electricity rate. The lease rate used in the analysis assumes a 30% capacity factor, an average wholesale price of $0.04/kilowatt-hour. Of the total BOEM lease revenue, 27% goes to the State of Oregon.

Table 2-5. Additional Study Parameters Considered

Additional Parameters	Value	Local Share
Financial Parameters		
Percentage Financed	50%	0.0%
$ Years Financed (Term)	20	
Interest Rate	7%	
Percentage Equity	50%	
Corporate Investors (Percent of Total Equity)	90%	0.0%
Individual Investors (Percent of Total Equity)	10%	0.0%
Return on Equity (Annual Interest Rate)	12%	
Tax Parameters		
Local Property Tax (Percent of Taxable Value)		
Assessed Value (Percent of Construction Cost)		
Taxable Value (Percent of Assessed Value)		
Property Tax Exemption (Percent of Local Taxes)		
Local Property Taxes		0%
Local Sales Tax Rate		
Lease Cost (if applicable)		
Lease Cost ($/MW/year)	$2,102	9%

3 Results

NREL researchers used the JEDI model to estimate the economic impact of each of the three cases. Results showed significant economic impacts, given the prescribed robust deployment scenarios. Figure 3-1 summarizes the impacts for Case 1A, which assumes the 80-TWh deployment scenario and lower regional share for the WEC device. Table 3-1 summarizes the impacts for all three cases. Impacts reported are centered on JEDI model results, which include employment, property taxes, and local economic activity during the construction and operation phases. Although estimating all WEC-related impacts was beyond the scope of this analysis, new WEC installations may provide many other tangible (e.g., use tax generation, sales tax generation, water savings, vendor profits, and transmission line impacts) and intangible impacts (e.g., electricity price stability and environmental benefits).

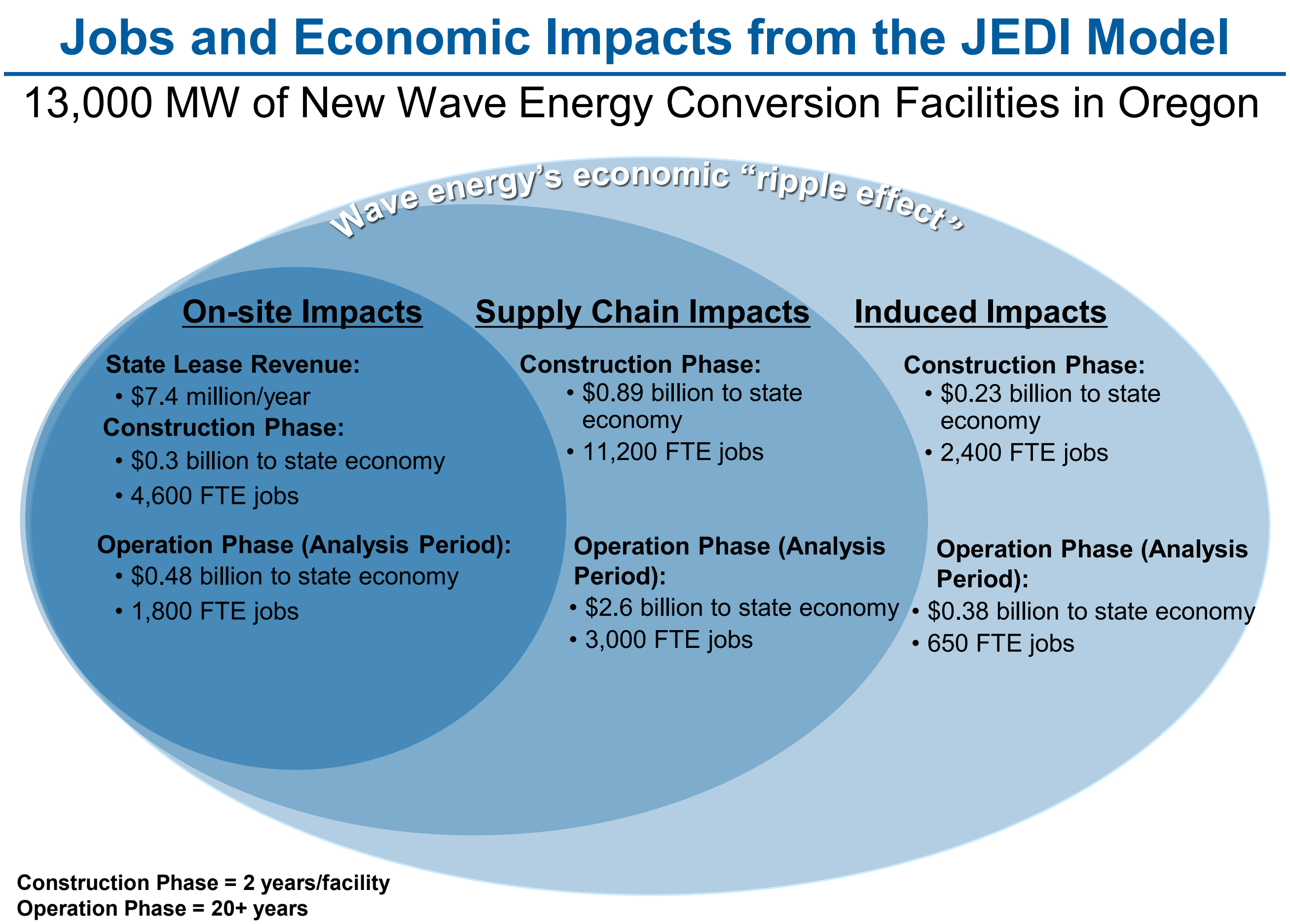

Figure 3-1. Economic ripple effect from 13,000 MW of WEC facility deployment (Cases 1A and 1B) in Oregon coastal counties from 2026 to 2045 (assuming no regionally-manufactured parts)

Table 3-1. Oregon Summary Impacts[17] from WEC Deployment (2026–2045)

