Science and Knowledge Informing Policy and People: The Human Dimensions of Wave Energy Generation in Oregon

Final Report to the
Oregon Wave Energy Trust

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Introduction to this Report

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Things were moving fast in 2004-2008

Oregon Sea Grant (OSG) and Oregon State University (OSU) have been investigating and supporting the development of ocean-based renewable energy for several years. By 2004, things began to move quite quickly. There was motivation from the State to get things moving quickly. The POWER group was meeting regularly. There were several developers who were eying Oregon as a “sweet spot” to test and launch their technology. Terms like “the gold rush” were being used on a regular basis to describe the situation.

OSG’s role was to support research and connect scientists, engineers, and developers to ocean users – specifically the commercial fishing industry – to talk, listen and share perspectives and experience about this new technology and the ocean place/space.

During this time, at the peak, seven or more preliminary permits had been applied for. Yet there were so many questions unanswered and issues that needed to be addressed. A series of environmental issues and questions led to an “environmental impacts” conference in Newport. A report of this conference is available.

Equally important yet – to this date – left unaddressed were a series of human dimension issues and questions. How is wave energy generation off of the Oregon coast being perceived in general? Who are the stakeholders and how are they engaged? Is this activity further defining differences in rural and urban perceptions of the coast and the direction of its economic and social development? Cumulatively how does the human dimension of the wave energy equation impact public perceptions, public policy and the successful adoption of wave energy technology along Oregon’s coast?

At the same time, policy maker and government were struggling to keep up in many ways. Who’s responsible for planning and regulating this new use of the ocean? FERC? MMS? State or local government? What should the processes be for permitting? What are all of the correct steps that should be followed?

In 2007, the Oregon Wave Energy Trust (OWET) put out a request for proposals to begin to discover answers to many of the environmental and human dimensions questions. A multidisciplinary group of social scientists – Flaxen Conway, Brent Steel, Michael Harte, and Bryan Tilt, Oregon State University – responded to this call. Working together, they created a new research program at OSU. The Human Dimension of Wave Energy (HDWE) research program was created to provide the opportunity for a cadre of social scientists – professors and graduate students – to study this new use of the ocean space and place.

Why invest in human dimension research?

Six individual yet interrelated projects under four project areas would coordinate their efforts to understand wave energy in terms of the political and regulatory process, and environmental, social and economic sustainability and acceptability. Researchers Delli Carpini and Keeter note that public knowledge "is essential if citizens are to discern their *real interests* (emphasis added) and take effective advantage of the civic opportunities afforded them" (1996: 3). Daigle argues the need for greater public involvement in coastal policy issues stating, "the only hope for further progress on environmental protection and sustainable development lies with a public that is not only informed but also engaged" (2003: 230). We believed, therefore, that it was important to assess the scope and depth of policy-relevant knowledge among stakeholders and the public, to learn where people tend to acquire their information about wave energy, and to flesh out the link between policy-relevant knowledge and understanding and acceptance of wave energy generation. By more clearly specifying the connection between knowledge holding and support for wave energy, purposeful public education and information dissemination efforts could be targeted more effectively, and policy processes could be designed to meet citizen and community concerns and maximize policy input. In short, by examining the literature, doing comparisons with other jurisdictions that have implemented wave energy, and gathering new scientific information, the HDWE was designed to discover information that could inform people, policy makers and their decisions about the best available social information and best management practices to integrate this information into wave energy planning and permitting.

Why have a research program?

Several people have asked us “Why have a research program and not just one or two projects – such as an economics study or a social study?” The answer is simple. This new use of the ocean space and place is multidimensional and complex. Just as you cannot have one research project that studies all of the environmental issues in one project, you can not have one research project study all of the human dimensions issues. OSU and OSG has learned from past experience – such as the Adapting to Change research program of the 1990s – that it’s important to study the various aspects of an issue or set of issues, but to not do it in a vacuum. Methodologies could be complementary instead of competitive. The overlap of commitment and time could be positive, not negative, but it would take each aspect being communicated and coordinated so as to enhance co-learning and co-discovery.

The timing was right and, with care, the funding could come together. There were six graduate students – five masters candidates (Holly Campbell, John Stevenson, Zack Covell, Daniel Hunter, and Yao Yin) and one PhD candidate (Maria Stefanovich) – who were here, ready, and interested. The funding from OWET could leverage almost twice as many dollars to support this effort.

As stated earlier, the HDWE investigated four facets of the human dimensions complex, with each facet represented by a related but independent research project ***area***:

Project Area 1: The Socioeconomic and Sociopolitical Influences on Wave Energy Permitting and Planning. This area has two research projects associated with it. The first (Stefanovich) project studied – through surveys – the level, depth, and connection between people's knowledge, values, and opinions and their actions/ resources that support or oppose wave energy (regionally, nationally, and internationally). The second (Stevenson) project focused on the role of government, citizens, and scientists in the implementation of energy policies. What roles are being played by government representatives, community leaders, and scientists? Who controls critical resources? What strategies and venues will they use to achieve their objectives? The goals of this project area was provide OWET and others information about the best management practices within the US, regionally, nationally, and internationally for identifying and addressing social and political acceptance or resistance.

Project Area 2: A Comparison of Wave Energy Generation to other forms of Electricity Generation. This area had one project associated with it (Yin). This project reviewed and synthesized the existing literature and secondary data comparing the economic, social and environmental costs of wave energy generation to LNG, oil, nuclear, hydro, wind, biomass, solar, and geothermal. The goal of this comparison was to provide useful information for OWET, decision makers, stakeholders, and the public in determining the best ways to avoid or overcome risks and barriers.

Project Area 3: Ocean Zoning in Oregon and Around the World: An assessment of best legal and regulatory practices for permitting and managing wave energy in Oregon. The project (Cambell) in this area went beyond looking specifically at existing ocean energy laws and regulations. It sought out approaches from other ocean resource laws and regulations that may be applicable to ocean energy development in Oregon --these were international, as well as regional and national examples related to other uses of the coastal ocean. Although many of the details are constantly changing, the goal of this work was to provide OWET and others with the best management practices within the US and internationally for permit streamlining and expedited roll-out of emerging energy technologies.

Project Area 4: A Stock Take of Perceptions of, and Effects on, Communities of Place and Communities of Interest. The goal of this work was to provide OWET and others achieve their goals of promoting the wave energy industry and ensuring responsible wave energy development in a way that is consistent with its guiding principles. These principles include understanding and respecting all stakeholder perspectives, coordinating collaborative efforts among stakeholders, and engaging stakeholders to find lasting agreements. There were two projects associated with this area. One (Covell) looked at communities of interest (organized interest groups) – how informed and involved are they? The other (Hunter) looked at three coastal communities of place (certain pieces of ocean space and their connecting shores and people) – how is or could wave energy effect it economically and socially?

So What …What can OWET and others do with this?

Research and experience have shown that permitting processes rarely fail on technical or science grounds, but rather because of a failure to pay attention to the human dimension. The emerging wave energy industry has the opportunity to be developed in a socially responsible manner. But what does "developed in a socially responsible manner" mean? And what are the steps it takes to assure this? And who needs to be involved to assure this? In other words, why engage with community and how should OWET and others engage with communities of place and interest?

The quick answer to those questions, based on research about community engagement, is to design and build programs that build on the three Cs: Connections (within and between people), Communication (direct and indirect), and Change (support smooth transitions through aiding adaptation).

This report provides a lot of information. If read thoroughly and thought about, there is much that can be of direct use in stimulating and supporting the three Cs above. The layout of the report is as follows:

- Introduction (this chapter)
- Six chapters of the individual reports from the six research projects.
- Note that each report comes with a brief summary, what was done and why, and concludes with considerations and/or recommendations. Most reports have additional information in the appendices.

It would be best if I let you all come to your own conclusions. As the coordinator of this research program, I've read and re-read each report several times. I'll take the liberty to direct your attention to several aspects of this report. We learned a lot of useful information; I believe there are three areas to pay particular attention to.

First, we learned that in a time where energy demands are increasing and existing supplies are either decreasing or creating other challenges, the ocean energy industry must move in a socially, economically, and environmentally responsible manner. These are keys for sustainability and acceptance. There are legal and regulatory best practices that can be incorporated. Developers will continue to manage their way through an evolving process. Governments will be continuing to develop or build their expertise as they manage the ocean space and place for the public who owns it.

Secondly, policies will continue to be made and hopefully monitored, evaluated, and improved. The public and policy actors need to be aware and engaged. Perceptions and opinions will be changed not by pressure or force, but with trusted knowledge and communication. Of special interest to OWET and others could be the trusted sources of information for each audience group. At least four of the six projects report back on this.

Third, investments in research and testing are not only sound because they bring about answers to important questions but also because the public and others support and expect this investment. The "jury is still out" on what forms of energy generation should/could be in Oregon's energy portfolio. Research and testing are important to developers (for technology advancement and sound business planning), policy actors and government (for innovative and effective policies), stakeholders (for site selection, technology improvement and functionality), and the public (for understanding and support).

Next steps for a HDWE research program?

The truth is, just like with most of the environmental research, we are still at the beginning. The results of the HDWE research program provide a baseline from which to start and measure change.

There are many areas that need further investigation. Some examples might include:

- The connection between (and lessons learned from the past) shore-based/land use planning and marine spatial planning.
- Further comparisons between marine renewables and land based renewables – especially the social side (community impacts, community engagement, workforce analysis and prediction, etc.)
- East and west coast comparisons re: community engagement and support for marine renewables.
- New audiences – supporters or dissenters (non-consumptive ocean users, urban communities, etc.)
- Using the lessons learned from HDWE; design a marine renewable project jointly with a community (engineering, marketing, tourism, investment, etc.).

References

Daigle, D. 2003. "Involving the Public in Coastal Conservation: Obstacles and Opportunities." In Values at Sea: Ethics for the Marine Environment, ed. Dallmeyer. Athens, Georgia: University of Georgia Press.

Delli Carpini, M., and S. Keeter. 1996. What Americans Know About Politics and Why it Matters. New Haven: Yale University Press.

Wave energy and public opinion in Oregon:
Summary of results from the
Oregon Energy Policy Survey, 2008

Maria Stefanovich, PhD candidate, Environmental Science,
Oregon State University, 2009

Summary

Overall, Oregonians have a positive attitude toward wave energy development (52%). Slightly more than 1/3 of statewide respondents (35%) do not have enough information to form an opinion, only 3% have negative attitude, and 10% - neutral.

There are regional differences in attitude toward and level of familiarity with wave energy development - coastal respondents appear to have more information to form an opinion than Oregonians living in the rest of the state. Coastal residents also hold more defined and intense opinions - 59% have a positive attitude and 6% have negative.

Respondents, who have a positive attitude toward wave energy development, are predominantly male, with conservative policy preferences, and anthropocentric orientation toward the environment (beliefs that humans were meant to rule over nature). They have medium to high income, postmaterialist or mixed values (give priority to environmental quality), live in the Willamette Valley or on the Coast, are over 56 years-of-age, employed, and educated (finished some college or have a university diploma). Respondents who have either positive or negative attitudes toward wave energy development are not necessarily the most informed about wave energy technology, e.g., of the 52% who have positive attitude, 25% are not familiar with wave energy technology. Analogously, of the 3% who hold a negative attitude, 27% are not familiar with the technology either. Respondents with the highest level of self-reported familiarity of wave technology share some of the characteristics of the respondents, most supportive of wave development (Table 1, page iv).

Level of 'real' knowledge of Oregon energy sources and uses can be summed up this way. Energy knowledge is quite good in Oregon. Of the three questions examining familiarity with: a) the largest electricity generating source in Oregon, b) the sector with the highest electricity consumption, and c) the term "off-grid," 18% of respondents gave three correct answers, 40% two correct answers, 33% one correct answer, and only 9% did not give any correct answers.

