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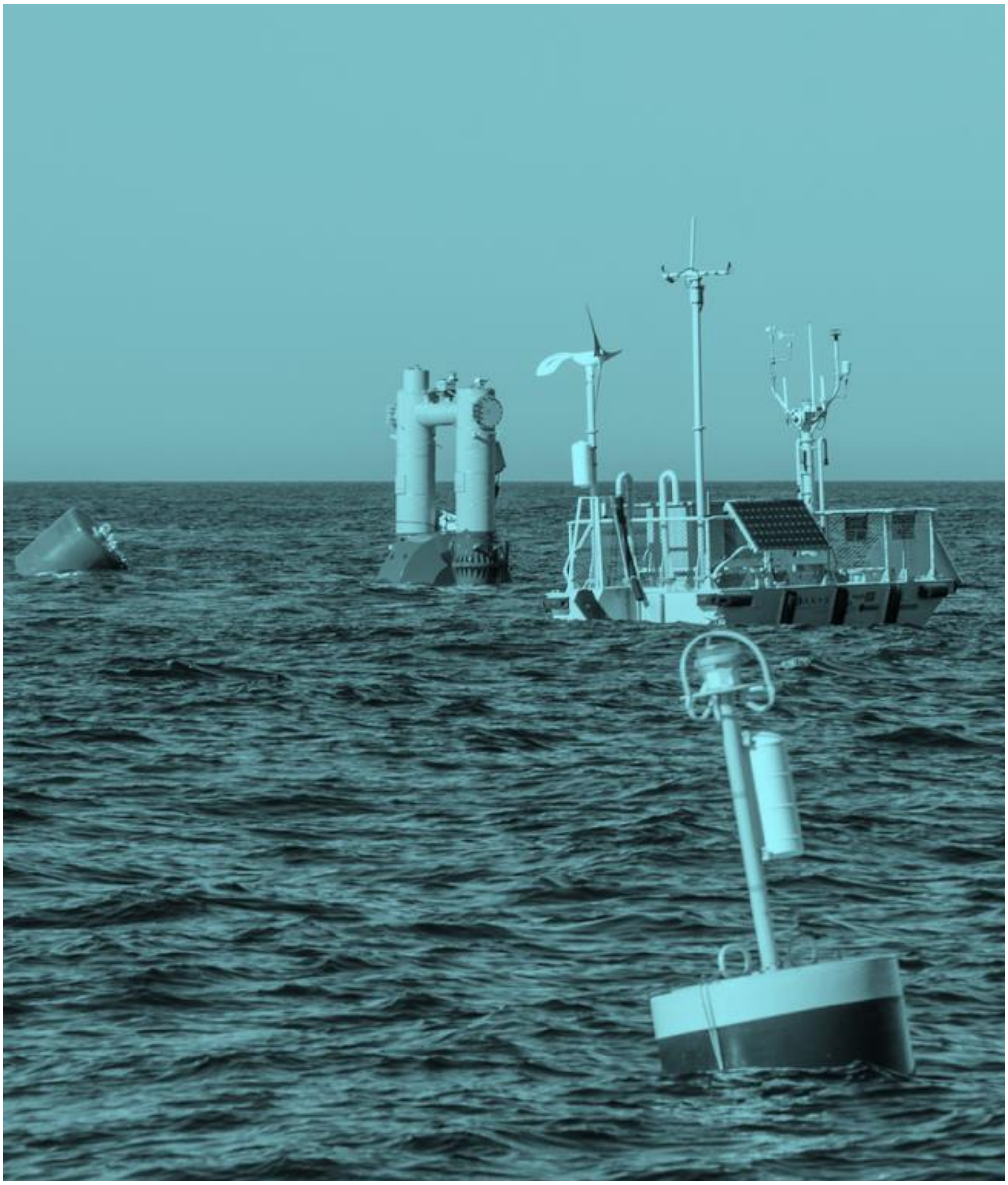
Wave Energy in Clatsop County, OR: An Economic Impact Analysis



NORTHWEST ECONOMIC RESEARCH CENTER

NeRC

Northwest Economic Research Center
College of Urban and Public Affair
Portland State University

Acknowledgments

The following report was researched and written by the Northwest Economic Research Center (NERC) at the request of the Oregon Wave Energy Trust (OWET).

Oregon Wave Energy Trust (OWET) is a nonprofit public-private partnership funded by the Oregon Innovation Council. Its mission is to support the responsible development of wave energy in Oregon. OWET emphasizes an inclusive, collaborative model to ensure that Oregon maintains its competitive advantage and maximizes the economic development potential of this emerging industry. Their work includes stakeholder outreach and education, policy development, environmental assessment, applied research and market development. OWET staff members Matthew Sanders and Jason Busch were instrumental in the completion of the report. They provided feedback and introductions to industry members. Columbia Power Technologies and M3Wave Energy Systems LLC provided data that was used in the model building and economic impact estimates.

NERC is based at Portland State University in the College of Urban and Public Affairs. The Center focuses on economic research that supports public-policy decision-making, and relates to issues important to Oregon and the Portland Metropolitan Area. NERC serves the public, nonprofit, and private sector communities with high quality, unbiased, and credible economic analysis. The Director of NERC is Dr. Thomas Potiowsky, who also serves as the Chair of the Department of Economics at Portland State University. Dr. Jenny Liu is NERC's Assistant Director, as well as an Assistant Professor in the Toulan School of Urban Studies at PSU. The report was researched and written by Jeff Renfro, Senior Economist. Research support was provided by Janai Kessi, Ayesha Khalid, and Kyle O'Brien, NERC Research Assistants. The report was designed by Marilyn Quintero, NERC Administrative Assistant.

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**WAVE ENERGY IN CLATSOP COUNTY, OR:
AN ECONOMIC IMPACT ANALYSIS**

EXECUTIVE SUMMARY

This study analyzes the economic impacts of building a wave energy commercial generation project in Clatsop County, Oregon. The modeled project is relatively small, and was produced by reviewing relevant wave energy literature and working with two local wave energy developers to estimate the expenditures and related costs of the project. We find that the construction and ongoing operation of a commercial wave energy project would create gains in employment, income, and output in the area as well as preparing Astoria for further wave energy development.