	Case 1A	Case 1B	Case 2B
Jobs (FTE)	**TOTAL**	**TOTAL**	**TOTAL**
During Construction and Installation Period			
Project Development and Onsite Labor Impacts	4,602	4,602	5,971
Construction and Installation Labor	1,549	1,549	2,004
Construction and Installation-Related Services	3,053	3,053	3,967
Equipment and Supply Chain Impacts	11,182	21,318	27,628
Induced Impacts	2,409	4,424	5,728
Total Impacts	**18,193**	**30,344**	**39,326**
During Operating Years (by 2045)			
Onsite Labor Impacts			
WEC Project Labor Only	1,827	1,827	2,370
Local Revenue and Supply Chain Impacts	3,022	3,022	3,920
Induced Impacts	650	650	841
Total Impacts	**5,499**	**5,499**	**7,131**
Earnings ($MM)	**TOTAL**	**TOTAL**	**TOTAL**
During Construction and Installation Period			
Project Development and Onsite Labor Impacts	$ 137	$ 137	$ 83
Construction and Installation Labor	$ 68	$ 68	$ 91
Construction and Installation-Related Services	$ 70	$ 70	$ 991
Equipment and Supply Chain Impacts	$ 368	$ 765	$ 199
Induced Impacts	$ 84	$ 154	$ 1,364
Total Impacts	**$ 589**	**$ 1,056**	**$ -**
During Operating Years (by 2045)			
Onsite Labor Impacts			
WEC Project Labor Only	$ 78	$ 78	$ 102
Local Revenue and Supply Chain Impacts	$ 104	$ 104	$ 135
Induced Impacts	$ 23	$ 23	$ 29
Total Impacts	**$ 205**	**$ 205**	**$ 266**
Output ($MM)	**TOTAL**	**TOTAL**	**TOTAL**
During Construction and Installation Period			
Project Development and Onsite Labor Impacts	$ 301	$ 301	$ 386
Equipment and Supply Chain Impacts	$ 888	$ 2,349	$ 3,043
Induced Impacts	$ 230	$ 418	$ 541
Total Impacts	**$ 1,419**	**$ 3,067**	**$ 3,970**
During Operating Years (by 2045)			
Onsite Labor Impacts			
WEC Project Labor Only	$ 78	$ 78	$ 102
Local Revenue and Supply Chain Impacts	$ 418	$ 418	$ 542
Induced Impacts	$ 62	$ 62	$ 80
Total Impacts	**$ 558**	**$ 558**	**$ 724**

[17] Results are provided in real 2012 U.S. dollars.

3.1 Gross Economic Activity

As shown in Table 3-1, the modeled scenario's construction and operation of WEC facilities results in significant economic activity in Oregon. From rented accommodations that host the influx of construction workers to the suppliers and transportation companies that provide equipment, supplies, and services to the WEC facilities, WEC development could result in a substantial impact to the region's economy.

Depending on the device local share, 13,000 MW of WEC facilities in Oregon (Cases 1A and 1B) could generate approximately $1.4–$3.1 billion in gross economic activity during the construction phase and by 2045 continuously supports a total of $0.6 billion in economic activity during the operation phase. The lower $1.4-billion construction phase value assumes no device local share, which means that Oregon-county-based OEMs provide 0% of the WEC device capacity for WEC installations. The higher value, $3.1 billion, assumes that regionally-based device suppliers provide 10% of Oregon WEC installations. Raising the device's regional share from 0% to 10% increases the total equipment and supply chain construction-phase impacts from $888 million to $2.3 billion. In turn, the increased supply chain economic activity increases the induced construction phase impacts from $230 to $418 million during the analysis period.

The large variation in construction-phase economic activity shows the importance of the device regional share. Recall from Table 2-3 or Figure 2-2 that the "device," (the WEC energy conversion equipment) represents almost 70% of the capital cost of a WEC installation. Thus, the total economic impact of a WEC installation depends heavily on the proportion of the device that is supplied from within the analysis area (Oregon's coastal counties, in this case). The device local share will have a similarly large impact on overall construction-phase jobs and earnings impacts.

Assuming the larger deployment scenario of more than 18,000 MW of WEC facilities, along with a 10% device local share (Case 2B), results in almost $4 billion of construction-phase gross economic activity and $0.7 billion total operation-phase economic activity by 2045.

The impacts noted above include only the portion of transactions that take place in Oregon's coastal counties. For example, equipment and components that were purchased from other parts of Oregon or other countries are treated as monetary leakages and are not included in these estimates. Cases 1A and 1B assume that 13,000 MW of WEC installations represent $17 billion[18] in expenditures, which supports over $8 billion in economic activity for the entire state. This $8 billion in economic activity is comprised of approximately $0.6 billion in on-site project labor, $5.8 billion in construction materials and supply chain equipment, and $1.5 billion in induced activities during the construction phase (Figure 3-2), for the State of Oregon.

[18] 2012 U.S. dollars

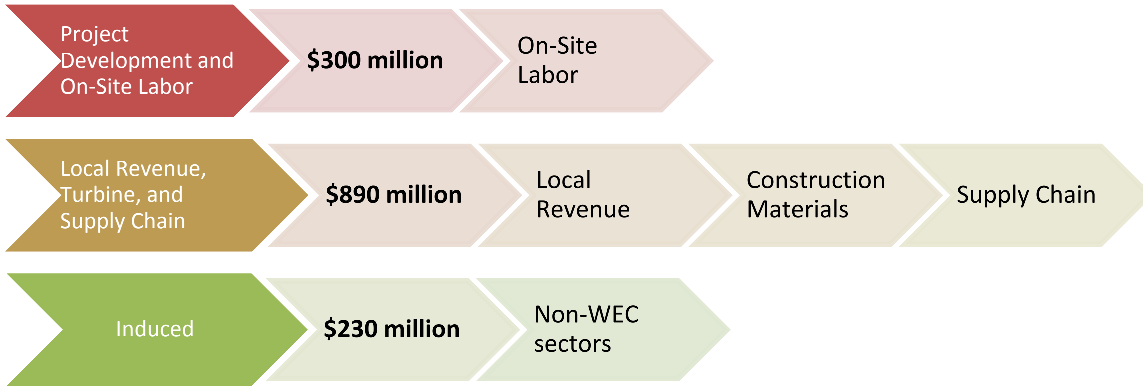

Figure 3-2. Estimated local spending supported by 13,000 MW of WEC facilities off the coast of Oregon during project construction (assuming no local content)