When it comes to information sources, people who are "very familiar" with wave energy technology very frequently get information about Oregon's energy situation and policy from universities, the Oregon Department of Energy, utilities, local leaders and the Internet.

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Introduction

Oregon State University, Oregon Sea Grant, and Oregon Wave Energy Trust (OWET) all wished to investigate public attitudes toward and level of familiarity with different renewable energy sources in the state of Oregon. More specifically, they wanted to examine support for or opposition to wave energy development.

Wave energy has been proposed as a viable alternative for generating electricity in the state. The findings of this report establish baseline data, which will serve for comparative analysis in future studies. They will also assist OWET in planning their communication strategy. Specific objectives of this report are as follows:

- To present information regarding citizen attitudes toward and familiarity with wave energy development in Oregon
- To examine the reasons for support or opposition to the development of wave energy
- To measure Oregonians level of 'real' knowledge of energy sources and uses
- To investigate the information sources Oregonians use to learn about energy
- To study Oregonians level of and reasons for concern regarding the current energy situation

Developing renewable energy policies has been a priority for Oregon. The state has adopted a renewable energy portfolio standard, known as "25 by 25," requiring Oregon's largest utilities to acquire 25% of their electricity from "new, homegrown renewable energy sources" by 2025 (Senate Bill 838, 2007). Smaller utilities have a lower target of 5% to 10% for renewable energy by 2025 as well. Implementing such policies is a challenging task not only because of the technological, environmental, and economic impact but because of the social implications as well. Public opinion in the United States plays a crucial role in policy formulation. Therefore, it is important to understand how people, who have a stake in both energy development and ocean conservation, perceive wave energy development.

Background

To examine attitude toward wave energy in Oregon, level of familiarity with wave technology, sources of information, and concerns about the current energy situation, the *Oregon Energy Policy Survey* was devised. It had 19 questions, divided in three sections:

1) General interest, activities, and knowledge about energy and environmental policy issues
2) Attitudes and values regarding the environment and politics
3) Socio-demographic characteristics

The survey method consisted of a mail survey to private households with a permanent mailing address. The survey was administered in September and October, 2008 to a random sample of adult (18+) residents in the state of Oregon. Residents were sampled from two randomly selected household samples, which included a statewide sample of 1,200 households and a subsample of 400 coastal households (i.e., those within approximately 20 miles of the coastline). The coastal subsample is used to insure adequate representation of coastal community residents within the general population sample. The analysis here presents the results of the two samples: a) the statewide sample, which includes the responses of Oregon residents across the state but not the coast, and b) the coastal sample, which includes the responses of coastal residents only. Table 1 provides a quick comparative analysis of respondents:

Table 1. Comparative characteristics of respondents most supportive of wave energy development and those most familiar with wave energy technology.

	Most supportive of wave energy development	Most familiar with wave energy technology
Place of residence in Oregon		
• Coast		√
• Portland metro		
• Willamette Valley	√	
• Rest of Oregon		
Time lived in Oregon		
• Short-term (<35 years)		√[1]
• Long-term (≥36 years)	√	
Gender		
• Male	√	√
• Female		
Age		
• Young (<56)		√[1]
• Old (≥56)	√	
Education		
• High School or less		
• College/ vocational		
• University graduate	√	√[1]
Income		
• Low		
• Medium		√
• High	√	
Employment		
• Employed	√	√
• Retired		
• Other (student, working at home, in-between jobs)		
Policy orientation[2]		
• Conservative	√	
• Moderate		
• Liberal		√
Environmental concern[2]		
• Anthropocentric	√	√
• Mixed		
• Biocentric		
Values[2]		
• Materialist		
• Mixed		
• Postmaterialist	√	√

[1]These characteristics are not statistically significant (p>.05) for determining respondents' level of familiarity.
[2] The meaning of these terms and concepts is provided in Section 1.13.

The response rate for the mail survey is relatively high (Table 2). Because of rounding, percentages may total between 99% and 101%. Unless otherwise stated, differences are all statistically significant.

Table 2. Response rate to the Oregon Energy Policy Survey, September 2008

	Sample Size	Surveys Returned	Response Rate
State-wide Sample	1,200	674	56%
Coastal Sample	400	232	58%

General attitude toward wave energy development in Oregon

Respondents were asked about their general attitude toward wave energy development off the Oregon coast with the question: "Wave energy refers to the extraction of electricity from the up-and-down motion of ocean waves using buoys or devices in the form of "wave energy farms." What is your general attitude toward the development of wave energy off of the Oregon coast?" The findings are displayed in Table 3:

Table 3. General attitude toward wave energy development off the Oregon coast.

	State-wide	Portland Metro	Willamette Valley	Coast
Very positive	25%	22%	28%	29%
Positive	27%	27%	33%	30%
Neutral	11%	16%	7%	12%
Negative	2%	1%	1%	3%
Very negative	1%	0%	2%	3%
Do not have enough information to form an opinion.	35%	35%	29%	23%

Four major points can be made from Table 3, including place of residence and attitude toward wave energy development:

1) The predominant attitude in the state toward wave energy development is **positive.** In particular, 59% of the coastal respondents have "very positive" and "positive" attitude toward the development of wave energy off the Oregon coast, compared to 52% of the statewide respondents. Of all respondents who have positive attitude toward wave energy development, residents in the Willamette Valley (61%) form the biggest group, followed closely by the coastal residents (59%), and then Portland-metro residents (49%).

2) Of all respondents who have **negative** attitude toward wave energy development, the coastal residents (6%) form the biggest group.

3) On the average, almost 4 out of 10 respondents **do not have enough information to form an opinion**. The percentage of respondents not having enough information to form an opinion about wave energy development off the Oregon coast is considerably lower for the coastal residents – there, only 2 out of 10 respondents do not have enough information to form an opinion.

4) Between 7% and 16% of respondents have indicated that they have a "**neutral**" attitude toward wave energy development. The reason(s) for having a neutral attitude cannot be defined at this point because respondents were not presented with specific questions about their attitudes.

Characteristics of the wave energy supporter in Oregon

This section defines if support for wave energy development is based primarily on sociodemographic attributes – age, gender, income, and level of education; on place and time of residence– where one lives and for how long; or on one's values and ideological preferences.

Attitude toward wave energy and socio-demographic characteristics

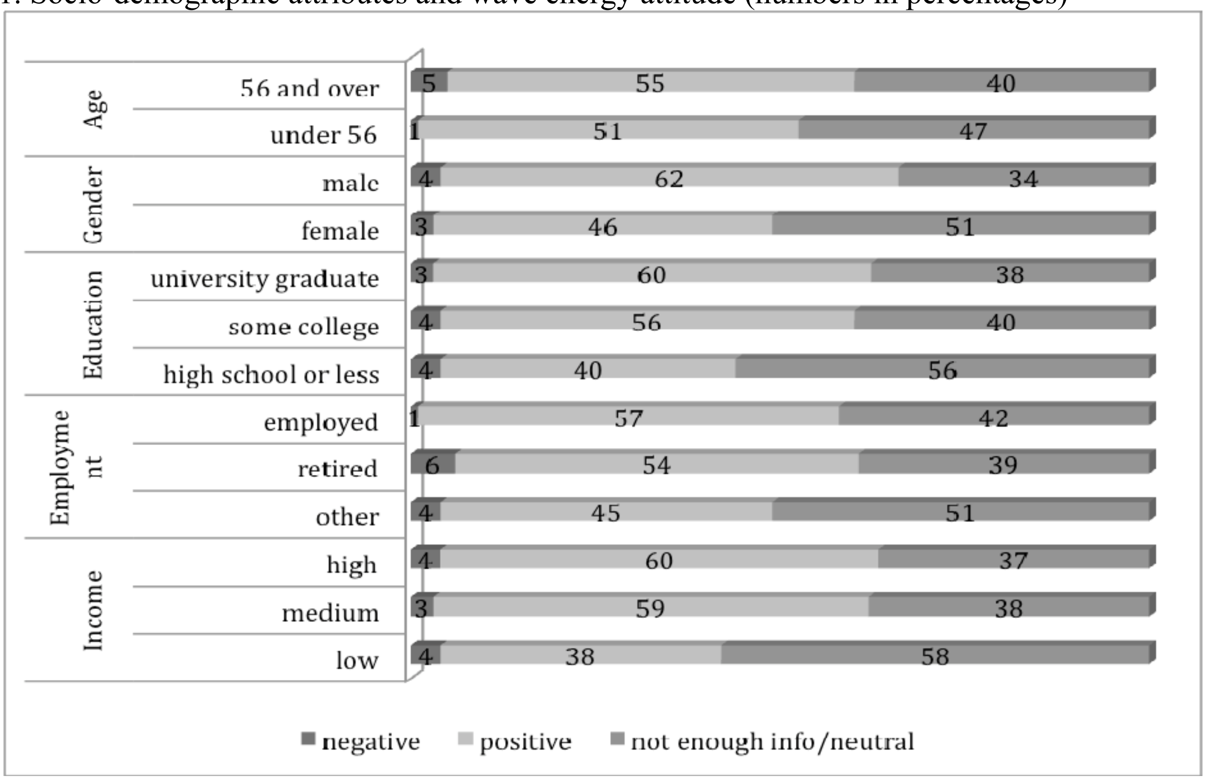
Age and attitude toward wave energy development

On the average, respondents from all age groups have positive attitude toward wave energy development. Figure 1 shows that older respondents have more information to form an opinion than do the younger ones, and also a larger percent of the older respondents (5%) have negative attitude compared to only 1% of the younger age group (under 56 years of age).

Gender and attitude toward wave energy development

The majority of male respondents have a positive attitude toward wave energy development (62%), while the majority of female respondents (51%) do not have enough information to form an opinion about wave energy development. Slightly more men (4%) than women have negative attitude (3%).

Figure 1. Socio-demographic attributes and wave energy attitude (numbers in percentages)



Education and attitude toward wave energy development

There is a strong relationship between one's level of education and attitude toward wave energy development off the Oregon coast – people with higher level of education are more positively inclined and also have more information to form an opinion than do people who have some college experience or hold a high school degree (Fig. 1).

Employment and attitude toward wave energy development

The majority of retired (54%) and employed respondents (57%) have a positive attitude. The retired also have the highest percentage of negative attitude (6%) and consider themselves to be most informed about wave energy development – only 39% of them do not have enough information to form an opinion, compared to 42% of the employed and 51% of the category 'other,' which includes students, unemployed, and house-employed (Fig.1).

Income and attitude toward wave energy development

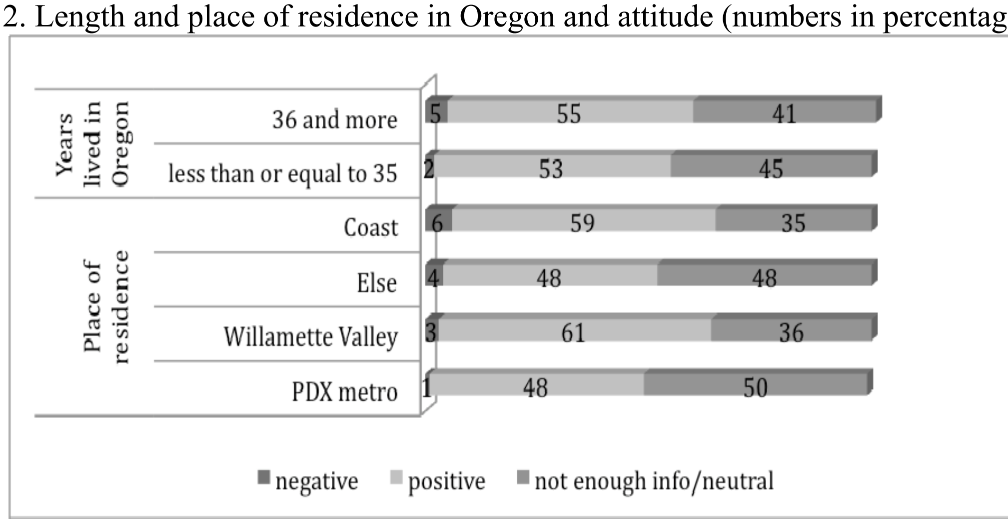
Low-income respondents (less than $25K) have the least amount of information to form an opinion (58%) and only 38% of them have a positive attitude toward wave energy development. The medium (between $25K and $75K) and the high (more than $75K) income respondents are mostly positively inclined toward wave energy development (60% and 59% correspondingly) and are also better informed.