Concern about the full costs of our reliance on fossil fuels, as well as an increased recognition of the vast energy-generating potential of ocean waves, has created renewed interest in wave energy projects. Compared to other renewable energy sources like wind and solar, wave energy is still in early development but project sites in Europe and small-scale demonstrations elsewhere have increased interest. Additionally, the Oregon coast has been identified as an area particularly suited for wave energy generation.

In order to estimate the total economic impact of the project we used IMPLAN, an input-output software. IMPLAN uses social-accounting matrices (SAMs) to model the industry interactions in the economy. These interactions are used to estimate the multipliers associated with expansions of various industries, which produce the total economic impacts.

After consulting relevant literature and wave energy developers, we created a hypothetical project that we feel could be developed in the near future at the Camp Rilea site. The project would have an installed capacity of 5 MW and a capacity factor of 35%. Using data from the wave energy developers and the literature, we created an amalgam of available cost information that matched the characteristics of the project site.

Initial Construction

For the initial construction phase of the project, we estimate a direct increase of 60 jobs in Clatsop County, with an additional 17 from the indirect and induced effects. In addition, the project would create revenues of $185,072 for the state and $132,345 for local jurisdictions.

Impact Summary

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	60	$1,928,818	$2,346,078	$5,570,505
Indirect Effect	6	197,088	356,669	626,465
Induced Effect	11	331,463	704,238	1,189,178
Total Effect	77	$2,457,369	$3,406,985	$7,386,147

Our estimates for the ongoing operation of the project are based on an assumed annual energy generation of 14,563.5 MWh. Based on this estimate, we expect the ongoing operation to directly support 25 additional jobs per year along with an additional 13 jobs created indirectly in Clatsop County.

Ongoing Operation

Impact Summary				
Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	25	$1,227,312	$3,280,203	$6,450,693
Indirect Effect	7	193,799	291,368	631,999
Induced Effect	6	220,625	393,908	791,815
Total Effect	38	$1,641,736	$3,965,479	$7,874,507

Since Clatsop County has a relatively small population and industrial base, there is a risk that economic benefits could leak out of the area. We assume some level of leakage in the analysis but there are several strategies that Clatsop County could employ to maximize the captured economic benefit. These include:

- Supporting a transparent business and political environment
- Focusing on business cluster development
- Infrastructure development
- Local use requirements

Clatsop County already has industries that rely on the ocean, including fishing, shipping, and tourism. Wave energy can coexist with these industries provided that all industry needs and expectations are clearly expressed and inter-industry planning and collaboration is encouraged.

The wave energy industry should benefit from expected cost reductions as the technology develops. Additionally, efforts at all levels of government to incentivize renewable energy sources and internalize the full cost of fossil fuels will decrease the cost difference between wave energy and fossil fuel based sources. A community that successfully incorporates wave energy into its electricity mix will have an advantage, as renewables become more cost-effective.

Introduction

Increasing awareness of the negative effects of climate change has created interest in a variety of renewable energy generation methods. It is widely recognized that the emission of greenhouse gases, particularly CO2, is one of the primary sources of global warming. The global economy is fundamentally dependent on fossil fuels as a major source of energy. Recognitions of the harm caused by the burning of fossil fuels, in addition to increasing oil prices, has created a movement towards the research and development of alternative energy. Solar, wind, and hydropower are already being incorporated into the national energy grid. Wave energy is earlier in the development process, but could significantly contribute to future energy needs.

The wave energy industry remains very much in the research and development stage, with some issues still needing to be solved through pilot projects and testing before making large-scale contributions to the power grid. While there are numerous companies and research groups currently working on wave energy projects, there is not yet a standard industry design for harnessing the oceans' tidal and wave power. In addition to corrosion caused by salt water, the unpredictable nature of the ocean results in inherently challenging design issues that need to be resolved. There are also technical and economic challenges surrounding the ability to connect to the power grid. Environmental consequences such as noise pollution and biophysical impacts must also be considered. Furthermore, there are a number of socio-economic challenges including possible conflicts with the commercial fishing industry as well as concerns from recreational users.

While wave energy patents dating back over 200 years are known, the industry has only recently begun to gain momentum. Specifically, the oil crisis of 1973 is generally thought of as a significant motivational factor which spurred research in wave energy. Although some prototypes were developed following the crisis, none could connect to the power grid. The 1980s saw a reduction in funding for wave energy projects. The combination of increasing oil prices and global climate change awareness helped to bring about an industry resurgence in recent years. Since the mid-1990s, many more prototypes have been developed with varying degrees of success.

In Europe, the wave energy industry has seen some of the most significant advances, in no small part due to the establishment of the European Marine Energy Centre (EMEC) in 2003, located at Orkney, Scotland. The establishment features open-sea testing facilities, connection to the power grid, and a concentration of industry expertise. In 2004, at EMEC, the Pelamis 750 became the world's first floating wave energy device to successfully generate electricity for the grid. Furthermore, Open Hydro became the first tidal turbine to connect to the grid in the UK in 2008. Aquamarine Power launched its Oyster device from EMEC in 2009. Numerous other companies have deployed prototypes at EMEC as well.

The financial difficulties surrounding wave energy were showcased with the Aguçadoura Wave Farm in Portugal. The facility was opened in 2008 and was the world's first wave farm. However, funding quickly ceased due to investment problems surrounding the global financial crisis. The site was closed just two months after its official opening.

Wave energy in the United States enjoyed resurgence in the 2000s. However, much like in the rest of the world, wave energy in the U.S. experienced funding challenges as a result of the global financial crisis. Growing public recognition of the negative implications of climate change and the need for renewable energy sources has helped keep wave energy relevant as the economy has recovered.