Figure 3-3 shows the impacts of each case throughout the analysis period. The figure goes two years beyond the end of the analysis period to show the operation- phase impacts of the WEC facilities installed during the final two-year installation cycle (2044–2045). As shown in Figure 3-3, construction-phase impacts vary over time depending on the amount of WEC capacity installed in each period. Operation-phase impacts grow over time as the cumulative WEC capacity increases. A similar trend can also be seen for the entire state of Oregon (see Figure 3-4). Corresponding to the number of jobs (see Figure ES-2), the magnitude of economic impacts from WEC installations is much greater for the entire state, given the larger economy.[19]

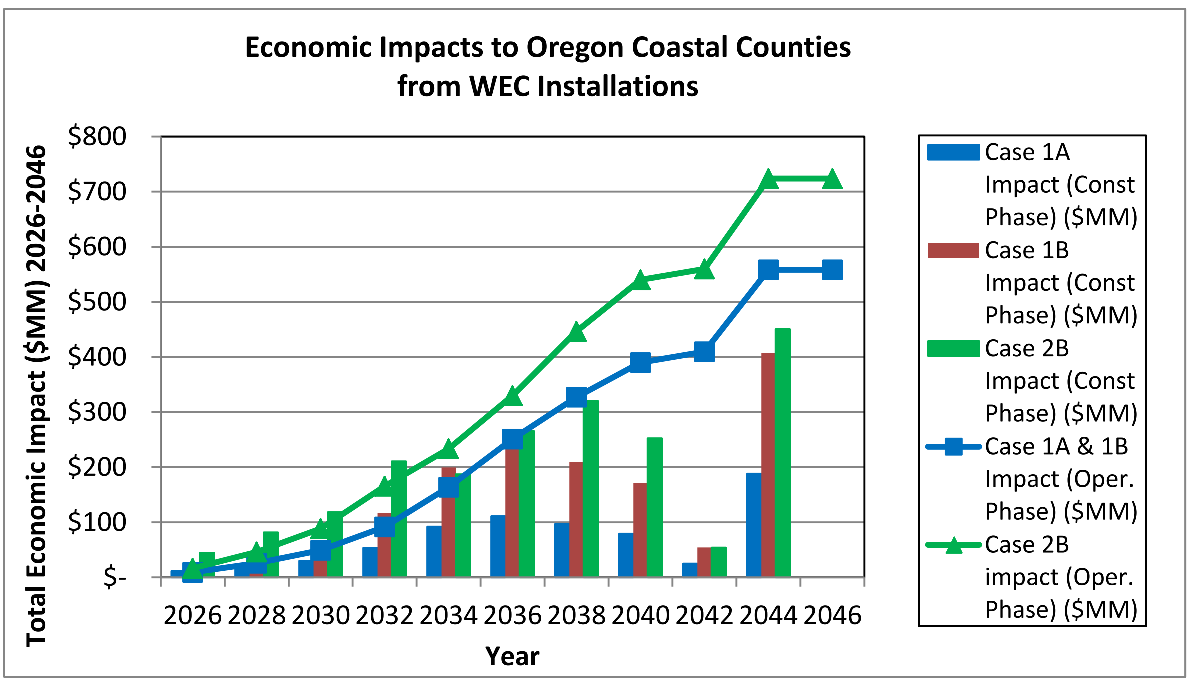

Figure 3-3. Estimated total economic impacts from WEC deployment in Oregon coastal counties throughout (and beyond) the analysis period

[19] Note that the report (Jimenez and Tegen 2015) in which the entire state's economy was considered, there was an additional scenario, Case 2C, which is not included in this analysis. Case 2C examined impacts from a scenario in which Oregon manufacturers export devices outside the state.

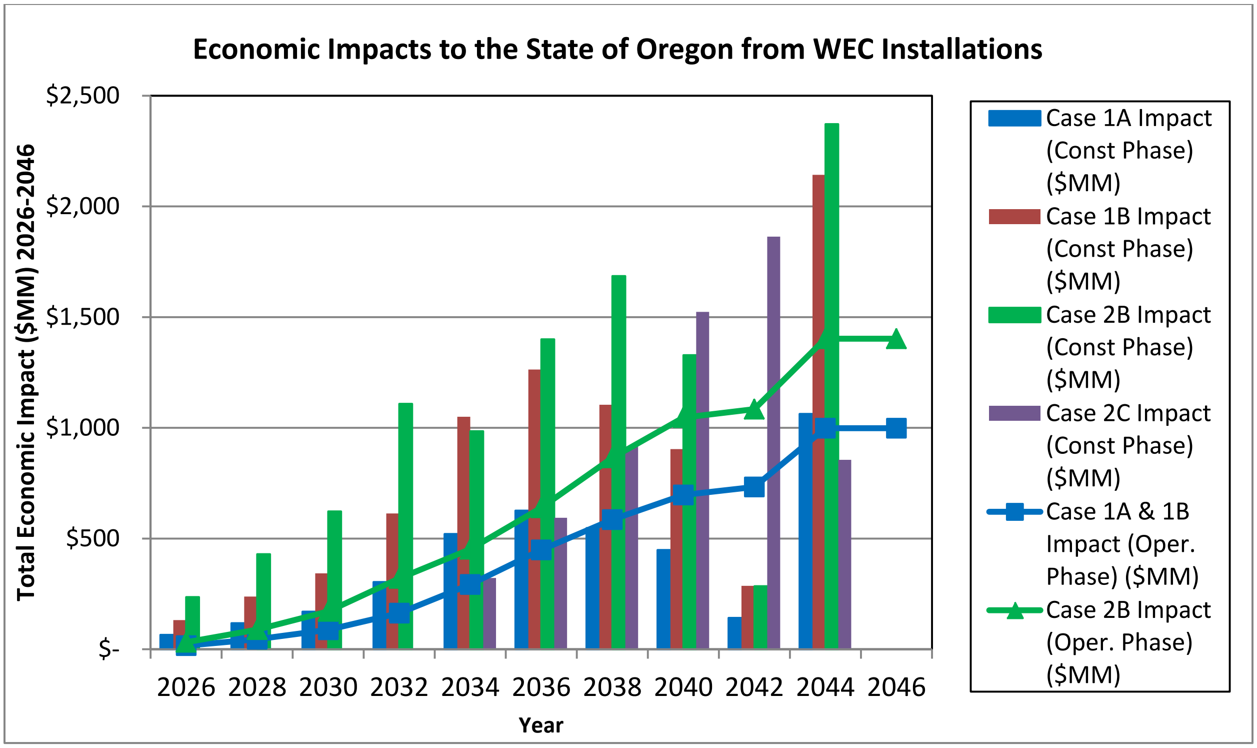

Figure 3-4. Estimated total economic impacts from WEC deployment in the State of Oregon throughout (and beyond) the analysis period