Attitude and place and time of residence

Length of residence and attitude toward wave energy development

Length and place of residence have been shown to impact the way one feels about a particular place; in some cases even more than the sociodemographic variables previously described. Because of research showing that the longer one lives in a particular place, the more attached s/he feels to it, we expect people who have lived longer in Oregon to be more supportive of wave energy development than people who have lived here for a shorter period of time primarily because of Oregon's reputation as one of the "greenest" and most receptive of innovation states (Barker, 2009; Mayer, 2009). Surprisingly, the results point to an almost equal split – 55% of respondents who have lived in the state for more than 36 years and 53% of those who have lived 35 years or less in Oregon, have a positive attitude toward wave energy development (Fig. 2).

Figure 2. Length and place of residence in Oregon and attitude (numbers in percentages).



Attitude and values, environmental concern, and policy orientation

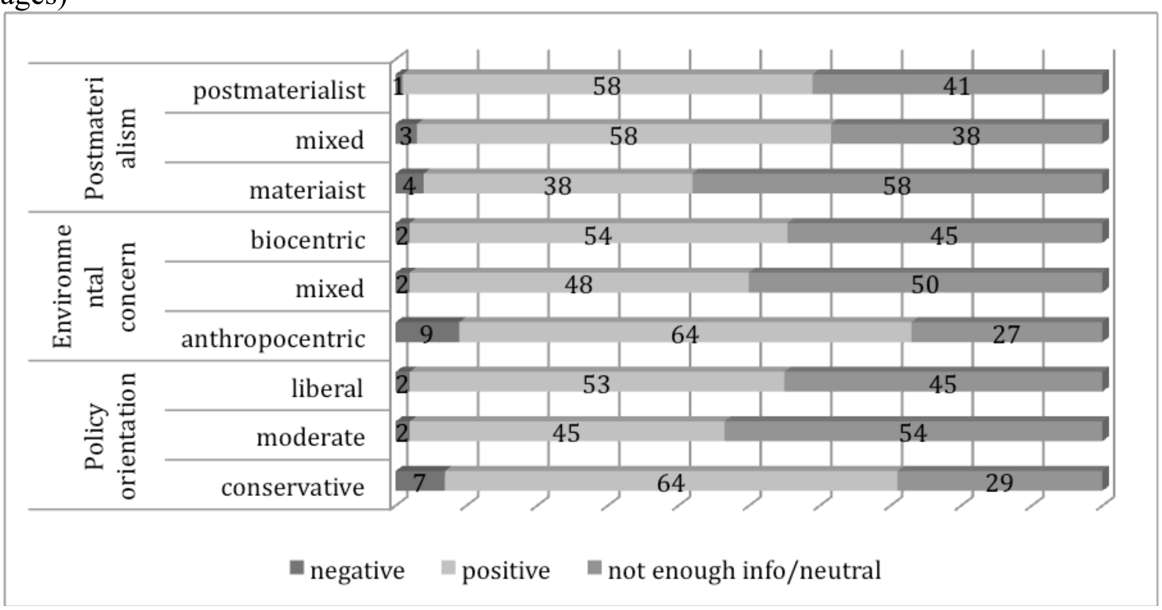
Attitude and values – postmaterialist, mixed, or materialist

Postmaterialism is a social science approach, developed by the political scientist Ronald Inglehart in 1977. Inglehart (1990, 2000) maintains that people in more developed countries would exhibit higher level of environmental awareness than would people in less developed countries because of preoccupation with satisfaction of basic needs like food, shelter, and physical well-being. Inglehart develops three categories that characterize one's level of material development:

- Postmaterialist - People who would give priority to the protection of freedom of speech and the participatory nature of democracy or "giving people more say in important governmental decisions."
- Materalistic - People who are concerned with "maintaining order in the nation" and "fighting rising prices"
- Mixed – everyone in between

The results support Inglehart's theory. Figure 3 shows that people holding both postmaterialist and mixed views are equally positive toward wave energy development (58%). People with materialist views have the most negative attitude (4%) and are least informed – 58% of them do not have enough information to form an opinion. The implications of these findings are discussed in the Summary of Section 2.

Figure 3. Attitude and values, environmental concern, and policy orientation (numbers in percentages)



Attitude and environmental concern – anthropocentric, mixed, or biocentric

- Environmental concern refers to "beliefs about humanity's ability to upset the balance of nature, the existence of limits to growth for human societies, and humanity's right to rule over the rest of nature". The three categories are as follows (Dunlap & Van Liere, 1978; Dunlap, Van Liere, Mertig, & Jones, 2000):
- Biocentric - People who exhibit high level of environmental concern
- Anthropocentric - Those who believe that humans have the right to rule over nature
- Mixed – Everything in between

The results show that more people with anthropocentric orientation have positive attitude (64%) and have more information to form an opinion (27%) than do people with either biocentric (54%) or mixed (45%) orientations. However, people with anthropocentric orientation also have the most negative attitude (9%), followed by people with mixed (2%) and biocentric (2%) orientation. The implications of these findings are also discussed in the Summary of Section 2.

Attitude and self-identified ideology - liberal, moderate, or conservative

Policy preferences are defined based on one's political beliefs about economic and social policies, and the government's role in them.

- Conservative - Generally, Americans with conservative preferences are pro-business and pro-development and are against government's intervention in the market. One of the reasons conservatives are against environmental reforms is because environmental reforms are considered extensions of government regulations, and as such hamper development (Dunlap, 1975).
- Liberals - Tend to be pro-innovation, pro-government support for those in need, and environmental protection from business. Studies maintain that people who have liberal policy preferences are more proenvironmental than are people with conservative policy preferences (Fransson & Garling, 1999).

The findings of this survey show (Figure 3) that the largest percentage of wave energy supporters comes from people with conservative orientation on policy issues (64%), followed by people with liberal orientations (53%), and then by people with moderate preferences (45%). Respondents with conservative policy orientations form the smallest group that does not have enough information to form an opinion (29%), as compared to 45% of liberal and 54% of moderate respondents. This is an indication that respondents view wave energy development more as an economic opportunity rather than as a policy tool that could be used to fight pollution and global warming. The policy implications of this finding are discussed below.

Summary of This Section

People across Oregon have positive attitude toward wave energy development. All of the value orientations, political considerations, and sociodemographic characteristics show statistically significant relationships (for a detailed table of the statistical relationships that support these findings, see Appendix 2).

To be developed and implemented, wave energy requires people to pay attention to the environment and be concerned with global warming, traditional fuel depletion, and understanding of the general environmental problems we are facing today. Therefore, we expected people with liberal, biocentric, and postmaterialist views to be most supportive of wave energy development.

The results support one of these expectations – that people with postmaterialist values are more supportive of wave energy development. The results, however, fail to support the other two expectations. What do these findings tell us and why are they important?

First, not only respondents with postmaterialist but also with mixed values have positive attitudes toward wave energy development. However, the percentage of respondents with materialist values who have a positive attitude is the smallest - 42% for the statewide and 22% for the coastal sample. The majority of respondents with materialist values do not have enough information to form an opinion. This indicates that people who give priority to economic security and "fighting rising prices" have not made up their mind about wave energy development yet. Since postmaterialism is often associated with respondents' income level – the more economically secure one is, the more likely he /she is to exhibit postmaterialist value orientations (Mayer, 1992; Smith, 2002) - frequency analysis of respondents' income was performed. The analysis indicated support for the correspondence between income and postmaterialist values. For example, it showed only 38% of the low income Oregonians (less than $25K) have positive attitude toward wave energy development, indicating that although people support renewable energy in principle, support is conditional on income and perceptions of the economic benefits renewables would provide.

Second, the majority of respondents with anthropocentric value orientations from the statewide sample (69%) and the coastal sample (67%) have positive attitude toward wave energy development, indicating that support for wave energy development comes predominantly from people who think that humans "are meant to rule over the rest of nature" and who place priority on economic development and material well-being through technological advances. Even though, it is argued that people who are most aware of the negative human impact on the natural environment and are concerned with global warming and the damages inflicted by fossil fuel burning, i.e. have biocentric orientation, would be most supportive of wave energy development because they would see it as a viable alternative to sustainability and species preservation in the long run; the results of this analysis show that respondents, who support wave energy, see it as a form of harnessing nature's forces to serve man's needs, providing an economic rather than an environmental benefit.

Third, the highest percent of respondents with negative attitude toward wave energy development comes from the coastal respondents with biocentric orientations – 21%. Different explanations could be offered for this finding. It might be the case that the coastal respondents with biocentric orientations know more about wave energy and its potential ecological impacts than the rest of the survey respondents. Indeed, only 25% of the coastal respondents with biocentric orientations indicate not having enough information to form an opinion – the lowest percentage of all. However, if these respondents have negative attitude toward wave energy development because they believe it will be potentially harmful for the environment, further analysis needs to examine what they think of the impact of fossil fuel burning, for example.

Seeing wave energy development as just an economic rather than an environmental benefit is supported by the fact that more conservatives support wave energy development than do people with liberal or moderate policy orientations. The policy implications of this finding are twofold. First, to get people to adopt wave energy faster, the urgency of the climate situation and the depletion of traditional energy sources should be made clear. Second, to increase the acceptability of wave energy, policy makers should stress the socioeconomic benefits it could provide, rather than just the environmental ones.

How can we describe the wave energy supporter in Oregon?

The strongest determinants of the wave energy supporter turn out to be: policy orientation, gender, one's anthropocentric/biocentric orientation, income, materialist/postmaterialist values, place of residence, employment, and education. Respondents' age and time spent in Oregon are also important predictors of attitude but at a lesser degree of significance. Based on the findings, the wave energy supporter in Oregon could be described as follows:

The wave energy supporter in Oregon is predominantly male, conservative, and has an anthropocentric orientation. He has medium to high income, postmaterialist or mixed value orientation, lives in the Willamette Valley or on the Coast, is over 56 years-of-age, is employed and is educated (finished some college or has a university diploma).

Familiarity with wave energy technologies and sources of information

This section defines if people who are most familiar with wave technology are also most supportive of wave energy development. It also examines respondents' sources of information and answers questions such as: are people who watch TV better informed about the energy situation and energy policy than are people who get their information from utilities, community leaders, or universities. Lastly, it looks into the relationship between level of familiarity with specific renewable energy technologies and one's knowledge of the energy situation.

Respondents were asked to directly identify their own level of familiarity with specific renewable energy technologies with the question: "How familiar are you with specific renewable energy technologies, including wave, biofuel, wind, solar, and geothermal energy?" Frequency of responses, concerning wave technology are presented in Table 4.

Table 4. Level of familiarity with wave energy technology across Oregon

	State-wide	Portland Metro	Willamette Valley	Coast
Not Familiar	41%	44%	30%	27%
Somewhat Familiar	38%	35%	50%	40%
Familiar	17%	18%	15%	26%
Very Familiar	5%	4%	5%	7%

Table 4 indicates low level of familiarity with wave energy technology - 8 out of 10 people in Oregon are not familiar at all or are somewhat familiar with wave technology. There is some variation in the level of familiarity across Oregon, e.g., 73% of coastal respondents exhibit some level of familiarity with wave energy technology compared to 59% of statewide respondents.