The United States, particularly the Pacific Coast, has been identified as a suitable location for future wave energy projects. The Electric Power Research Institute's 2011 Mapping and Assessment of the United States Ocean Wave Energy Resource identified the Pacific Northwest and Northern California as having a large energy generation potential. In 2013 Oregon amended its Territorial Sea Plan to allow for marine renewable energy development projects in state coastal waters. The amendment identifies four areas where wave energy projects will be encouraged, including water off the coasts of Lakeside, Reedsport, Nestucca, and Camp Rilea. This amendment opens the door for further research and concentration of expertise on the topic of wave energy in Oregon.

Previous Research

There are few examples of advanced wave energy capability outside of Europe, but researchers and academics have investigated the potential impacts and outcomes of further industry development.

Emerging energy companies have been actively involved in developing new wave energy technologies such as the Pelamis, the Limpet and the Archimedes Wave Swing. Commercial plants for the production of wave energy are being built in Europe, the U.S., Asia, Australia and elsewhere.

Wave energy offers the potential for long-term reduction in carbon emissions but it is unlikely to make a significant contribution to renewable electricity generation in the short run due to its nascent stage of development. The installed ocean capacity (including wave and tidal), by the end of 2009, was approximately 300 MW worldwide.[1] All ocean technologies, other than tidal barrages, are in the demonstration stage or undergoing research and development. The theoretical potential of ocean energy technologies has been predicted to be 7,400 EJ/year, which far exceeds current and future human needs.[2]

In the EU, ocean energy generation has a potential to increase to 3.6 GW of installed capacity by 2020 and around 188 GW by 2050, and the major proportion will come from wave energy. It is predicted that wave energy would have 529 MW of installed capacity by 2050 and around 100 GW by 2050. This is equivalent to 1.4TWh/year by 2020 and more than 260 TWh/year by 2020. It has been estimated that 300kg of CO_2 can be avoided for each MWh generated by ocean energy. Hence, for 20 GW (40 TWh, year) of installed wave energy, approximately 14.5 Mt/year of CO_2 emissions can be avoided (Waveplam, Wave Energy: A Guide for Investors and Policy Makers)[3].

The environmental and socio-economic impacts of wave energy are relatively unknown, particularly for large scale wave energy development projects. There is a possibility of conflict with the commercial fishing industry. There are also concerns that the sediment characteristics within and adjacent to wave parks may be altered due to changes in wind, wave, and currents that could modify sediment transport processes. Changes in sediment characteristics can affect the surrounding communities. This is because local scour foundations can be adversely impacted, therefore, creating the need for scour protection at many sites.

To gauge the sustainability of wave energy in Oregon, Yao Yin[4] provides an environmental sustainability matrix showing the impact of geosphere, atmosphere, hydrosphere and biosphere of nine different types of energy sources including wave energy. The geosphere impacts of wave energy are that it can change beach profiles and decrease transport of sediment. Atmospherically, it is considered a clean technology. Hydrosphere concerns are that it may impose adverse effects on the ocean by changing physical attributes of waves. Finally, biosphere impacts include harm done to marine organisms, including birds and mammals.

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[1] Lewis, Anthony; Estefen, Segen. 2011. "Ocean Energy." From Special Report on Renewable Energy and Climate Change Mitigation. Intergovernmental Panel on Climate Change. Last Accessed 9/19/13. Available At: http://srren.ipcc-wg3.de/

[2] Lewis, Anthony, et al. 2011.

[3] Waveplan. Wave Energy: A Guide for Investors and Policy Makers. Ente Vasco de la Energia. 2010. Last Accessed: 9/19/13. Available At: http://www.waveplam.eu/files/downloads/D.3.2.Guidelienes_FINAL.pdf

[4] Yin, Yao. 2009. Is Wave Energy Comparatively Sustainable in Oregon? Thesis submitted to Oregon State University. Last Accessed: 9/19/13. Available At: http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/12116/yaoyin.pdf?sequence=1

Yin's economic sustainability matrix shows that wave energy's market costs ranges from $.18/kWh to $.30/kWh.[5] Federally, there is a renewable energy production incentive, and also an open solicitation program. Wave energy projects would have a positive economic impact since manufacturing, installation, operation and maintenance of wave energy facilities will generate revenue and employment. Studies suggest that wave energy has a significant potential for positive economic impact and job creation, with about 10 to 12 jobs created per MW in the EU. By 2020, the wave energy sector will generate more than 4,000 jobs based on the predictions for installed capacity, and by 2050, the jobs would increase to 264,323 in the EU. [6]

In a previous study, the potential economic impact of the wave energy industry on Oregon was calculated for the year 2007. Three construction phases are identified namely R&D Facility, Wave Farm Commercial, and Wave Cluster. The R&D Facility construction phase would generate $3 million in economic output and 48 jobs. The Wave Farm Commercial construction phase would generate $680 million in economic output and 4,089 jobs (assuming construction costs of about $750,000/MW). The Wave Cluster construction phase would generate $889 million in economic output and 6,032 jobs.[7]

Operation of wave energy projects for one year is expected to have a positive economic impact on the Oregon state economy. In particular, R&D Facility operations would generate $13 million in economic output and 100 jobs. Wave Farm Commercial operations would generate $57 million in economic output and 316 jobs. Wave Cluster operations would generate $2.4 billion in economic output and 13,630 jobs[8]. According to the Oregon Labor Market Information System (OLMIS), total employment in Lincoln, Douglas, and Coos counties in 2007 was 80,629 jobs. The potential employment impacts of the wave industry on the Oregon Coast are substantial. It is estimated that 3,547 new jobs would be created in the coastal economy by the three wave industry construction phases, which would last for the duration of the construction process. Also, operation of the wave industry project is likely to generate over 11,000 local jobs once the industry is mature.[9]

[5] Yin, Yao. 2009.

[6] Waveplan. 2010.

[7] Grover, Steven. 2009. Economic Impacts of Wave Energy to Oregon's Economy: A Report to Oregon Wave Energy Trust. ECONorthwest. Last Accessed: 9/19/13. Available At: http://www.oregonwave.org/wp-content/uploads/Economic-Impact-Study-FINAL-mod.pdf

[8] Grover, Steven. 2009.

[9] Grover, Steven. 2009.