3.2 Employment Impacts

3.2.1 Construction Jobs

During the construction phase, construction workers, engineers, surveyors, WEC installers, electrical contractors, administrative employees, and managers who live in the project location support local economic activity. Local workers may be employed directly at the new WEC facility, depending on the talent pool and skill set in the area. Other workers from outside the seven-county region may settle within the region. Another category of workers reside out of region and only live within the region during the construction phase, moving on when construction is complete. Workers who reside in-state spend their earnings on groceries, childcare, education, utilities, tax payments, family entertainment and recreation, clothing, and so on. Out-of-region workers generate a different set of economic impacts. These temporary workers support a smaller ripple effect in the region's economy because most of their earnings are spent outside of the region, with a smaller portion circulating through the coastal economy. Most of their impacts are limited to spending on lodging, food, beverages, and transportation, which is often subsidized by the construction company. Because it is difficult to track the spending of out-of-region workers' earnings, they have not been included in this analysis.[20]

[20]By not including earnings from out-of-state workers in the analysis, we minimize the risk of overestimating the impacts in Oregon.

The number of employees building a WEC facility depends on the construction phase of the project. For example, the peak construction phase may require a significantly higher number of workers than the initial and final phases.

The NREL analysis indicates that large-scale deployment of WEC facilities in Oregon, per the three deployment scenarios, could support approximately 18,000–39,000 FTE jobs during the construction phase. Approximately 4,600–6,000 of these FTE jobs would be held by on-site workers (e.g., project development, engineering, construction, and electrical). Anticipated supply chain FTE jobs total approximately 11,000–28,000 (including providers of construction materials, supplies, and transportation), depending on the fraction of the device market that's captured by in-state manufacturers. Induced jobs amount to approximately 2,000–6,000 FTE jobs, again depending on the device market share captured by in-region manufacturers.

Figure 3-5 shows the year-by-year job impacts for the three cases.

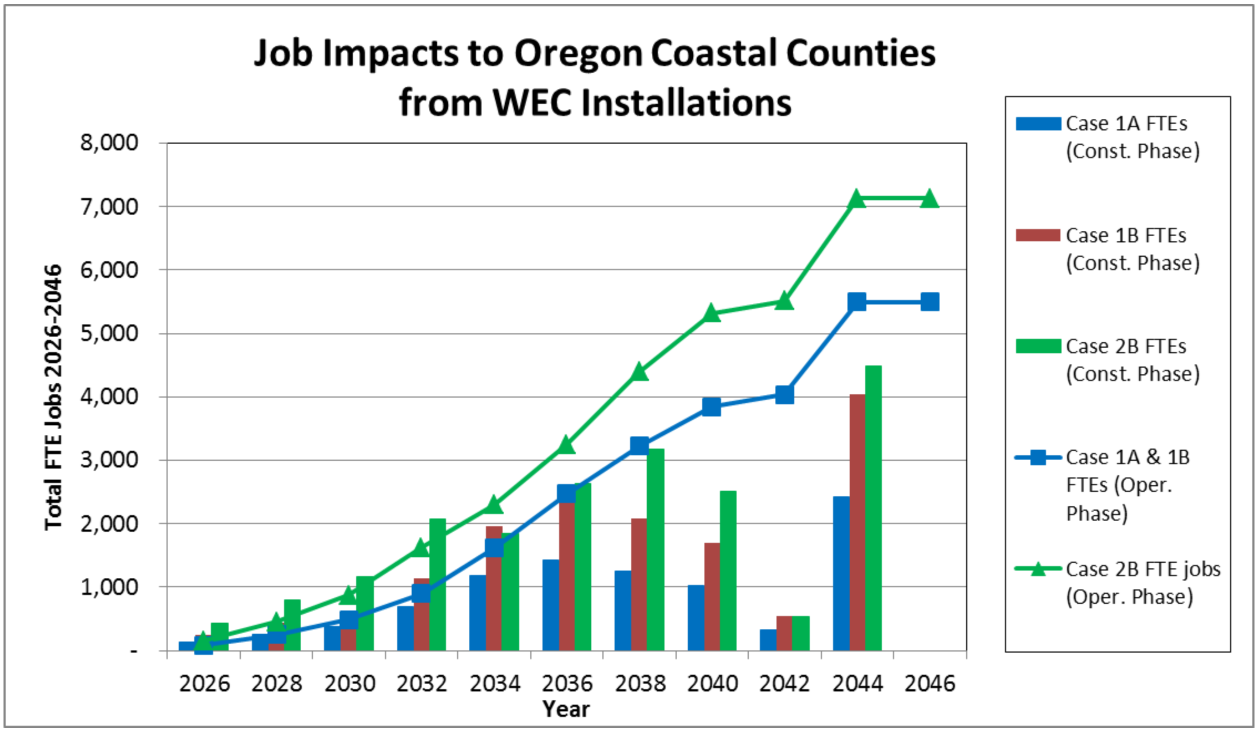

Figure 3-5. Estimated total employment impacts from WEC deployment in Oregon counties

3.2.2 Operation and Maintenance Jobs

Over the WEC facility's anticipated 20- to 30-year operating life, long-term employees operate and maintain the facility by replacing components, troubleshooting electrical and mechanical malfunctions, repairing the hydraulic system, conducting diving operations, performing remotely operated vehicle procedures, and conducting ship operations. The analysis assumes that the majority of these positions are filled by Oregonians or by people who relocate to Oregon.