Characteristics of respondents most familiar with wave technology

The most important determinants of one's level of familiarity are gender, materialist/postmaterialist value orientation, place of residence, income, and policy preferences (Appendix). Also significant determinants are one's anthropocentric /biocentric environmental orientation and employment status. Age, education, and time spent in Oregon do not have a significant effect on respondents' level of familiarity.

In particular, respondents who are most familiar with wave energy are predominantly male with postmaterialist value orientations, living on the coast with medium income and liberal policy orientation. They are employed and have anthropocentric views.

Similarities between respondents most familiar with wave technology and those most supportive of wave development

Comparing the characteristics of respondents who are most familiar with wave energy technology with the characteristics of respondents who are most supportive of wave energy development, shows that despite the similarities between both groups, there are also many differences, leading to the conclusion that there are actually two distinct groups of Oregonians:

a) The most supportive of wave energy development and
b) The most familiar with wave technology.

In both groups, more men than women support wave energy and know more about the technology (Table 1). Other characteristics that both groups share are their postmaterialist and anthropocentric orientations, and their employment status – respondents who are employed are both more familiar and more supportive. While the level of familiarity is highest among the medium income group, the level of support is highest among the medium and the high-income respondents. Coastal residents and respondents with predominantly liberal policy preferences are most familiar with the technology, while residents in the Willamette valley and those with conservative policy ideologies are most supportive. In addition, while respondents older than 56 are more supportive, age is not a major determinant of familiarity. Respondents who have lived 36 or more years in Oregon and those who have university degrees are both more familiar and more supportive than their counterparts.

Energy quiz: How much do Oregonians really know about energy?

Respondents were presented with three quiz-type questions aimed at measuring their "real" level of energy knowledge. Respondents were quizzed about:

a) The largest source of energy generation for electricity in Oregon,
b) The electricity sector with the highest energy consumption, and
c) The term "off-grid," used to describe homes that do not get electricity from conventional utility power sources.

Respondents were instructed to skip a question if they were not sure about the answer, but not many did - only 9% omitted quiz question 1, 18% quiz question 2, and 14% quiz question 3. The number of responses is high enough to depict a realistic profile of Oregonians' "real" level of energy knowledge, which is pretty good - 40% of respondents gave two correct answers, 33% one correct answer, 18% three correct answers, and only 9% gave no correct answers. These percentages do not differ significantly across the regions of the state (Table 9).

Eighty-two percent of respondents answered correctly the first question about the largest source of energy generation for electricity in Oregon. According to the Energy Information Administration, "Oregon is one of the Nation's leading generators of hydroelectric power, which accounts for more than one-half of State electricity generation" (EIA - Energy Information Administration, 2009). The U.S. Department of Energy shows that Oregon's total electricity generation for 2005, came from hydro (69%), natural gas (20%), coal (8%), and only 3% came from renewable sources like biomass, geothermal, solar, and wind (U.S. Department of Energy, 2008).

The correct answer to the question about the electricity sector with the highest energy consumption was provided by slightly more than 1/3 of respondents. Most electricity in Oregon for 2005 was used by the residential sector (39%), the commercial sector (33%), and the industrial sector (27%) (U.S. Department of Energy, 2008). Oregonians, however, believe the industrial sector to be the largest consumer of electricity while in fact it is the third largest – after the residential and the commercial sectors - using far less electricity than any of them.

Oregonians show a high level of familiarity with the term "off-grid" – 64% of them responded with the correct answer.

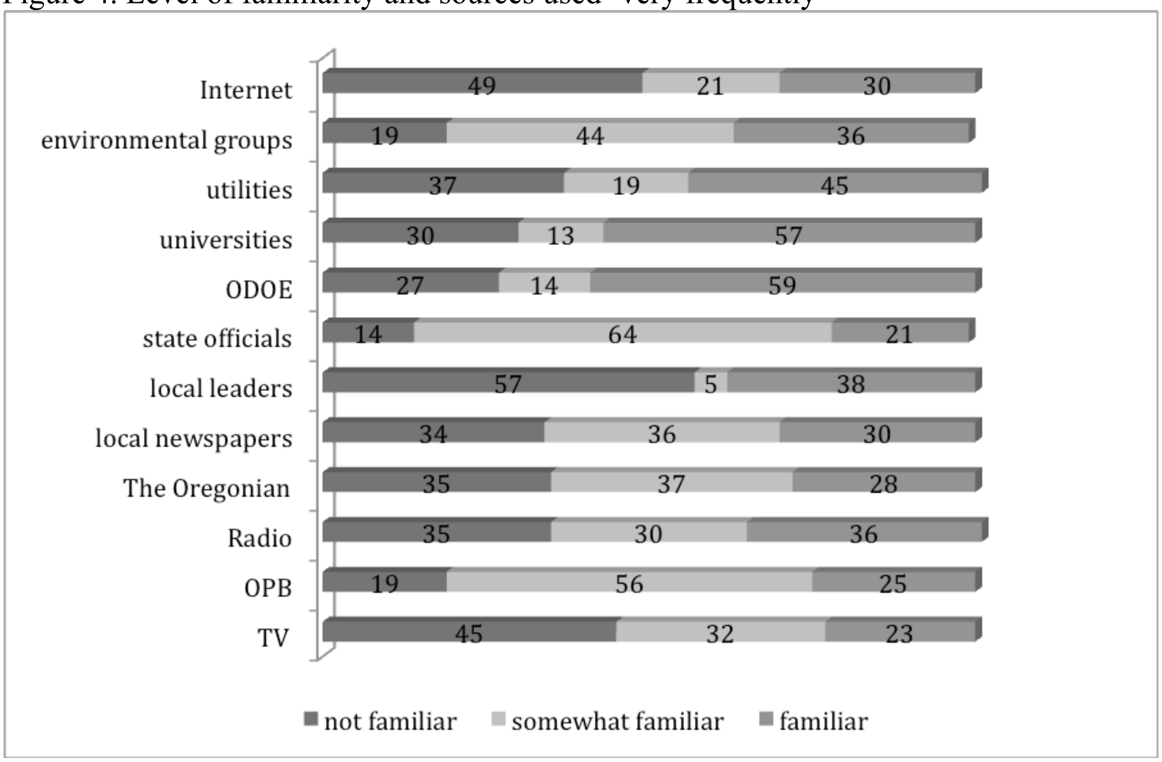
Sources of information Oregonians use to get informed about Oregon's energy and policy

Respondents were asked to identify the frequency of use of 12 information sources that included organized official sources, such as government officials, and various media sources, such as local newspapers. The question read: "We would like to know which of the following information sources you currently use or would use to learn more about Oregon's energy situation and policy. Please circle the number of the frequency of your use." Respondents were given the following answer choices: "very frequently," "frequently," "infrequently," and "never."

Factor analysis organized the 12 information sources in four general groups. These sources explain 59% of respondents' level of familiarity (Tables 10, 11). The four groups are labeled: 1) Organized official sources, 2) Print media, 3) Audio media, and 4) Image media. The first group "Organized official sources" accounts for a quarter of the 59% of respondents' familiarity and includes: local community leaders, the Oregon Department of Energy, state elected officials, universities, utilities, and environmental groups.

More specifically, respondents, who are familiar with wave energy, very frequently get information from the Oregon Department of Energy (59%) universities (57%), and the utilities (45%, Figure 4). Those, who are somewhat familiar, very frequently use state officials (64%), Oregon Public Broadcasting (56%), and the environmental groups (44%). A detailed description of the relationship between one's level of familiarity and frequency of information sources used, is provided in Appendix 4 in both table and graph formats.

Figure 4. Level of familiarity and sources used 'very frequently'



Summary of This Section

Establishing the validity of the relationship between one's support for wave energy development and one's familiarity with the technology and the energy situation in general, is important because it sheds light on the reasons for support of or opposition to wave energy development. Based on the analysis of the reasons, separate communication strategies can be devised for the groups with different levels of informedness. For example, the analysis shows that only about 10% of one's level of familiarity is explained by his/her attitude toward wave energy. Additional 4% are explained by gender alone. Moreover, the interaction between one's place of residence, income, and employment predicts 2.4% of one's level of familiarity. These results show that there are other determinants not covered by the socio-demographic variables here. Further research would be necessary for their determination.

The analysis also shows that of the 54% of respondents who have positive attitude toward wave energy development, 25% are not familiar with wave energy technology and of the 3% who have negative opinion toward wave development, 27% are not familiar (Table 8, p.37). This is an important finding because it shows that one's level of familiarity with the technology does not necessarily determine one's level of support s/he expresses. Respondents, who are most familiar and least supportive, are men who live on the coast. They seem to fit the profile of coastal residents involved with activities in the ocean – commercial or recreational fishing. These respondents are most familiar with wave energy technology and are also most concerned with wave energy development because of its potential to affect their livelihoods.

In formulating OWET's communication strategy for wave energy development, particular attention should be paid to these residents in explaining to them the benefits of wave energy – both the economic and the environmental ones. These residents could be reached most effectively through the organized official groups, including the Oregon Department of Energy, universities, and the utilities.

What are Oregonians main concerns about the current energy situation?

The questions in this section relate to respondents' level of concern about the energy situation and the energy future of the United States. The results show 6 out of 10 Oregonians consider themselves to be "somewhat informed," and 3 out of 10 think they are "well-informed" about renewable energy policy issues. Respondents sometimes discuss issues related to renewable energy with their family and friends; and believe that people like them can make a small (45%) to a moderate (32%) impact on renewable energy policy.

The majority of Oregonians are concerned about the U.S. energy policy. Eighty-four percent agree that it is important to decrease the U.S. dependence on foreign oil and gas and 83% are concerned about foreign ownership of America's energy resources. However, respondents are less concerned that the country doesn't have enough energy resources (54%) or that they could personally be affected by a shortage of electricity in the near future (42%).

Slightly more than two-thirds (69%) of Oregonians agree that not enough money is being spent on research and development of alternative fuels. There is a firm belief in the state that it is possible to increase energy supplies while protecting the environment at the same time (83%) and that new technologies will make it possible to have enough electricity for all of us in the future (72%).

In general, while Oregonians strongly agree that something needs to be done to decrease the U.S. dependence on foreign energy sources and increase support for renewable technology development at the national level, they seem to distance themselves from the problem and do not feel personally concerned with energy shortages. This detachment is expressed in their belief that yes, there is an energy problem, but it is somewhere out there, and they cannot do much to alleviate this problem. For example, even though 73% agree there is solid evidence that the average temperature on earth has been getting warmer over the past few decades, less than two-thirds (60%) believe it is caused by human activities. In addition, while Oregonians consider themselves to be familiar about energy issues, they do not know that it is the residential sector that uses far more energy than the industrial or the commercial sectors. In other words, they do not feel the issue of energy consumption to be their responsibility because they do not know how it actually affects them.

Recommendations / Considerations

The majority of both scientists and citizens now agree that global warming is present. Where they differ is in their feelings of urgency to do something about the climate situation. While scientists believe that humanity is reaching a tipping point, where the consequences of our actions will not be reversible if we do not implement some measures to curb CO2 emissions; Americans, and Oregonians in particular, believe that it is still possible to increase the global energy supplies while protecting the environment (83%) and that there will not be a shortage of electricity in the near future. People do not feel personally threatened by global warming or energy depletion. We turn on the switch and there is electricity. We go to the gas pump and tank up, maybe not for $20 as it used to be in the 1970s, but for $60 as it is now, in 2009, 9 years into the 21st century. The point is – we can still do it, because there is gas. What will happen when there will be no gas?

Energy policy development requires a long-term vision of the relationship between human needs and desires and the sustainable use of natural resources. In view of the findings, the following recommendations – concerning both policy and research – are advanced.