Project Description

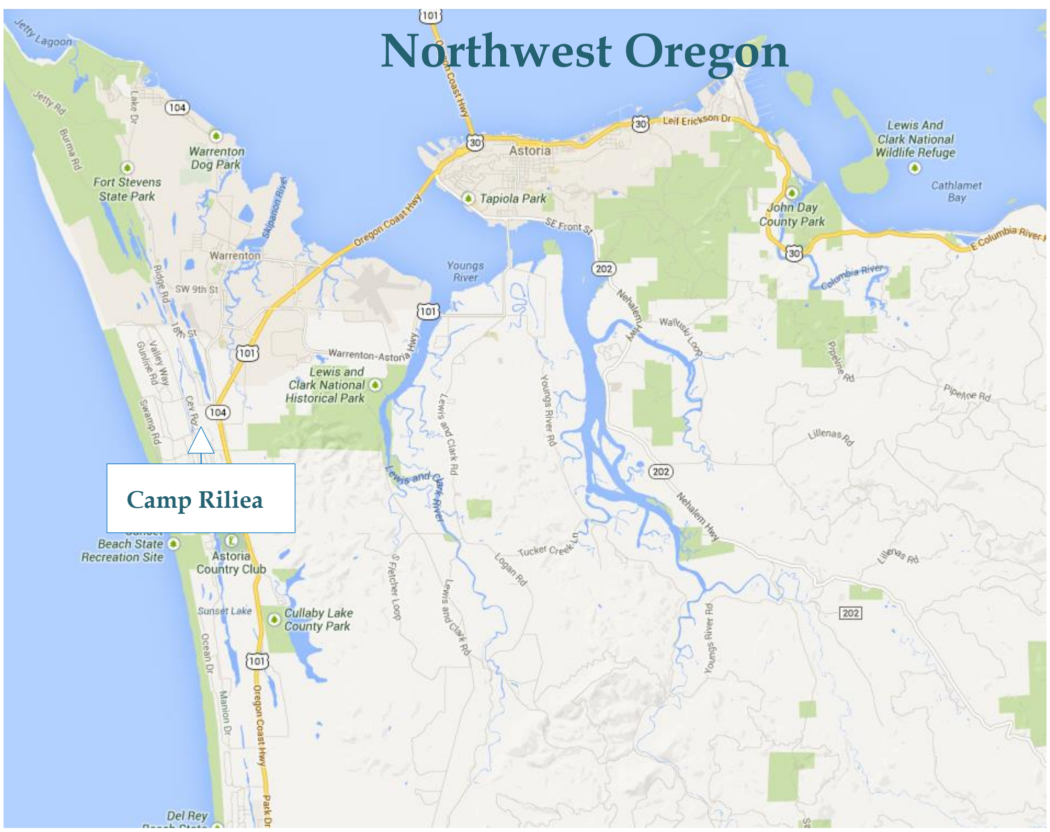
There is currently no wave energy pilot project slated for Clatsop County, although Camp Rilea has been designated a potential site by the state. In order to estimate the potential economic impacts of a wave energy project at this site we combined data from our review of wave energy literature with forecasted project budgets from two Oregon wave energy firms: Columbia Power Technologies (CPT) and M3Wave Energy Systems (M3). By altering the assumptions of these cost estimates, we were able to create a budget for an imagined project grounded in current cost estimates. It shall be noted however, that neither CPT nor M3 currently have any plans for deployments at Camp Rilea; their participation in this study was for educational purposes only. Combining data sources also allowed us to hide the details of the confidential cost estimates that were provided to us. We also needed to alter assumptions because of the viability of various wave energy generation methods at the site. The technology being developed by Columbia Power Technologies is not ideal for the Camp Rilea site. Camp Rilea will most likely support a near-shore array, while CPT technology is better suited for deep water deployment.

Based on our literature review and conversations with local wave energy developers, we arrived at 5MW as a reasonable assumed installed capacity for an early stage commercial wave energy project at the Camp Rilea site. Our cost estimates were altered to match this scale. The analysis is split into two parts: initial construction and ongoing operation.

Initial Construction

The initial construction phase includes the construction of the commercial site, manufacture of wave energy device, construction of the mooring and subsurface structures, and the connection to the electrical grid. We assume that some initial research and development has already occurred. These expenditures include:

- Manufacture of wave energy device
- Construction or purchase of electronic and mechanical components
- Structure and mooring expenditures
- Transportation costs
- Labor and management costs
- Commissioning expenses



Ongoing Operation

The economic impact estimates of ongoing operation are based on the assumed energy generation for the project. Operating expenses, maintenance, and labor were calculated based on a $/kWh calculation. In our review of wave energy devices, we found that most have capacity utilization rates between 30-40%. There were outliers as high as 50% and as low as 25%. For this project, we used a capacity utilization rate of 35%. After conversations with wave energy experts, we decided to include an up-time estimate of 95% to account for potential unexpected downtime and maintenance. Based on these numbers, we calculate annual energy production of 14,563.5 MWh. For reference, this is enough energy to power 3,000 homes in the Pacific Northwest.[10]

[10] Northwest Power and Conservation Council. 2010. Sixth Northwest Conservation and Electric Power Plan. Last Accessed: 9/19/13. Available At: http://www.nwcouncil.org/energy/powerplan/6/plan/

Wave Energy Designs

In this report, the project that we are modeling is an amalgam of existing wave energy designs. There are multiple designs that are currently being developed and tested. It is possible that as the wave energy sector matures, a completely different design will become dominant and have a different level of economic impact. Here are a few of the more commonly cited designs being tested today:

Pelamis[11]

Pelamis Wave Power designed the Pelamis machine, an offshore wave energy converter. The converter is a tube-like attenuator, and operates in water depth greater than 50m, which can translate to several miles off the shoreline. Five of the tube-like structures are connected by joints and float on the ocean's surface. Electricity is generated as water moves down the length of the structure, by the bending motion allowed by the joints. It is estimated that one machine produces enough electricity to meet the annual demand of 500 homes. The company also has a second generation P2 design which is larger in scale and is capable of capturing more energy than its predecessor.