According to the analysis, large-scale WEC deployment in Oregon would result in 5,500 (Cases 1A and 1B) to 7,100 (Case 2B) ongoing jobs by the time 13,000 MW or 18,000 MW is operational (respectively).[21] Of these ongoing jobs, approximately 1,800–2,400 would be on-site positions; 3,000–3,900 would be equipment and supply chain sector jobs; and 700–800 would be positions in other sectors (e.g., restaurants, hotels, and retail stores) resulting from the induced activity.

3.3 State Lease Revenue

Under the assumptions described in Section 2.2.2, 13,000 MW of WEC installations will yield $7.4 million annually to Oregon's government, and 18,000 MW of WEC installations will provide an estimated $10 million annually. This revenue can be used to fund and improve Oregon's infrastructure and public services or other appropriate funding avenues determined by the state. The seven counties would benefit from the annual revenue, receiving 30% of the revenue generated from projects off of their coastlines (O'Neil 2014).

[21] Unlike the construction phase, in which several temporary workers are hired, during the operation phase, permanent workers are hired at the state level. Thus, the number of jobs reported during this period remains constant for every year that the WEC facility is operating. In other words, 13,000 MW of wind project development in Oregon would support 6,800 local jobs every year that the WEC facilities are in operation— approximately 20 years.

4 Oregon Manufacturing Sensitivity Analysis

Economic development impacts depend, to a great degree, on the extent to which goods and services are acquired at the local level. WEC device and component manufacturing is anticipated to constitute 70% of the total construction cost of a WEC installation, thereby offering the largest potential source of economic development benefits at the state level. Because of this, Oregon counties are actively seeking to establish a WEC supply chain to maximize the economic benefits within Oregon of its significant wave energy resource (Oregon Wave Energy Trust 2014).[22]

To examine the effects of in-state manufacturing, this study includes a sensitivity analysis that investigates different values for a case in which there is local manufacturing for the WEC, or "device local share." Case 1A assumes a 0% value for the device local share, whereas Case 1B assumes 10%.

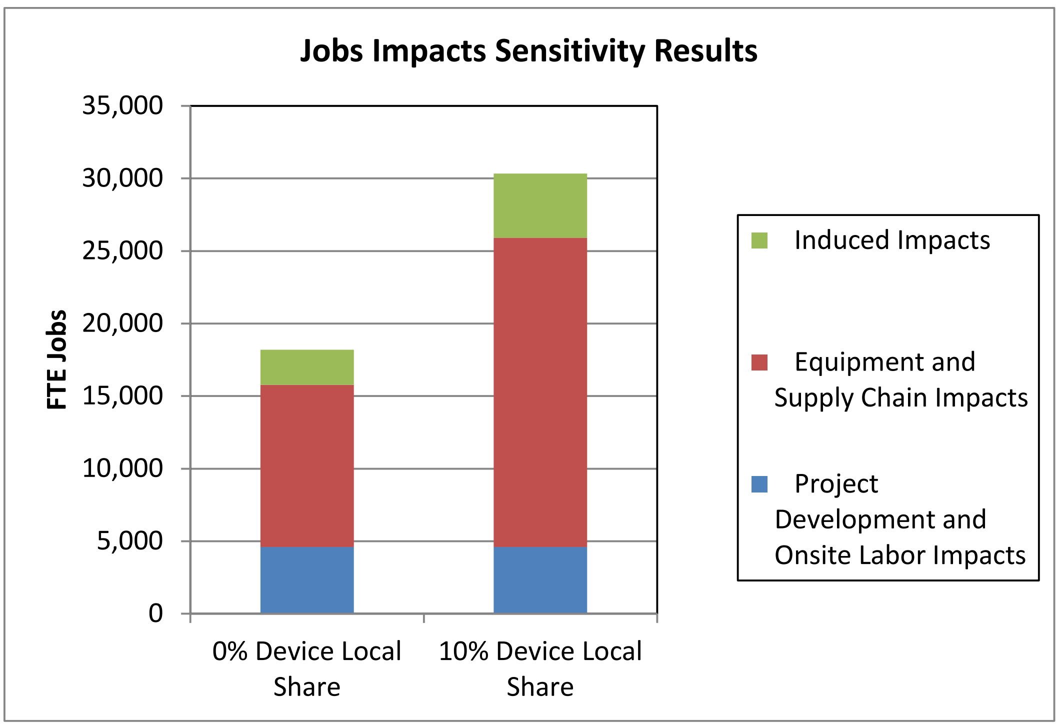

Figure 4-1. Manufacturing scenarios and associated job impacts during construction comparing WEC devices with 0% (Case 1A) and 10% (Case 1B) local device share

Figure 4-1 shows the dramatic impact of local manufacturing on jobs: 13,000 MW of WEC facilities could support a total of roughly 4,600 project development and on-site construction-phase FTE jobs between 2026 and 2045. Figure 4-2, showing construction-phase economic activity for the two scenarios, again shows the supply chain economic activity dwarfing the economic activity related to developing and installing the projects. Establishing an in-state

[22] In 2013, Oregon had a durable goods manufacturing workforce of approximately 123,000 people, according to the Bureau of Labor Statistics (2014). The opportunity to locally manufacture WEC devices could support additional jobs.

supply chain that captures even a modest portion of WEC installations will dramatically increase the economic impact of large-scale WEC deployment.