1. Awareness of global environmental issues needs to be increased. While 71% of Oregonians believe there is solid evidence that global warming is happening, 25 % of them attribute it to natural patterns in the earth's environment and 15% still answer "do not know."
2. People do not feel personally responsible for the causes and consequences of climate change and oil depletion. While they agree that energy security is a priority for the country, they do not know what they can do to contribute to energy conservation and security, e.g., they are not familiar with the fact that the residential sector consumes the largest amount of electricity – more than the commercial and the industrial sectors. In addition to showing people how to make their homes energy efficient, people need to know why they need to do it. Learning why and eliciting behavioral changes is a process that will take a long time because it requires change in people's habits and everyday practices.
3. There seems to be a disconnect between self-identified familiarity and "real" knowledge. People seem to think they are familiar with the energy situation and policy issues but in fact, they have many misconceptions about the impact of their actions. These misconceptions need to be discussed and cleared away.
4. A thorough and systematic information campaign needs to be organized about wave energy, here, in Oregon. Of all renewable energy technologies, respondents are least familiar with wave energy.
5. The environmental impacts and benefits of wave energy compared to other energy sources - both renewable and traditional - needs to be stressed as well.
6. Different strategies for increasing awareness of wave energy need to be used for people with different sociodemographic characteristics and values. For example, while women need general information about wave energy, i.e., they need to be made aware that wave energy exists as an energy option (51% of them do not have enough information to form an opinion), men need to be familiarized not only with the economic, but also with the environmental benefits it can provide.
7. The reasons for the lower support of wave energy by the coastal residents need to be understood well. One way of doing this is through a closer examination of respondents' values and concerns. The results of this analysis show that while 59% of the coastal respondents have anthropocentric orientations, only 12% have biocentric. However, the highest percent of

respondents with negative attitude toward wave energy development comes from the coastal respondents with biocentric orientations – 21%. Oftentimes, fishermen have declared, “We, fishermen, are tied so closely to the marine ecosystem, we see ourselves as part of it” (Chambers, 2008). If that is really the case, then the environmental impact of wave energy needs to be explained to fishermen in relation to the impact of traditional fossil fuel use.

8. The reasons for the “neutral” attitude should be examined. We cannot say for sure that people have a neutral attitude because they do not have enough information to form an opinion (and if that were the case, why didn’t they select that option), because they think “neutral” sounds better than “I don’t have enough information to form an opinion” because it might show them as uninformed; or they have some information to form an opinion but they either do not want to share it or have not made up their mind yet. Further research is necessary in this area to determine the reasons for support or opposition toward wave energy development off Oregon. Of all respondents who do not have enough information to form an opinion or are neutral, coastal residents constitute the smallest percentage (35%), which shows that people on the coast are better informed than the rest of the Oregonians about wave energy development.

9. Respondents, who are most familiar, rely on organized official sources to get their information – universities, utilities, and the Oregon Department of Energy. To increase citizen awareness and level of familiarity with wave energy, partnerships must be formed with these entities and co-operations established so that people know that the information they are getting is credible.

10. To understand respondents’ concerns and reasons for support of or opposition to wave energy development, the wave energy development process should be examined in its entirety. Some of the reasons for the slow take-off of renewable energy generation have been shown to be the negative public attitude to particular projects, with large-scale projects creating more opposition than small-scale ones; the developers’ approach of ‘decide-announce-defend’ to siting with minimal public involvement, and other inadequacies of the siting and permitting processes (Devine-Wright, 2005; Firestone & Kempton, 2007; Walker, 1995; Zoellner, et al., 2008). In Oregon, fishermen have declared, “We are *not* opposed to the development of wave energy, [b]ut three things are of utmost importance: How the process moves forward, where the buoys are sited, and who benefits. Or, conversely, who loses” (Chambers, 2008).

To conclude, while the results of the *Oregon Energy Policy Survey* reveal a general widespread support for developing wave energy in Oregon, to understand the specifics of the public attitudes better, more in-depth analysis of the various aspect of the whole process must be undertaken. In addition, longitudinal observations are needed to help predict the responses and concerns of Oregonians to new developments. Thus, this document constitutes an integral part of the research performed by the Human Dimensions of Wave Energy Research Program at Oregon State University in 2008-09.

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Appendix 1

Relationship between wave energy attitude and respondents' characteristics

Table 5. Determinants of wave energy attitude in Oregon

	Wave energy attitude (%)					
	Negative	Positive	Not enough info to form opinion	Chi-square	p-value	Effect size
Age				12.6	<.01	.12
<56	1	51	47			
≥56	5	55	40			
Gender				26.4	<.001	.17
Male	4	62	34			
Female	3	46	51			
Education				21.7	<.001	.11
High School or less	4	40	56			
College/ vocational	4	56	40			
University graduate	3	60	38			
Employment				21.9	<.001	.11
Employed	1	57	42			
Retired	6	54	39			
Other	4	45	51			
Income				30.4	<.001	.13
Low	4	38	58			
Medium	3	59	38			
High	4	60	37			
Place of residence				26.4	<.001	.12
Pdx metro	1	49	50			
Willamette Valley	3	61	36			
Else	4	48	48			
Coast	6	59	35			
Time in Oregon				6.4	<.05	.09
<35 years	2	53	45			
≥36 years	5	55	41			
Policy orientation				47.6	<.001	.17
Conservative	7	64	29			
Moderate	2	45	54			
Liberal	2	53	45			
NEP				41	<.001	.15
Anthropocentric	9	64	27			
Mixed	2	48	50			
Biocentric	2	54	45			
Values				25.6	<.001	.12
Materialist	4	38	58			
Mixed	3	58	38			
Postmaterialist	1	58	41			

Appendix 2

Relationship between level of wave energy familiarity and respondents' characteristics

Table 6. Determinants of wave energy familiarity in Oregon

	Level of familiarity (%)					
	Not familiar	Somewhat familiar	Very familiar & Familiar	Chi-square	p-value	Effect size
Age				1.9	>.05	.05
<56	36	38	26			
≥56	39	39	22			
Gender				60.8	<.001	.26
Male	25	45	31			
Female	49	33	18			
Education				7.7	>.05	.07
High School or less	37	44	19			
College/ vocational	41	35	24			
University graduate	35	39	27			
Employment				15.1	<.05	.09
Employed	34	39	27			
Retired	39	38	23			
Other	55	23	22			
Income				23.3	<.001	.12
Low	45	42	13			
Medium	35	36	29			
High	33	42	25			
Place of residence Pdx				37.6	<.001	.14
metro	44	35	21			
Willamette Valley	30	50	20			
Else	49	28	23			
Coast	27	40	32			
Time in Oregon				.6	>.05	.03
<35	38	37	25			
≥36	37	40	23			
Policy orientation				21.4	<.001	.11
Conservative	38	35	27			
Moderate	41	43	16			
Liberal	33	36	31			
NEP				14.8	<.05	.10
Anthropocentric	29	40	31			
Mixed	41	41	18			
Biocentric	37	37	26			
Inglehart				64.4	<.001	.20
Materialist	46	46	8			
Mixed	42	35	23			
Postmaterialist	20	42	39			

Appendix 3

Table 7. Level of familiarity and sources of information

	Level of familiarity (%)					
	Not familiar	Somewhat familiar	Familiar	Chi-square	p-value	Effect size
TV				19.5	<.01	.11
Never	32	28	40			
Infrequently	32	44	25			
Frequently	38	41	21			
Very frequently	45	32	23			
OPB				77.9	<.001	.21
Never	34	38	28			
Infrequently	50	38	12			
Frequently	36	30	35			
Very frequently	19	56	25			
Radio programs				41.3	<.001	.15
Never	50	36	15			
Infrequently	37	43	20			
Frequently	27	39	33			
Very frequently	35	30	36			
The Oregonian				8.2	>.05	.07
Never	41	37	22			
Infrequently	32	44	23			
Frequently	40	34	26			
Very frequently	35	37	28			
Local newspapers				15.9	<.05	.10
Never	45	38	17			
Infrequently	39	40	21			
Frequently	32	39	30			
Very frequently	34	36	30			
Local leaders				26.9	<.001	.12
Never	45	34	21			
Infrequently	33	43	24			
Frequently	28	42	30			
Very frequently	57	5	38			
State officials				24.5	<.001	.12
Never	47	33	19			
Infrequently	32	42	26			
Frequently	42	31	27			
Very frequently	14	64	21			
OR Dept of Energy				54.6	<.001	.18
Never	51	33	16			
Infrequently	32	44	24			
Frequently	28	39	33			
Very frequently	27	14	59			
Universities				97.5	<.001	.27
Never	53	29	18			
Infrequently	34	46	21			
Frequently	17	48	35			
Very frequently	30	13	57			

Table 7. Level of familiarity and sources of information (continued)

	Level of familiarity					
	Not familiar	Somewhat familiar	Familiar	Chi-square	p-value	Effect size
Utilities				57.8	<.001	.18
Never	62	19	19			
Infrequently	37	44	19			
Frequently	31	42	27			
Very frequently	37	19	45			
Environ. groups				16.5	<.01	.10
Never	43	37	20			
Infrequently	36	40	24			
Frequently	36	39	25			
Very frequently	19	44	36			
The Internet				31.3	<.001	.13
Never	41	43	16			
Infrequently	36	40	24			
Frequently	29	42	29			
Very frequently	49	21	30			

Level of familiarity and frequency of use of specific sources of information

Figure 5. Level of familiarity and frequency of TV use (numbers show percentages).

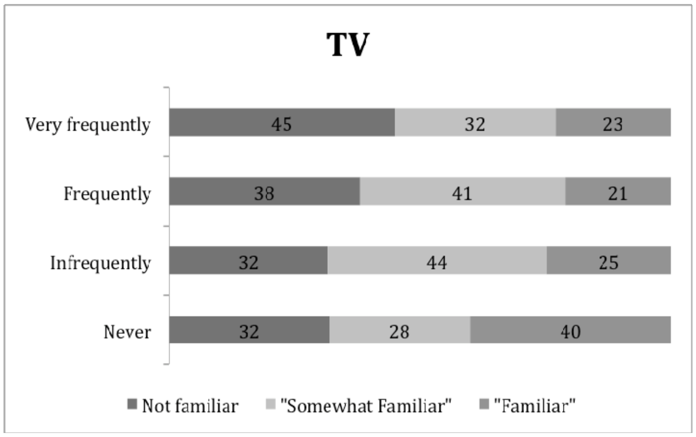


Figure 6. Level of familiarity and frequency of OPB use (numbers show percentages).

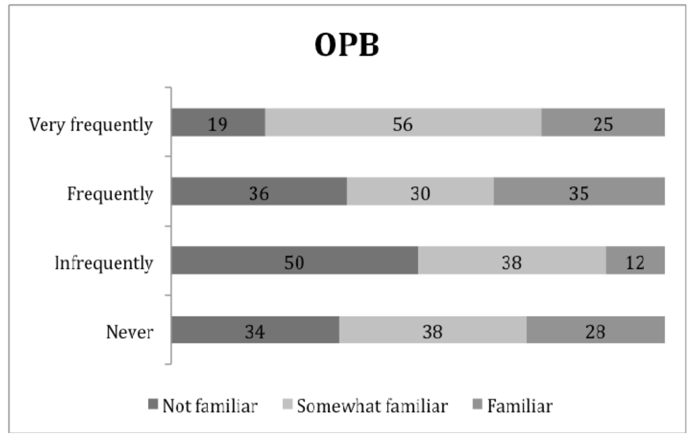


Figure 7. Level of familiarity and frequency of Radio programs use (numbers show percentages).

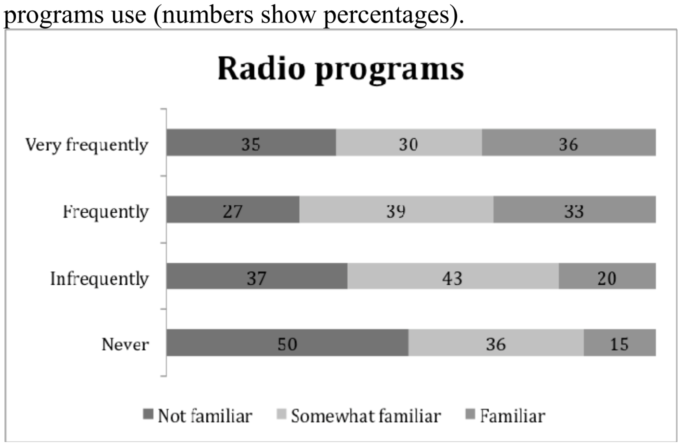


Figure 8. Level of familiarity and frequency of reading the Oregonian (numbers show percentages).