Oyster[12]

Aquamarine Power's Oyster wave energy converter is a near-shore device capturing energy from waves by pumping highly pressurized water to an onshore hydroelectric turbine. The device is deployed in water depths of 10-15m, typically a half kilometer from the shore. The design is a buoyant oscillating wave surge converter, or flap, connected by hinge to a section attached to the seabed. The flap moves as a result of incoming waves and sends water via an underwater pipeline to the onshore hydroelectric turbine. The Oyster 1 device was successfully connected to the Scottish grid in 2009. A second generation Oyster 800 device is currently undergoing sea trials.

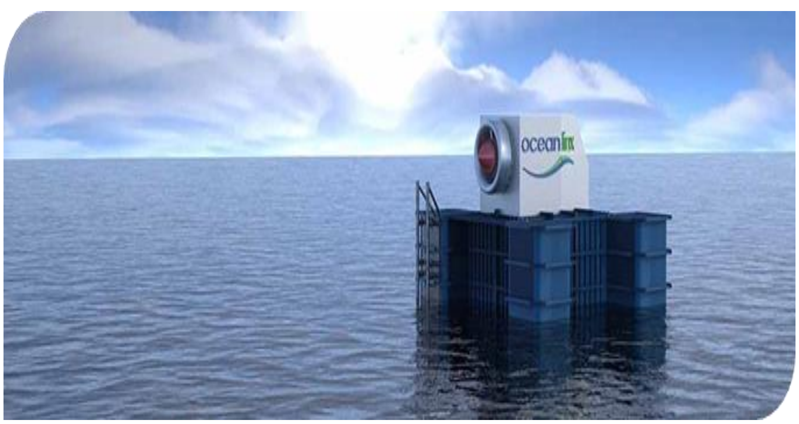
[11] Pelamis Wave. http://www.pelamiswave.com/pelamis-technology
[12] Aquamarine Power. http://www.aquamarinepower.com/technology/how-oyster-wave-power-works/

PowerBuoy[13]

Ocean Power Technologies (OPT) has produced their PowerBuoy wave energy converter. The design is an offshore point absorber designed for deployment in 30-60m in water depth. The buoy is attached to the sea floor and rises and falls with incoming swells. This motion generates electricity which is transmitted to shore via an underwater cable. A grid-connected device was tested at the US Marine Corps Base in Hawaii. OPT has gained approval from the U.S. Federal Energy Regulatory Commission to build a grid-connected power station off the coast of Reedsport, Oregon.

Wave Dragon[14]

Wave Dragon ApS has created the Wave Dragon overtopping type wave energy converter. The device floats above the water and funnels water from waves so they spill overtop into its reservoir. The water then drains from the reservoir through turbines which generate electricity. The converter is deployed in water at least 20m deep, preferably over 40m. There is currently a prototype connected to the grid in Denmark.



greenWAVE, ogWAVE, blueWAVE[15]

The Australian company, Oceanlinx, has designed multiple different oscillating water column wave energy converter devices. Their devices are partially submerged and fully enclosed above water. As the water level rises and falls with waves, air is pushed through an above water turbine which generates electricity. These devices deploy in varying water depths and are capable of different electrical output levels. Oceanlinx has achieved grid connection with its prototype units.

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[13] Ocean Power Technologies. http://www.oceanpowertechnologies.com/technology.htm
[14] Wave Dragon. http://www.wavedragon.net/index.php?option=com_content&task=view&id=4&Itemid=35
[15] Oceanlinx. http://oceanlinx.com/technology

DESCRIPTION OF IMPLAN

In order to capture the full impact of a wave energy commercial generation project on the economy of Astoria we used IMPLAN, an input-output software that simulates changes to the economy. NERC customized an IMPLAN model that covers Clatsop County for this analysis. IMPLAN models are constructed using Social Accounting Matrices (SAMs) based on spending and purchasing data from the Bureau of Economic Analysis (BEA) supplemented by data from other publicly available sources. SAMs are constructed that reflect the actual industry interactions in a region, and include government activities that are not traditionally reflected in this type of economic analysis.

SAMs create a map showing how money and resources flow through the economy. In a simulation, new economic activity is assumed to occur in an industry or group of industries. Based on past spending and purchasing activity, IMPLAN simulates the purchasing and spending necessary for this new economic activity to occur. IMPLAN tracks this new economic activity as it works its way through the economy. Also included in SAMs are household and government behavior. In addition to following purchasing and spending through the private sector, IMPLAN also estimates the impact of changes in disposable income and tax revenue.

Each industry is modeled using a production function, which reflects the supply chain of the industry and its connections to other industries. The original economic change is multiplied through this process as new economic activity motivates additional economic activity in other parts of the supply chain, and through changes in spending habits.

Using data provided by Columbia Power Technologies and M3, we defined the direct impacts of the project. The budget information was converted to expenditures associated with the North American Industry Classification System (NAICS) codes. These expenditures were then converted to the IMPLAN sectoring scheme.

IMPLAN also allows the user to define Local Purchasing Percentages (LPPs). LPPs scale down impacts based on researcher knowledge of the geographic placement of specific expenditures. In this case, because Clatsop County is such a small geographic unit of analysis, it was important to eliminate expenditures that would surely take place outside of the county, and benefit other communities. IMPLAN automatically does some of this work for us by removing impacts associated with industries that are absent from the area. In this case, many of the technical components of the wave energy generators are not manufacturing in Clatsop County and the industries that produce these have no presence there. As a result, this portion of the project has no economic effect in the county. Some expenditures are of goods and services that are available in Clatsop County, but the industry is underdeveloped or does not provide exactly what the project would require. To capture this, we changed the LPP assumption of 100% local purchase to levels that matched the SAM values in the underlying economic model. Some activities will make positive economic contributions to Clatsop County, but one project will not lead to an enormous expansion of some supporting activities, particularly if those activities or goods can be purchased from mature, nearby industries. In the end, using this customization only made a difference of six jobs in the total impact, but is more accurate than the standard estimation method.

IMPLAN breaks out analysis results into three types: direct, indirect, and induced.