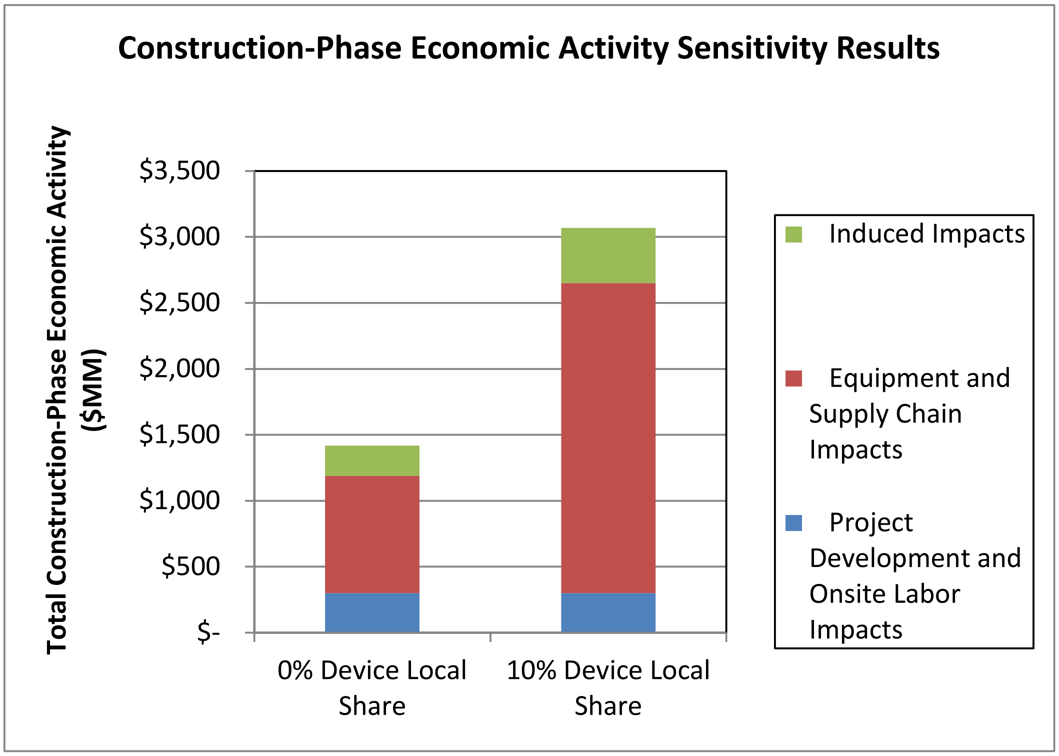

Figure 4-2. Manufacturing scenarios and associated economic impacts during the construction phase

5 Conclusion

Large-scale WEC deployment could have a significant impact on Oregon's economy. Over the 20-year analysis period, deployment of 13,000 MW of WEC facilities (Cases 1A and 1B) would support over 18,000 construction-phase FTE jobs (an average of approximately 910 construction-phase FTE jobs annually) and result in 5,500 ongoing operation-phase FTE jobs by 2045. Gross economic activity for this case totals $1.4 billion during the construction phase, $0.6 billion by 2045 during the operation phase, and $0.6 billion annually after the analysis period. The economic impacts are even greater if in-state manufacturers capture a larger portion of the Oregon market (Case 1B), or if there are more installations (Case 2B).

NREL analysis shows that WEC device manufacturing appears to be the leading economic development driver in this analysis. It has the potential to provide significantly more jobs and associated economic impacts compared to other WEC activities. Specifically, for Case 1B, where in-state manufacturers capture 10% of the state market, the estimated supply chain jobs dwarf the jobs that are directly involved in developing and installing the facilities. Development of a local manufacturing base, as well as use of local labor and materials, can greatly enhance the economic impacts of WEC technology deployment and provide further opportunities for economic diversification and growth. As stated above, this analysis assumed improvements in technology and the cost of WEC devices. It also assumes that any permitting and siting concerns have been resolved so that responsible and appropriate deployment can take place. Without these improvements and resolutions, such high deployment of this electric-generation technology would not be possible.

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Appendix

Table A-1 shows the jobs in each Jobs and Economic Development Impacts category for each year of the scenario. The jobs listed during operating years are not cumulative, so to reach the total number of operation and maintenance (O&M) jobs, the jobs from each year must be summed. For example, in 2026, there are 99 megawatts (MW) of wave energy converter (WEC) devices installed, and an estimated 91 Oregon jobs to operate and maintain that fleet. Two years later, when there are 199 MW installed, Table A-1 shows 162 jobs. To reach the total O&M jobs supported by projects installed in 2026-2028, we add operating year totals to get 253 Oregon-based operations and maintenance jobs that are ongoing, so they will exist over the life of the energy-generation system. This same method of reporting is used in the following tables for operation-phase jobs.

Table A-1. Case 1A Results – Full-Time Equivalent (FTE) Jobs

JOBS	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	72	132	193	347	596
Construction and Installation Labor	25	46	66	118	201
Construction and Installation-Related Services	47	86	128	229	395
Equipment and Supply Chain Impacts	176	320	470	842	1,449
Induced Impacts	39	71	102	183	313
Total Impacts	287	523	765	1,371	2,358
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	30	54	78	138	236
Local Revenue and Supply Chain Impacts	50	89	129	228	391
Induced Impacts	11	19	28	49	84

JOBS	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	720	631	517	164	1,229
Construction and Installation Labor	242	212	173	55	411
Construction and Installation-Related Services	477	419	344	109	818
Equipment and Supply Chain Impacts	1,749	1,533	1,257	399	2,988
Induced Impacts	377	330	270	86	640
Total Impacts	2,845	2,493	2,044	649	4,857
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	286	249	205	65	486
Local Revenue and Supply Chain Impacts	473	412	339	107	804
Induced Impacts	102	89	73	23	173

Table A-2. Case 1A Results–Earnings

Earnings [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 2.97	$ 5.12	$ 6.44	$ 11.14	$ 18.40
Construction and Installation Labor	$ 1.90	$ 3.15	$ 3.52	$ 5.89	$ 9.36
Construction and Installation-Related Services	$ 1.08	$ 1.97	$ 2.92	$ 5.24	$ 9.04
Equipment and Supply Chain Impacts	$ 5.75	$ 10.50	$ 15.43	$ 27.69	$ 47.66
Induced Impacts	$ 1.35	$ 2.45	$ 3.55	$ 6.34	$ 10.88
Total Impacts	$ 10.08	$ 18.07	$ 25.42	$ 45.17	$ 76.94
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 1.29	$ 2.32	$ 3.33	$ 5.91	$ 10.13
Local Revenue and Supply Chain Impacts	$ 1.71	$ 3.08	$ 4.44	$ 7.87	$ 13.49
Induced Impacts	$ 0.37	$ 0.66	$ 0.96	$ 1.70	$ 2.92