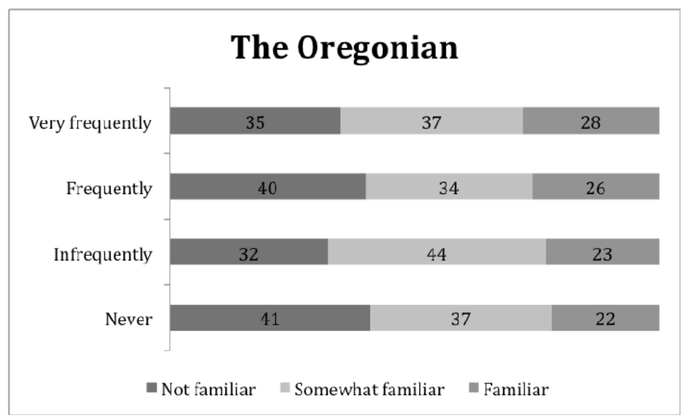


Figure 9. Level of familiarity and frequency of reading local newspapers (numbers show percentages).

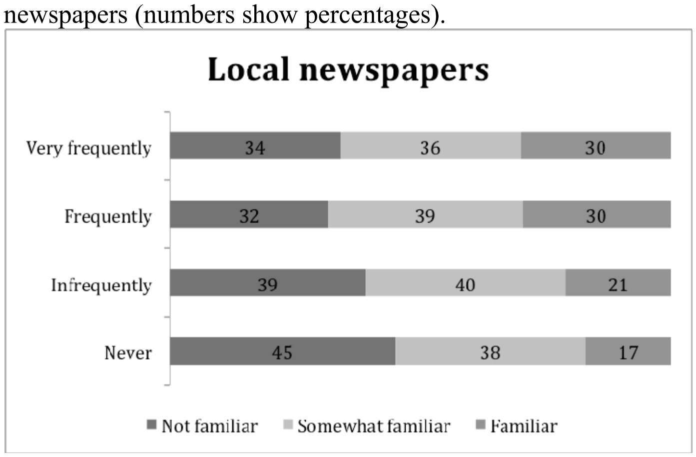


Figure 10. Level of familiarity and frequency of reference to local leaders (numbers show percentages).

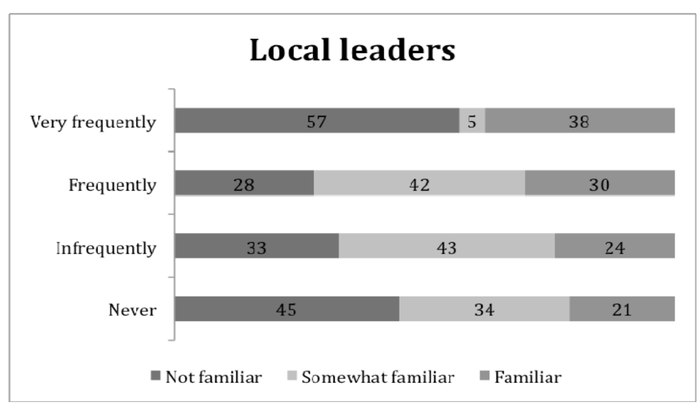


Figure 11. Level of familiarity and frequency of reference to state officials (numbers show percentages).

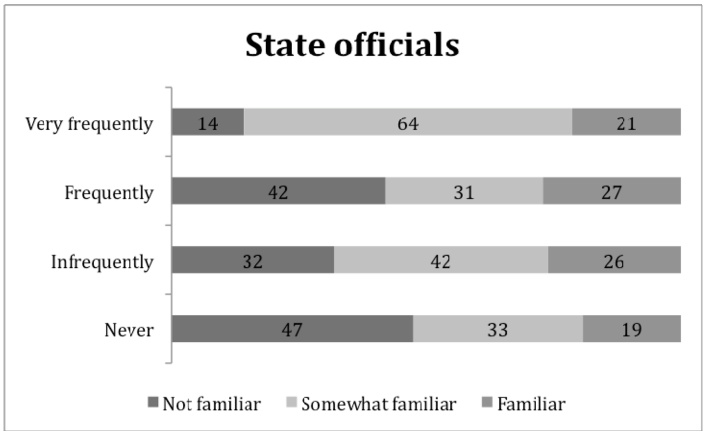


Figure 12. Level of familiarity and frequency of reference to the Oregon Department of Energy (numbers show percentages).

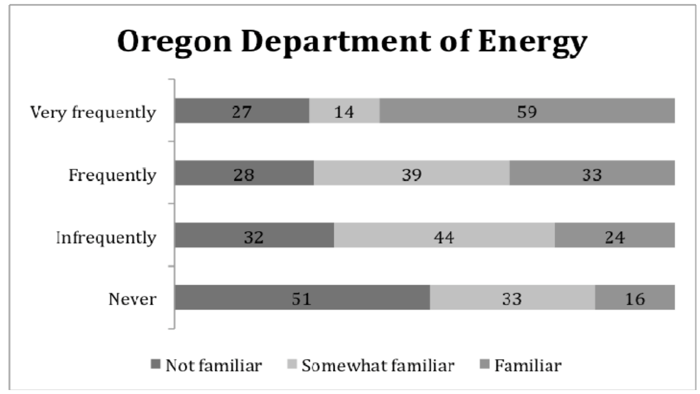


Figure 13. Level of familiarity and frequency of reference to universities and colleges (numbers show percentages).

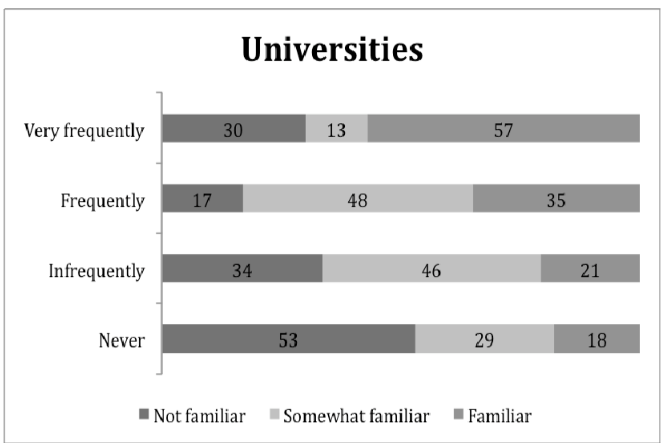


Figure 14. Level of familiarity and frequency of reference to utilities (numbers show percentages).

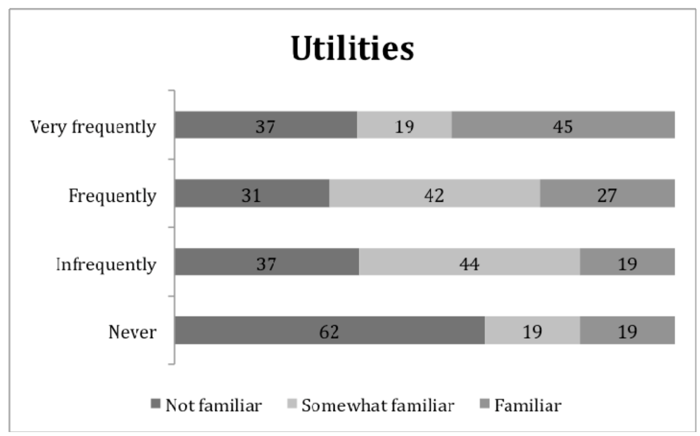


Figure 15. Level of familiarity and frequency of reference to environmental groups (numbers show percentages).

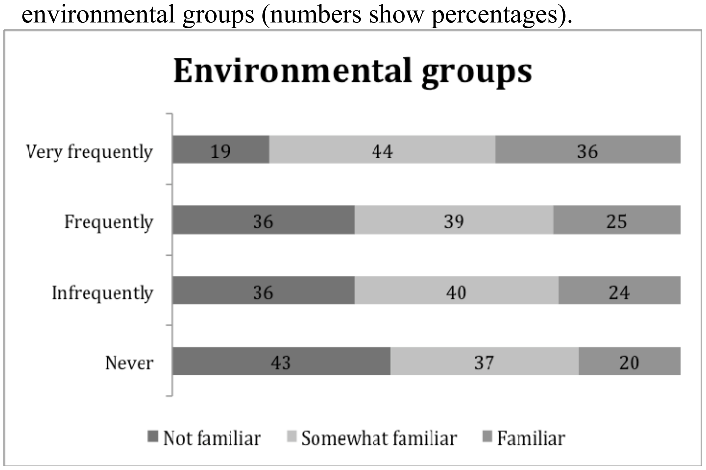
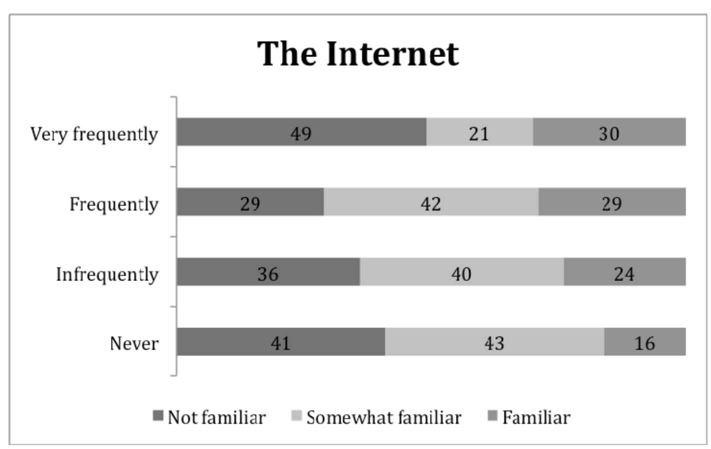


Figure 16. Level of familiarity and frequency of Internet use (numbers show percentages).



Appendix 4

Additional tables

Table 8. How level of familiarity with wave energy technology defines attitude toward wave energy development

Level of familiarity (IV)	Attitude toward wave energy development (%) Positive	Negative	Not enough info	Chi-square	p-value	Effect size
				101.71	<.001	.24
Not familiar	25	27	53			
Somewhat familiar	44	23	34			
Familiar	24	30	12			
Very familiar	7	20	1			

Table 9. Number of correct answers and area of residence

Number of correct answers	Area of residence (%) PDX	Valley	Else	Coast	Chi-square	p-value	Effect size
					14.6	>.05	.08
0	8	12	16	7			
1	37	30	30	33			
2	37	43	36	43			
3	19	16	18	18			

Table 10. Exploratory factor analysis of frequency of use of information sources contributing to level of familiarity with wave energy technology.

	Factor loadings[1]			
Information sources:	Factor 1: Organized official sources	Factor 2: Print media	Factor 3: Audio media	Factor 4: Image media
Local community leaders	.75			
Oregon Dept Energy	.72			
State elected officials	.69			
Universities	.68			
Utilities	.66			
Environmental groups	.51			
Local newspapers	.51	.56		
The Oregonian		.80		
OPB		.42	.64	
Radio			.84	
Television				.75
Internet				-.58
Eigenvalue	3.15	1.37	1.31	1.23
Percent (%) variance explained	26.27	11.39	10.93	10.24
Cumulative percent (%) of variance	26.27	37.67	48.60	58.83

[1] Principal Components factor analysis with Varimax rotation converged in 5 iterations. Only factors with eigenvalues greater than 1 and items with factor loadings greater than .40 were retained in the final factor structure. Items coded on 4-point scale of 1 = never to 4 = very frequently.