Direct: These are defined by the modeler, and placed in the appropriate industry. They are not subject to multipliers. In this case, purchasing, employment, and wage data were collected from the sources described above and placed into the appropriate industry.

Indirect: These impacts are estimated based on national purchasing and sales data that model the interactions between industries. This category reflects the economic activity necessary to support the new economic activity in the direct impacts by other firms in the supply chain.

Induced: These impacts are created by the change in wages and employee compensation. Employees change purchasing decisions based on changes in income and wealth.

IMPLAN RESULTS

The following results are NERC's estimate of the economic impacts in Clatsop County of constructing and operating a wave energy commercial project. The results do not reflect the total economic impact of the project. IMPLAN estimates the amount of activity that "leaks" out of the geographic area of interest. In this case, our model covered Clatsop County. Many of the internal electrical and mechanical components are not manufactured in the area. Most of the economic benefit of manufacturing these components occurs outside of our study area.

A key assumption of this method of analysis is that the modeled activity is new and would not have occurred without this project. The increases in employment, labor income, and output that we estimate are in addition to the normal functioning of the county's economy.

NERC estimates that the project would directly create 60 new jobs, with an additional 17 jobs being created through supporting activities. Labor Income would increase by a total of $2,457,369, and Output in the Clatsop County economy would increase by $7,386,147.

Initial Construction

Impact Summary				
Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	60	$1,928,818	$2,346,078	$5,570,505
Indirect Effect	6	197,088	356,669	626,465
Induced Effect	11	331,463	704,238	1,189,178
Total Effect	77	$2,457,369	$3,406,985	$7,386,147

The increase in economic activity also generates new tax revenue for governments at all levels. The increase to Oregon's tax revenues of $185,072 is small compared to the overall Oregon budget, but additional local taxes and fees of $132,345 is meaningful. It is likely that the additional revenue generated by fees and licensing is underestimated in this analysis. Our data suggests that developers consider these fees significant costs. While it is likely that not all of these fees would stay in the county, we are still probably underestimating the total effect. Staff time and resources needed to navigate the licensing process is included in the economic impacts above, but the benefits to the local government are not possible to accurately estimate without more data.

IMPLAN Impacts

The impact summary results are given in terms of employment, labor income, total value added, and output:

Employment represents the number of annual, 1.0 FTE jobs. These job estimates are derived from industry wage averages.

Labor Income is made up of total employee compensation (wages and benefits) as well as proprietor income. Proprietor income is profits earned by self-employed individuals.

Total Value Added is made up of labor income, property type income, and indirect business taxes collected on behalf of local government. This measure is comparable to familiar net measurements of output like gross domestic product.

Output is a gross measure of production. It includes the value of both intermediate and final goods. Because of this, some double counting will occur. Output is presented as a gross measure because IMPLAN is capable of analyzing custom economic zones. Producers may be creating goods that would be considered intermediate from the perspective of the greater national economy, but may leave the custom economic zone, making them a local final good.

Tax Impacts- Initial Construction

	Total
Oregon	
State Personal and Corporate Income Taxes	$77,073
Other State Taxes, fees, and licenses	$107,999
Total	$185,072
Local Governments	
Property Taxes	$130,154
Other Local Taxes, Fees, and Licenses	$2,191
Total	$132,345
Federal Government	
Federal Personal and Corporate Income Taxes	$166,388
Social Insurance and Excise Taxes	$300,013
Total	$466,401
Total	$783,818

For the estimates of the ongoing operation of the project, we scaled the results to reflect only the effect on the county's economy as we did for the initial construction phase. The activity associated with ongoing operation is based on an estimated electricity generation amount. Maintenance, capital costs, and labor were estimated in terms of electricity generation. If the test site generates more or less electricity than we anticipate, our estimates would be off.

The reported figures for ongoing operation are annual numbers. This means that in every year of operation (at the estimated generation level), the test site would support a set number of jobs. For example, in the first year of operation the test site would directly support 20 jobs. In the second year of operation, the test site should continue to support these same 20 jobs. For every year of operation, these estimates assume an increase of economic activity above the counterfactual scenario (no wave energy site).

NERC estimates that the ongoing operation of the wave energy test site would generate a total of 38 new jobs, with 25 of those jobs being directly related to operation of the test site. Labor income in Clatsop County would increase by $1,641,736 and there would be an additional output of $7,874,507 in the local economy.

Ongoing Operation

Impact Summary

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	25	$1,227,312	$3,280,203	$6,450,693
Indirect Effect	7	193,799	291,368	631,999
Induced Effect	6	220,625	393,908	791,815
Total Effect	38	$1,641,736	$3,965,479	$7,874,507

The impact on tax revenues is greater because of the different mix of industries affected by the ongoing operation. Not surprisingly, the initial construction phase included more one-time expenditures while the ongoing operation requires more skilled labor. While these numbers still do not make a major impact on the Oregon tax rolls, the $424,104 in additional tax revenue for local government bodies is significant.

Tax Impacts-Ongoing Operation

	Total
Oregon	
State Personal and Corporate Income Taxes	$65,042
Other State Taxes, fees, and licenses	$308,081
Total	$373,123
Local Governments	
Property Taxes	$422,655
Other Local Taxes, Fees, and Licenses	$1,449
Total	$424,104
Federal Government	
Federal Personal and Corporate Income Taxes	$212,644
Social Insurance and Excise Taxes	$313,412
Total	$526,056
Total	**$1,323,283**

In both the initial construction and ongoing operation phases, we observe indirect and induced estimates lower than we normally see for these types of projects. There are two main reasons for this: First, the limited scope of the geographic unit of analysis creates more economic leakage. Rerunning this project using the neighboring counties or the entire state would show a larger economic impact. Including Multnomah County would most likely capture some of the skilled labor and manufacturing that goes into the process. Second, since wave energy generation is new, there is little data that demonstrates how these particular projects interact with the rest of the economy. We used IMPLAN codes related to non-residential construction and energy generation, but it is possible that when actually built, the wave energy test site could impact the local economy differently. We are confident in our results, but this analysis would benefit from having more actual examples of wave energy generation sites.