Earnings [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 21.48	$ 18.36	$ 14.72	$ 4.62	$ 34.20
Construction and Installation Labor	$ 10.56	$ 8.76	$ 6.84	$ 2.12	$ 15.47
Construction and Installation-Related Services	$ 10.93	$ 9.59	$ 7.87	$ 2.50	$ 18.73
Equipment and Supply Chain Impacts	$ 57.55	$ 50.46	$ 41.40	$ 13.14	$ 98.40
Induced Impacts	$ 13.10	$ 11.46	$ 9.38	$ 2.97	$ 22.25
Total Impacts	$ 92.13	$ 80.28	$ 65.50	$ 20.73	$ 154.85
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 12.25	$ 10.68	$ 8.77	$ 2.78	$ 20.81
Local Revenue and Supply Chain Impacts	$ 16.30	$ 14.23	$ 11.68	$ 3.70	$ 27.72
Induced Impacts	$ 3.53	$ 3.09	$ 2.54	$ 0.80	$ 6.03

Table A-3. Case 1A Results – Total Economic Impacts

Output [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 5.54	$ 9.79	$ 13.29	$ 23.43	$ 39.54
Construction and Installation Labor					
Construction and Installation-Related Services					
Equipment and Supply Chain Impacts	$ 13.87	$ 25.31	$ 37.23	$ 66.82	$ 115.02
Induced Impacts	$ 3.71	$ 6.73	$ 9.73	$ 17.41	$ 29.85
Total Impacts	$ 23.11	$ 41.83	$ 60.26	$ 107.65	$ 184.41
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 1.29	$ 2.32	$ 3.33	$ 5.91	$ 10.13
Local Revenue and Supply Chain Impacts	$ 6.86	$ 12.36	$ 17.79	$ 31.57	$ 54.08
Induced Impacts	$ 1.01	$ 1.82	$ 2.62	$ 4.67	$ 8.00

Output [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 47.00	$ 40.73	$ 33.07	$ 10.44	$ 77.80
Construction and Installation Labor					
Construction and Installation-Related Services					
Equipment and Supply Chain Impacts	$ 138.89	$ 121.81	$ 99.93	$ 31.71	$ 237.53
Induced Impacts	$ 35.94	$ 31.45	$ 25.76	$ 8.16	$ 61.11
Total Impacts	$ 221.84	$ 193.99	$ 158.76	$ 50.31	$ 376.44
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 12.25	$ 10.68	$ 8.77	$ 2.78	$ 20.81
Local Revenue and Supply Chain Impacts	$ 65.37	$ 57.04	$ 46.82	$ 14.85	$ 111.13
Induced Impacts	$ 9.69	$ 8.46	$ 6.95	$ 2.21	$ 16.53

Table A-4. Case 1B Results – FTE Jobs

JOBS	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	72	132	193	347	596
Construction and Installation Labor	25	46	66	118	201
Construction and Installation-Related Services	47	86	128	229	395
Equipment and Supply Chain Impacts	341	619	900	1,612	2,767
Induced Impacts	72	130	188	335	575
Total Impacts	485	881	1,281	2,294	3,938
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	30	54	78	138	236
Local Revenue and Supply Chain Impacts	50	89	129	228	391
Induced Impacts	11	19	28	49	84

JOBS	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and Onsite Labor Impacts	720	631	517	164	1,229
Construction and Installation Labor	242	212	173	55	411
Construction and Installation Related Services	477	419	344	109	818
Equipment and Supply Chain Impacts	3,334	2,919	2,391	758	5,676
Induced Impacts	692	605	495	157	1,175
Total Impacts	4,745	4,155	3,404	1,079	8,080
During Operating Years					
Onsite Labor Impacts					
Hydro Project Labor Only	286	249	205	65	486
Local Revenue and Supply Chain Impacts	473	412	339	107	804
Induced Impacts	102	89	73	23	173

Table A-5. Case 1B Results – Earnings

Earnings [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 2.97	$ 5.12	$ 6.44	$ 11.14	$ 18.40
Construction and Installation Labor	$ 1.90	$ 3.15	$ 3.52	$ 5.89	$ 9.36
Construction and Installation-Related Services	$ 1.08	$ 1.97	$ 2.92	$ 5.24	$ 9.04
Equipment and Supply Chain Impacts	$ 12.23	$ 22.21	$ 32.29	$ 57.80	$ 99.23
Induced Impacts	$ 2.50	$ 4.52	$ 6.53	$ 11.66	$ 19.99
Total Impacts	$ 17.70	$ 31.85	$ 45.25	$ 80.60	$ 137.62
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 1.29	$ 2.32	$ 3.33	$ 5.91	$ 10.13
Local Revenue and Supply Chain Impacts	$ 1.71	$ 3.08	$ 4.44	$ 7.87	$ 13.49
Induced Impacts	$ 0.37	$ 0.66	$ 0.96	$ 1.70	$ 2.92

Earnings [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 21.48	$ 18.36	$ 14.72	$ 4.62	$ 34.20
Construction and Installation Labor	$ 10.56	$ 8.76	$ 6.84	$ 2.12	$ 15.47
Construction and Installation-Related Services	$ 10.93	$ 9.59	$ 7.87	$ 2.50	$ 18.73
Equipment and Supply Chain Impacts	$ 119.57	$ 104.70	$ 85.78	$ 27.20	$ 203.62
Induced Impacts	$ 24.05	$ 21.04	$ 17.22	$ 5.46	$ 40.84
Total Impacts	$ 165.11	$ 144.09	$ 117.71	$ 37.27	$ 278.66
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 12.25	$ 10.68	$ 8.77	$ 2.78	$ 20.81
Local Revenue and Supply Chain Impacts	$ 16.30	$ 14.23	$ 11.68	$ 3.70	$ 27.72
Induced Impacts	$ 3.53	$ 3.09	$ 2.54	$ 0.80	$ 6.03

Table A-6. Case 1B Results – Total Economic Impacts

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Output [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 5.54	$ 9.79	$ 13.29	$ 23.43	$ 39.54
Construction and Installation Labor					
Construction and Installation-Related Services					
Equipment and Supply Chain Impacts	$ 37.71	$ 68.44	$ 99.31	$ 177.70	$ 304.93
Induced Impacts	$ 6.78	$ 12.28	$ 17.73	$ 31.69	$ 54.31
Total Impacts	$ 50.02	$ 90.51	$ 130.33	$ 232.81	$ 398.79
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 1.29	$ 2.32	$ 3.33	$ 5.91	$ 10.13
Local Revenue and Supply Chain Impacts	$ 6.86	$ 12.36	$ 17.79	$ 31.57	$ 54.08
Induced Impacts	$ 1.01	$ 1.82	$ 2.62	$ 4.67	$ 8.00