Table 11. Reliability Analysis of the factors contributing to the level of familiarity with wave energy technology

Information sources and factors:	Mean	Standard deviation	Item total correlation	Alpha if deleted	Cronbach Alpha
Factor 1: Organized official sources					.78
Local community leaders			.63	.73	
Oregon Dept Energy			.57	.74	
State elected officials			.57	.75	
Universities			.59	.74	
Utilities			.46	.76	
Environmental groups			.48	.76	

Mapping the Political Landscape of Wave Energy Development in Oregon

John Stevenson
Oregon State University, 2009

Summary

Since 2006, Oregon has promoted the development of wave energy off its coast. While the state is well suited for the technology because of an abundant wave resource and supporting coastal infrastructure, there remain potential barriers to implementing this policy including uncertainties about the technology and concerns for impacts to the local environment and existing ocean users. Among many studies commissioned to address these potential road-blocks, this research maps the political landscape and identifies areas of census and division among policy actors.

Key findings in this study indicate general support for testing wave energy, but that inflexibility in project location and efforts to develop commercial scale wave parks are areas of division among policy actors. To avoid political barriers, this study recommends that decision makers emphasize testing wave energy through collaborative processes that include actors in decisions about project location and environmental monitoring protocols, while avoiding efforts to move directly to commercial scale development until test results have been analyzed. This will provide stakeholders an opportunity to develop more supportive policy positions rather than focusing efforts on preventing commercial scale development.

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Introduction

In 2006, Oregon's governor advocated developing renewable energy to combat global warming and stimulate the state's economy with green jobs. In the following year, the state legislature passed the Oregon Renewable Portfolio Standard (RPS) that required electricity providers to supply 25% of state's electricity from renewable resources by the year 2025. Included in this package was a suite of tax incentives and funding for research and development of emerging technologies. The wave energy industry has benefited from this policy in particular with just over $4 million to fund the Oregon Wave Energy Trust (OWET) for the purpose of promoting the technology's development off Oregon's Coast. Technical assessments indicate that the coast of Oregon is well suited for the technology because of the abundant wave resource and supporting coastal infrastructure to transmit the electricity to coastal populations.

However, the wave energy industry is only in its infancy and some 20 years behind wind technology, which is considered the most market competitive of the renewable energy resources. Major technical considerations for wave energy development include its ability to withstand a harsh ocean environment and efficiency for extracting energy from the resource, both of which are considered key to its economic success. Other considerations include impacts that the technology may have on the surrounding marine environment including concerns for migratory grey whales, and changes to sediment transport in near-shore coastal processes. Social and economic concerns have also been raised, with concerns voiced about loss of commercial and recreational fishing grounds and other recreational activities including surfing and kayaking.

The legal framework managing wave energy has also complicated efforts to develop the resource. When this study began in late 2007, an on going federal jurisdictional dispute between the U.S. Federal Energy Regulatory Commission (FERC) and the U.S. Minerals Management Service (MMS) about who would regulate wave energy loomed over this developing industry and created uncertainty for developers, state resource agencies and public stakeholders about permitting and licensing processes. This overlaid Oregon's own coastal management frameworks, which are currently undergoing modification to identify appropriate areas for wave energy development in its Territorial Sea Plan (TSP). Cumulatively, these factors may influence the degree of support or opposition among policy stakeholders, which in turn can affect the state's effort to foster wave energy development, specifically, and the RPS implementation more generally. This study attempts to map the political landscape of wave energy development to identify issues of consensus and conflict among stakeholder groups. In doing so, this study provides information that OWET and the state can use to develop strategies for managing the political landscape and steer wave energy development around political barriers. In the pages to follow, this paper provides the background of wave energy development in Oregon, the purpose of this research and the specific methods used to collect data. This will be followed by a discussion of key findings from this study and close with recommendations for managers and opportunity for future research.

Background and Purpose of this Study

Renewable Energy Policy

Over the last two decades many states have adopted a RPS to address concerns about energy independence, greenhouse gases, and capitalize on opportunities to grow their economies (Huang et al 2007). In February of 2006, Oregon Governor Theodore Kulongoski proposed an RPS for Oregon that called for 25% of the state's electricity to be generated from renewable sources by 2025 (Kulongoski 2006). In 2007, the Oregon State Legislature passed Senate Bill 838, which codified the governor's 25% by 2025 target. The Oregon RPS included an additional 24 bills that provided for variety of renewable incentives and efficiency improvements including funding for research and development, tax credits for renewable firms, and installation of energy efficient appliances for homeowners (ODOE 2007). Wave energy industries have experienced considerable benefits from this policy. In June of 2007, the Oregon State Legislature provided $4.2 million to OWET for the responsible development of wave energy. Since that time, OWET has made efforts to facilitate wave energy development by identifying ecological and economic research needs, addressing the complex state and federal regulatory framework, and developing outreach strategies to work with communities affected by these developments.

Ocean Renewable Technologies

Currently, 42% of Oregon's electricity comes from hydropower, followed by coal (41%), natural gas (10%) nuclear (3%), biomass (3%), and wind and geothermal (1%) (Yin 2009**).** However, recent studies have indicated that significant contributions could be made from wave energy resources. In Oregon, this resource is abundant and could be developed through its established ports and coastal electricity grid that could support seven 100 MW wave energy power plants (Hagerman et al. 2004), and provide up to one half of the 25% by 2025 RPS requirement (Brekken 2009). However, the realization of this technology off Oregon's coast is still uncertain. By most indications, wave energy technology is still in its infancy (Brekken 2009) and, much like wind technology 20 years ago, several wave energy conversion devices have been developed but no single technology has been proven superior (ibid). Major considerations for the technology's success include *survivability*, or the ability to withstand the ocean's severe storms and corrosive environment, and how *cost-effective* it will be for the production, maintenance and operation of these devices. Despite these uncertainties, Previsic et al. (2004) suggest that wave energy could become competitive with wind energy if the technology can capture between 40-60% of the resource. But many of the figures are theoretical estimates and most likely will not be validated until these devices are tested in the ocean (Brekken 2009).

Management Frameworks

The legal framework regulating wave energy development is complex, and until recently, was hampered by a jurisdictional dispute between the FERC and the MMS concerning regulatory authority over wave energy development (Stoel Rives 2008). This dispute was tentatively resolved with the signing of a Memorandum of Understanding (MOU) when the Obama Administration took office in early 2009, which left FERC, in coordination with MMS, as the primary licensing agency for wave energy development. The FERC licensing process was originally designed for licensing hydo-power projects on land but has been adapted for wave energy development in the ocean using a two-phased process (Campbell 2009): the first requires filing for a *preliminary permit*, to conduct feasibility studies and stakeholder outreach while the second filing is to obtain a *license* (Campbell 2009). FERC also allows developer to pursue a *settlement agreement* in which affected parties come to agreement about the substance of the licensing application, including details about location, environmental monitoring and mitigation strategies.

At the state level, Oregon has entered into a MOU with FERC to help ensure licensing decisions are coordinated with state preferences. Oregon is also amending it TSP, to identify spatial areas that are ecologically and economically appropriate for wave energy development through several mapping efforts, one of which has begun mapping economically important fishing areas through a cooperative effort between the state, fishing groups, and NGO partners.[1] At the time of this writing, no habitat mapping has occurred, but has been allocated approximately $4 million in federal funds with another $1 million possibly from the state (Pakenham, A. personal communications, June 19, 2009). Overall these efforts are important for Oregon because if the TSP amendment process is incorporated in the state's federally approved Coastal Management Plan, it would require that federal agency decisions, such as wave energy licenses affecting state waters, be consistent with that plan under the Coastal Zone Management Act (CZMA) (Crane 2006).

Oregon's Ocean Environment

The specific resources managed off Oregon's coast are vast. Oregon's near-shore environment is characterized by a variety of habitat types including rocky-intertidal zones, soft-sandy bottoms, kelp beds, and rocky-reef habitats (ODFW 2005). Each of these habitats supports many species of invertebrates, fish, and marine mammals, some of which are unique only to particular habitat types. It has been difficult to evaluate what impact wave energy development might have on this ecosystem largely because these technologies have yet to be evaluated in that environment. To address this uncertainty, Oregon State University hosted the Ecological Effects Workshop in October of 2007 that convened prominent scientists to identify potential concerns and develop a research agenda to addresses each in turn. The outcomes identified several potential issues, including impacts to coastal sediment transport; collisions between wave energy devices and large marine animals such as gray whales; changes in trophic structure resulting from growth of the fouling community on hard structures; introduction of chemicals (anti-fouling paints; hydraulic fluid); introduction of electro-magnetic fields from electricity transmission; generation of new acoustic signatures (sound); and attraction of marine organisms to navigational safety lights (McMurray 2007). While each of these impacts can be considered individually, the workshop underscored the need to assess their cumulative effect, especially as they relate to scale and duration of wave energy developments (McMurray 2007). Overall, the workshop provided a starting point for

[1] Oregon Coastal Zone Management Association and EcoTrust.

monitoring wave energy developments and posited important questions to consider during evaluation.

Existing Ocean Uses

Oregon's near-shore ecosystem also underpins its commercial and recreational fisheries. According to a 2006 report issued by NOAA National Marine Fisheries Service (NMFS), commercial landings in Oregon have been valued at nearly $1.1 billion (NOAA 2006) with fisheries for Oregon Dungeness crab, pink shrimp and albacore tuna comprising the three most valued landings in 2008, according to the Oregon Department of Fish and Wildlife (ODFW 2008). Recreational fisheries are more difficult to value because landings are not sold on the wholesale market. However, the 2006 NMFS report indicates that this sector provided more than $250 million to Oregon's economy as a result of drawing in customers for charter boat operations who then patron lodges, restaurants, bait shops and other local business (NOAA 2006).

Similarly, non-extractive recreational users including surfers, sea kayakers, scuba divers, and general beach visitors are active along Oregon's coast. There is also poor information about these user groups but a recent study looking at the health risks of ocean users estimated that active surfers spent more than 70 days a year in Oregon's surf (Stone et al. 2008). Another indicator of recreational use is membership to recreational groups. Surfrider Foundation, a nonprofit organization that represents surfers and other ocean recreational users, has more than 600 active members and maintains a network more than twice that through several chapters in the state (Gates, G., personal communication, May 17, 2009). Anecdotally, Oregon also has dozens of surfing and recreational outfitting shops but at the time of this writing no formal data could be found.

A Need to Understand Political Context

Understanding how all of these factors manifest into the political context of marine spatial planning issues is important to any policy effort. Unfortunately, it can also be somewhat of an afterthought following months or even years of careful environmental or economic assessment which can be undermined by any number of political missteps. Perhaps the most lasting example of this is the 1969 oil blow out from Union Oil's Platform A in California's Santa Barbara Channel that sent images of once pristine beaches covered in crude oil and dying marine life across televisions around the country and led to a 30 year moratorium on drilling off the West Coast of the United States (Smith 2002). More recently, opposition to the sitting of wind turbines in the Nantucket Sound off Cape Cod, Massachusetts has embroiled developers in lawsuits (Firestone et al. 2004) and delayed project development for nearly a decade. There is a wealth of literature reflecting these types of examples and note the inadequacy of many project managers to successfully manage the political landscape (Barndt, 1998; Johnson and Dagg 2003; Klein et al 2007; Guénette and Alder, 2007; Flannery and O´ Cinne´ide 2008; Plasman 2008; Pomeroy and Douvere 2008).

As an alternative to relying on trial and error, a more proactive approach is to conduct a stakeholder analysis as a starting point for developing strategies to manage the political landscape. Also known as political mapping, this effort can be particularly useful to managers by highlighting potential barriers to implementation based on the beliefs and influence of particular groups involved, and identifying opportunities to build consensus.