BROADER IMPACTS

Retaining Benefits from Outside Investment

There are genuine concerns in smaller communities when large, outside entities choose to conduct business in close proximity to their geographic location. Hefty retail box stores and foreign direct investment provide useful examples of this issue. One of the primary concerns is related to the crowding out of local business as a result of the foreign entity entering the local market. Furthermore, because these entities are not headquartered locally, communities must consider whether local labor will be used, and whether most of the earnings will be remitted. These issues are well documented in popular as well as academic literature. Foreign direct investment is an area of significant research which is directly related to this subject. Much research has been done analyzing how the host locations can best retain and maximize the benefit of foreign entities operating within their economic communities. According to our review of the literature, these are some of the more important factors and policies used to capture the economic benefits:

Transparent Business and Political Environment

Transparency can play a large role in reducing the uncertainty a foreign entity experiences when deciding to enter a local market, as well as allowing the local government to engage in policies aimed at benefiting from foreign investment. Investors tend to avoid unnecessary risk due to uncertainty because it can make the business environment unpredictable. By increasing transparency, local authorities can pursue policies allowing communities to achieve greater benefit from foreign investment without increasing the uncertainty experienced by foreign investors. Furthermore, a transparent environment also encourages reinvestment in the local community by the foreign entity as it allows for more efficient investment. By providing a transparent environment, local government is implying a certain level of interest in working cooperatively with a foreign entity. This symbiotic relationship encourages more participation in the local economy and possible future development.

Focus on Business Clusters

Developing regional expertise aids in helping a smaller community achieve maximum benefit from the existence of foreign entities. The reasons for this are intuitive. If a company is the lone entity in its industry, it will be forced to look elsewhere when needing outside assistance. However, if there exists a business cluster in that company's industry, it can look regionally to address its needs. The cumulative effect of industry clusters over time is a positive network externality. All entities receive greater benefit from the cluster as the level of industry expertise in a geographic area increases. Once this effect has been established, it becomes easier to attract more entities, achieving even greater local benefits.

Development of Infrastructure

There needs to be a certain level of infrastructure available to the foreign entity in order to capture some of the gains locally. Human capital is a prime example of this. Host communities undoubtedly prefer foreign entities to hire local labor. However, the local labor may not have the proper skills or education needed by the foreign entity; therefore, they would need to bring in labor from elsewhere. By investing in human capital, a host community gives the foreign entity the option to hire local labor. It is also important for the financial system to be developed sufficiently. The foreign entity will have a more difficult time reinvesting capital locally if the financial system is not sufficient to do so. Having an adequate existing level of technology also aids a local economy's gain from foreign investment. The foreign entity may bring new or different technology to a local community. However, the community may experience difficulties in assimilating the technology. Higher levels of existing technology can allow for better absorption of new technology by the host community. Similarly, higher levels of research and development help the host community assimilate technology brought by foreign entities. It is assumed that some of the physical infrastructure and human capital developed during the creation of a wave energy site would be transferrable to future projects. This will lower the cost of future projects, making the county a more attractive and cheaper site for development.

Required Use of Local Resources

Sometimes government authorities use regulatory requirements to aid in capturing the economic benefit from foreign entities doing business locally. Often foreign entities must import supplies at the onset of entering a new geographic location. However, some governments have found success in steering foreign entities to use local suppliers by instituting local content requirements. At the very least, governments can help foreign entities match local suppliers with the foreign entity. Policies requiring the use of local labor could also be effectively implemented if the local labor force is sufficiently educated and trained for hire.

It is important that these policies are deployed carefully. Local purchasing requirements can increase costs of a project if applied too broadly. If a firm is worried about incurring these types of additional costs, they may choose to site a project elsewhere.

Affected Industries

The construction and ongoing use of any new or large project has the potential for broad impacts on a wide variety of industries. Development of a wave energy site offers no exception to this rule. There are a number of prospective stakeholders in a wave energy project with special interests in the Oregon coastline. Specific to implementation of a large scale wave energy project, stakeholders cited in literature include, but are not limited to, the fishing industry, shipping, recreation and tourism, housing, and environmental groups.

Indeed the effect of a wave energy facility may depend on the type of converters being used. Since the industry has yet to develop a standard design, discussion surrounding the impacts of converters can be difficult. Depending on how each converter is designed, the impacts may vary widely. However, despite the variance in design, it is common to generalize wave energy converters in terms of distance to the shoreline. The broad converter categories can then be labeled as near-shore, mid-shore, and offshore.

Predictably, near-shore converters reside closest to the shoreline. Mid-shore is then the next closest, while offshore is the farthest away, and can be deployed miles from the shoreline. The nomenclature of these categories is somewhat deceiving as perhaps more important than distance to shore is water depth. Naturally, near-shore water depth is the most shallow while off-shore the most deep. Both near-shore and mid-shore wave energy converters tend to be smaller in scale and generate less energy. Off-shore designs generate the most energy, but tend to be more expensive to deploy. From a design perspective, near-shore converters tend to connect to an onshore construct where electricity is generated and stored. Due to the great distance from shoreline, offshore devices generally must connect to an offshore energy substation. The energy is then transported to the shore by trunk line.

Environmental Impacts

In some ways, the environmental impacts of wave energy converters are not well understood due to the lack of deployment. However, there has been substantial research on this topic, which is of interest to environmental groups. Although wave power is considered a green renewable energy source, the potential benefits of preventing climate change need to be weighed carefully with any negative environmental impacts ensuing from the deployment of such devices. Often cited concerns include possible pollution, noise, disruption of migratory patterns, and habitat interference. Some designs include the use of fluids, which could be harmful to the environment if leaked into the ocean. Noise caused by the machinery can discourage some species, which would then disrupt the natural habitat of the area surrounding the converters. Similarly, migratory patterns can be disrupted due to noise pollution and the existence of large underwater structures. There also remains the possibility that the structures themselves will become home to certain varieties of ocean species. If species attach themselves to the structure a new habitat can be formed. In that circumstance, periodic extraction and redeployment for maintenance and cleaning purposes will disrupt these species. It is also conceivable that structures protruding from the ocean surface will have an impact on marine birds.