Output [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 47.00	$ 40.73	$ 33.07	$ 10.44	$ 77.80
Construction and Installation Labor					
Construction and Installation-Related Services					
Equipment and Supply Chain Impacts	$ 367.31	$ 321.53	$ 263.37	$ 83.50	$ 625.04
Induced Impacts	$ 65.36	$ 57.18	$ 46.80	$ 14.84	$ 111.01
Total Impacts	$ 479.68	$ 419.44	$ 343.24	$ 108.78	$ 813.86
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 12.25	$ 10.68	$ 8.77	$ 2.78	$ 20.81
Local Revenue and Supply Chain Impacts	$ 65.37	$ 57.04	$ 46.82	$ 14.85	$ 111.13
Induced Impacts	$ 9.69	$ 8.46	$ 6.95	$ 2.21	$ 16.53

Table A-7. Case 2B Results – FTE Jobs

JOBS	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	131	239	352	630	561
Construction and Installation Labor	45	82	119	213	189
Construction and Installation-Related Services	85	157	233	417	373
Equipment and Supply Chain Impacts	613	1,120	1,637	2,922	2,600
Induced Impacts	129	235	341	607	539
Total Impacts	873	1,593	2,330	4,159	3,701
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	54	97	139	252	223
Local Revenue and Supply Chain Impacts	89	161	230	416	369
Induced Impacts	19	34	49	89	79

JOBS	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	800	966	763	164	1,364
Construction and Installation Labor	268	323	255	55	455
Construction and Installation-Related Services	532	643	508	109	909
Equipment and Supply Chain Impacts	3,702	4,463	3,522	757	6,292
Induced Impacts	767	924	729	156	1,301
Total Impacts	5,270	6,353	5,013	1,077	8,957
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	316	382	306	65	537
Local Revenue and Supply Chain Impacts	523	631	507	107	888
Induced Impacts	112	135	109	23	191

Table A-8. Case 2B Results – Earnings

Earnings [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 5.07	$ 8.81	$ 11.30	$ 19.38	$ 16.67
Construction and Installation Labor	$ 3.12	$ 5.22	$ 5.97	$ 9.83	$ 8.14
Construction and Installation-Related Services	$ 1.95	$ 3.59	$ 5.33	$ 9.55	$ 8.53
Equipment and Supply Chain Impacts	$ 21.99	$ 40.15	$ 58.71	$ 104.79	$ 93.25
Induced Impacts	$ 4.48	$ 8.15	$ 11.85	$ 21.11	$ 18.75
Total Impacts	$ 31.53	$ 57.11	$ 81.85	$ 145.28	$ 128.67
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 2.29	$ 4.18	$ 5.96	$ 10.78	$ 9.55
Local Revenue and Supply Chain Impacts	$ 3.05	$ 5.56	$ 7.92	$ 14.35	$ 12.71
Induced Impacts	$ 0.66	$ 1.19	$ 1.70	$ 3.09	$ 2.76

Earnings [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 23.05	$ 27.19	$ 21.01	$ 4.46	$ 36.92
Construction and Installation Labor	$ 10.87	$ 12.47	$ 9.38	$ 1.96	$ 16.11
Construction and Installation-Related Services	$ 12.18	$ 14.71	$ 11.63	$ 2.50	$ 20.81
Equipment and Supply Chain Impacts	$ 132.79	$ 160.10	$ 126.33	$ 27.14	$ 225.71
Induced Impacts	$ 26.67	$ 32.13	$ 25.33	$ 5.44	$ 45.23
Total Impacts	$ 182.51	$ 219.41	$ 172.67	$ 37.05	$ 307.86
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 13.54	$ 16.36	$ 13.13	$ 2.77	$ 23.00
Local Revenue and Supply Chain Impacts	$ 18.02	$ 21.77	$ 17.48	$ 3.69	$ 30.63
Induced Impacts	$ 3.90	$ 4.70	$ 3.78	$ 0.80	$ 6.65

Table A-9. Case 2B Results – Total Economic Impacts

Output [$MM (2012)]	2026	2028	2030	2032	2034
During Construction and Installation Period					
Project Development and On-site Labor Impacts	$ 9.69	$ 17.28	$ 23.78	$ 41.71	$ 36.58
Construction and Installation Labor					
Construction and Installation-Related Services					
Equipment and Supply Chain Impacts	$ 67.75	$ 123.64	$ 180.50	$ 322.02	$ 286.44
Induced Impacts	$ 12.16	$ 22.14	$ 32.19	$ 57.35	$ 50.96
Total Impacts	$ 89.60	$ 163.06	$ 236.46	$ 421.08	$ 373.98
During Operating Years					
Onsite Labor Impacts					
WEC Project Labor Only	$ 2.29	$ 4.18	$ 5.96	$ 10.78	$ 9.55
Local Revenue and Supply Chain Impacts	$ 12.24	$ 22.29	$ 31.77	$ 57.56	$ 50.97
Induced Impacts	$ 1.79	$ 3.27	$ 4.67	$ 8.46	$ 7.55

Output [$MM (2012)]	2036	2038	2040	2042	2044
During Construction and Installation Period					
Project Development and Onsite Labor Impacts	$ 51.44	$ 61.45	$ 48.07	$ 10.28	$ 85.32
Construction and Installation Labor					
Construction and Installation Related Services					
Equipment and Supply Chain Impacts	$ 407.76	$ 491.52	$ 387.76	$ 83.30	$ 692.68
Induced Impacts	$ 72.49	$ 87.32	$ 68.85	$ 14.79	$ 122.94
Total Impacts	$ 531.69	$ 640.29	$ 504.69	$ 108.37	$ 900.94
During Operating Years					
On-site Labor Impacts					
WEC Project Labor Only	$ 13.54	$ 16.36	$ 13.13	$ 2.77	$ 23.00
Local Revenue and Supply Chain Impacts	$ 72.26	$ 87.30	$ 70.09	$ 14.80	$ 122.81
Induced Impacts	$ 10.69	$ 12.88	$ 10.35	$ 2.20	$ 18.23