Fishing

There are genuine concerns reverberating from the fishing industry in regard to wave energy. Dungeness crab is an important product to the Oregon fishing industry and it is possible that the space used by a wave energy facility will directly conflict with regions popularly used for crab basket deployment. Of course, crab is only one of many ocean species fished off the Oregon coast. To the extent the wave energy converters disrupt the migratory patterns and natural habitat of these species, there is potential for the fishing industry to be adversely affected. It is also likely that the ocean area controlled by a wave energy facility will be mutually exclusive with the fishing industry. The displacement of the fishing industry to other waters can be an adverse disruption. Many smaller fishing vessels do not have the range to travel significant distances. If the proposed facility conflicts with their standard fishing area, these fishermen have cause for concern.

Shipping

Shipping is another industry that may conflict with ocean use to the extent that the wave energy facility and converters may obstruct existing shipping routes. Barges and other transport vehicles would need to divert around the coastal waters controlled by the facility. Offshore devices are more likely to be in direct conflict with shipping routes than the near and mid-shore converters.

Tourism and Real Estate

Visually, wave energy converters may not blend in with the natural ocean landscape. Landowners with an ocean view may have the unfortunate occurrence of being situated within eyeshot of structures protruding from the water. Investors often purchase ocean view properties partly for the luxury of enjoying the scenic beauty. In consequence, housing values may decrease resulting in a significant overall loss in wealth. A potential long term effect might be substitution in housing purchases to areas away from the wave energy facility. This could spur development of previously unused beachfront land or increased demand for existing structures. Being closer to the shoreline, the near-shore and mid-shore converters have greater potential for impairing the coastal visual landscape than offshore devices.

The tourism and recreation industries also have a strong interest in preserving the natural beauty of Oregon's beaches. People travel to the Oregon coast specifically to enjoy this habitat. Any degradation of views previously discussed is applicable here as well. Furthermore, the transfer of energy from waves to the converter has the potential effect of attenuating wave strength once it reaches the shore. Potentially, this could change the contour of the beaches by affecting sand displacement. It is difficult to determine whether the change will be more or less favorable for public use. The uncertainty surrounding beach sand patterns is nevertheless undesirable. Recreational ocean use, such as surfing, body boarding, and skim boarding are also potentially harmed by a reduction in wave strength.

Residential Energy Usage

A potential hurdle in using wave energy for power production is that it is a costly source of electricity. The levelized cost of wave energy production is anticipated to be almost three times that of coal-based power. Since it is difficult to store electricity, the supply of electricity must match with demand. As mentioned above, energy production from a non-renewable energy resource is cheaper than those using renewable resources. Given that the demand for electricity remains unchanged, substituting wave energy for cheaper fossil fuel sources increases the price of electricity in the overall system. Calculating the exact increase is beyond the scope of this project, but based on existing research from other parts of Oregon, we assume that the impact on the monthly electricity bill of a typical Clatsop County resident would be an increase of a few dollars per month for a project of this size. This could have an effect on electricity usage in the area, which could lead to additional economic impacts not incorporated in the preceding analysis.

It is also worth noting that a large scale project may have different impacts, and levels of impact, than the deployment of only a few, small wave energy converters. If the facility is used to deploy multiple types of converters, varying in design and size, the overall impact will be a function of the conglomerate, not only the individual prototypes. Ameliorating the impacts may also be more complicated when dealing with multiple designs and a larger-scale facility. The severity of impacts inflicted upon these industries and interest groups can vary greatly depending on the location chosen for site development. For example, building near residential housing can exacerbate the issues related to potential depreciation of housing values. Locations less obtrusive to the commercial fishing and crabbing would mitigate the concerns of the fishing industry. Furthermore, there may be unforeseen stakeholders not mentioned in this section. Finding a location that satisfies the needs of every stakeholder may be extremely difficult. A more likely solution will involve some compromise and a location encouraging a greater overall welfare of the local community.

Fotopedia: http://images.cdn.fotopedia.com/

CONCLUSION

At the national level the response to rising fuel costs and the dangers of climate change has been unfocused and has resulted in an "all-of-the-above" strategy. Solar and wind energy are further along in the development process and enjoy implicit and explicit support from elected officials across the country, but large-scale implementation of these technologies has been problematic and slower than expected. Since the economic and technical aspects of moving away from fossil fuel based energy production have not been solved, opportunities still exist for new methods and technologies.

Earlier, this report detailed the enormous potential of wave energy generation in the U.S. and around the world. A wave energy test facility would not only benefit the development of renewable energy sources nationally and internationally, but would also advance the pioneering local community ahead of the rest of the U.S. in the development and exploitation of the resource. This report focuses on the immediate economic impacts of building and operating the wave energy test site, but there are additional opportunities to build on early successes and establish Clatsop County and the Oregon Coast as leaders in wave energy development.

Since the county is small and other industries in the area rely on access to the ocean, it is important that development of this project and the broader wave energy sector proceed purposefully and in collaboration with the appropriate stakeholders. Wave energy developers and local government officials can follow examples from Oregon and the U.S. that demonstrate successful multi-stakeholder collaborations related to resource exploitation. As demonstrated, Clatsop County stands to benefit from the development of this industry, but that does not mean that each industry will benefit equally. In particular, potential trade-offs between the fishing industry and wave energy developers should be discussed openly and compromise should be encouraged. When attracting new cluster development, demonstration of the viability of a new technology is just one piece; demonstration of local support and collaboration signals a lack of difficulty for businesses.

The cost of electricity generated from ocean waves is currently more expensive than other forms of renewable energy or traditional fossil fuel based generation. It is reasonable to think that these costs would come down as the technology develops, similar to how the costs of other forms of renewables have decreased with the growth of their industries. Like the other renewables, wave energy development would benefit from carbon pricing or carbon mitigation schemes. By internalizing externalities associated with fossil fuel use, the decision to exploit wave energy for electricity generation becomes both environmentally and economically responsible.

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