To this end, this study has mapped the political context of wave energy development in Oregon**.** Specifically, this study identifies who is involved in Oregon wave energy development, what they believe and how they shape policy decisions. In doing so, this study maps policy areas that will inhibit or facilitate wave energy development among the stakeholder groups involved, illustrates specific strategies employed, and identifies key venues where they attempt to influence decision-making. With this in mind, the following questions guided this research:

1. *Who are the primary policy actors in wave energy development?*
2. *What are their core beliefs about wave energy development?*
3. *What networks exist among policy actors?*
4. *What resources and venues do policy actors utilize to influence decision-making?*

Research Methods

To answer these questions, this study employed two research methods. The first were in-person interviews (14 total) with representatives from the federal, state and local governments; electric utilities; wave energy developers; consultants; and stakeholders including the commercial fishing industry, recreational user groups and conservation organizations. Scientist, engineers, and journalist were also included in this sample. During interviews, respondents were asked seven questions and ranged in length from approximately 30 minutes to nearly two hours. Interviews were conducted from September 2008 through February 2009.

Following the interviews, a mail-in survey was sent to 352 individuals who had been identified by respondents from in-person interviews as being involved with wave energy development in Oregon. Accounting for inaccurate address, approximately 50% of surveys were completed and returned (n = 168). The survey was composed of four sections: views on ocean management, stakeholder networks, general beliefs, and demographic information. Lastly, respondents were put into 11 categories including Federal, State, and Local (coastal) governments; Technical Experts (scientists/engineers); Energy Industry (developers; fabricators; labor unions, etc); Electric Utilities; Commercial and Recreational fishing; Recreational Users (surfers/kayakers); Conservation; and Media.

Key Findings

Tentative support for wave energy development

The results in this study suggest preliminarily support for a phased-development approach to wave energy off Oregon's Coast. Asked on a scale of 1 'strongly disagree' to 5 'strongly agree' if wave energy should be developed in general, the average of all respondents was 3.9. Greatest support came from electric utilities (4.3) and media (4.3), followed by representatives from state government (3.9), local government (4.0), and technical experts (scientists/engineers) (4.0), while fishing and conservation groups indicate less overall support (means ≤ 3.1). However, respondents from nearly all groups agreed or strongly agreed (total mean = 4.3) with testing wave energy projects in the ocean. Similarly, many groups agreed with expanding to commercial scale if test projects met expectations with the exception of commercial fishing (3.2) and recreational users (3.1), who were the least supportive of this concept. Respondents also indicated job creation as the best reason to develop wave energy (total mean = 3.9), while combating global climate change elicited a wider range of responses from stakeholders (1.8 thru 4.8).

These findings are similar to what was found during the interview data and reflected a general sense of interest but uncertainty about developing wave energy. For example, some informants indicated the need to stimulate coastal economies or address climate change, but expressed doubts if the technology would work and concern about impacts to the environment or existing ocean users. This may explain why most respondents generally agree with testing wave energy, but why some groups are reluctant to support a commercial build-out until demonstration projects have been evaluated.

Central Players in Wave Energy Development

Based on the above findings it follows that technical experts and forthcoming evaluation will have an important role in wave energy development. For example, technical experts are the most widely cited source of trustworthy information indicated by responses from the media, conservation, local and state governments, electric utilities as well as recreational users, and commercial fishing. Another indication that technical experts have a central role in this issue is that they are cited as being 'more helpful if they had additional resources,' in 23% to 50% of responses from 9 of 11 stakeholder groups.

Along with technical experts, state and local governments may also play a central role in wave energy development. For example, the state government is frequently cited as an ally among respondents from the federal government, technical experts, electric utilities, conservation, and local government. Similarly, local government is frequency cited by commercial and recreational fishing groups as an ally.

Indications of a mistrusted industry

Conversely, there is also evidence that the energy industry is widely viewed as an opponent by survey respondents. This is true among commercial and recreational fishing groups, but also among recreational users, conservation, technical experts, and federal, state, and local governments. There is also evidence that the energy industry is the most widely cited source untrustworthy information. This is most pronounced among responses from the media, conservation, recreational users, commercial fishing, but federal, state, and local government representatives, as well. Overall, this suggest that the energy industry is mistrusted and considered an opponent by most wave energy stakeholders, including those who general support developing the technology.

It is difficult to identify precisely why the energy industry is viewed as an opponent, but based on the interview data, there are two possible explanations. The first is related to project location, where some preliminary permits have identified areas with high valued fishing grounds, particularly for the Oregon Dungeness crab fishery, which created conflict between developers and fisherman. The conflict arises where the developers anchor devices to the sea bed which is perceived to affect the crab's habitat, in addition to the inability to fish the surrounding waters of the devices. An additional explanation is that developers have been perceived as attempting to move directly to commercial scale development with preliminary permit applications for 200-buoy parks, which was generally criticized among many of the interview informants. Cumulatively, these two examples may explain why the energy industry is perceived as an opponent. These findings are important because they will also influence the strategies that stakeholders take to ensure their concerns are addressed. (For results please see Appendix 1)

Resources and strategies used to influence decision-making

Other findings in this study suggest that a variety of resources and strategies are used by stakeholders to influence wave energy decisions. Looking at the survey results, most respondents indicate that state government has the most resources and is most influential. Other stakeholders rely on funding, professional staff, legal resources, access to authority, grassroot networks, trust, and public opinion to pursue a variety of strategies. In general, the interview results suggest that most stakeholder groups prefer to engage wave energy decision-making through cooperative stakeholder working groups such as the Reedsport Settlement agreement, Ocean Policy Advisory Council working groups, or the Rule-Making Advisory Council. However, there is also evidence that some stakeholder groups are willing to engage in more aggressive tactics if their policy goals cannot not be addressed through cooperative venues. These include filing 'motions-to-intervene' with FERC in order to gain standing or access to particular work groups, but also through political connections to address concerns through legislative enactment. For example, there is evidence that local government officials have attempted to address concerns about locating or 'siting' wave energy developments by increasing their authority over the Territorial Sea through amendments to existing statues.

Recommendations

Avoid Pre-determined Locations and Commercial Scale Projects

The most significant areas of division and potential conflict found in this study include inflexibility on where wave energy projects are located and attempts by developers to secure permits for commercial scale wave parks before developing a demonstration project. There is also evidence that these two issues catalyzed aggressive strategies among affected stakeholders, which moves decision making from cooperative work groups increasingly into legal and political venues. If decision-makers seek 'collaborative approaches' to developing wave energy in Oregon, they should begin by avoiding pre-determined project locations as well as efforts to secure commercial scale permits prior to developing demonstration projects.

Develop Test-Projects through Cooperative Stakeholder Processes

This study also found that testing wave energy projects was the greatest area of agreement among stakeholders. For many stakeholders, these projects provide an opportunity to obtain scientific information on wave energy upon which they can form more fully developed policy positions. To foster a cooperative atmosphere, decision-makers should capitalize on projects such as the Reedsport Settlement Agreement, which provided an opportunity for stakeholders to inform decisions about initial project size, monitoring protocols and how that information will feedback into an adaptive management framework. However, these efforts should also include flexibility in identifying project location, which was identified as a shortcoming of the Reedsport process by several interview informants.

Use State and Local Governments as Political Mediators

Finally, decision-makers should take advantage of the central role that state and local governments have among stakeholder groups. For example, the state government may offer bridges between the federal government, conservation groups and electric utilities, while the local government may offer the same for fishing groups. These networks can be particularly useful for identifying group representatives and help in facilitating cooperative work groups described above and mediating conflict that arises as new issues unfold.

Recommendations / Considerations

Looking forward, decision-makers should consider that wave energy development, like many renewable technologies, is new and does not have a long history that stakeholders can use to form judgments about the technology. This emphasizes the nascent quality of this issue and need to employ politically tactful decisions so that undecided stakeholders can eventually be incorporated as proponents of these efforts rather than opponents who levy barriers in years to come. As indicated above, this may be best accomplished by focusing on cooperative efforts that bring stakeholders together to inform decisions about demonstration projects. After evaluating these projects, decision-makers may more successfully solicit support from stakeholders to scale up to commercial size projects.

Appendix 1 – Tables of Findings

Table 1. Comparison of Secondary beliefs by Group Affiliation

Support for Wave Energy	Energy Industry	Electric Utility	Local Gov't	State Gov't	Technical Experts	Media	Federal Gov't	Rec. User	Conserv	Rec. Fishing	Com. Fishing	Total	*F*	*p*	Eta
(n)	17	13	18	32	11	6	5	14	6	12	27				
Wave energy should be developed	4.2^{ab}	4.3^{cde}	4.0^{fg}	3.9^{hi}	4.0^{j}	4.3^{kl}	3.4	3.5	3.1^{c}	3.1^{adfhk}	2.9^{begijl}	3.7	3.13	.001	.42
Test through experimental projects	4.3	4.3	4.2	4.5	4.5	4.2	4.4	3.9	4.0	4.7	4.1	4.3	.87	.562	.24
Expand to commercial	4.5^{A}	4.5^{B}	4.2	4.3^{C}	4.2	4.3	3.8	3.1	4.2	3.9	3.2^{ABC}	3.9	3.80	.000	.46

1. All numbers are means on a scale of 1 'strongly disagree' to 5 'strongly agree'
2. Means with different subscripts in the same row are significant at p< .05 based on either LSD (abc) or Tahame's T2 (ABC) post hoc tests

Table 2. Respondents Citation of Trusted Information

	Fed Gov't	State Gov't	Technical Experts	Conserv	Local Gov't	Com. Fishing	Rec. Fishing	Rec. User	Media	Energy Industry	Electric Utility
Number of Respondents	5	32	11	6	18	27	12	14	6	17	13
Number of Cites by Respondent	8	59	17	12	32	44	22	28	10	31	21
Frequency group was cited:											
Federal Government	25%	22%	**35%**	8%	3%	5%	-	11%	-	10%	-
State Government	**25%**	**19%**	6%	**17%**	9%	-	5%	11%	-	3%	5%
Technical Experts	13%	**41%**	**41%**	**50%**	**47%**	**34%**	**23%**	**36%**	**70%**	**71%**	**43%**

Conservation	13%	-	-	25%	3%	-	-	7%	20%	-	-
Local Government		2%	6%	-	13%	**36%**	**27%**	7%	-	-	-
Commercial Fishing		-	-	-	9%	9%	9%	4%	-	-	5%
Recreation Fishing		2%	-	-	-	-	14%	-	-	-	-
Recreational User		-	-	-	-	-	-	7%	-	-	-
Media		2%	-	-	-	2%	-	4%	-	3%	5%
Energy Industry	13%	12%	12%	-	16%	3%	**18%**	11%	-	13%	**24%**
Electric Utility	13%	2%	-	-	-	-	5%	4%	10%	-	**19%**

Table 3. Respondents Citation of Untrustworthy Information

	Fed Gov't	State Gov't	Technical Experts	Conserv	Local Gov't	Com. Fishing	Rec. Fishing	Rec. User	Media	Energy Industry	Electric Utility
Number of Respondents	5	32	11	6	18	27	12	14	6	17	13
Number of Cites by Respondent	10	61	16	12	26	51	24	26	12	29	22
Frequency group was cited:											
Federal Government	-	-	11%	9%	7%	**18%**	**17%**	9%	-	4%	7%
State Government	-	-	-	-	7%	10%	**17%**	-	**20%**	4%	**20%**
Technical Experts	**43%**		-	9%	**15%**	**16%**	**17%**	-	**20%**	8%	7%
Conservation	-	9%	-		**19%**	8%	**17%**	5%	-	8%	7%
Local Government	-	7%	11%	9%	4%	2%	-	9%	-	**15%**	7%
Commercial Fishing	-	**22%**	**22%**	9%	4%	-	-	5%	-	**19%**	**20%**
Recreation Fishing	-	7%	**22%**	-	4%	-	-	5%	-	8%	13%
Recreational User	-	2%	11%	-	-	-	-	-	-	8%	7%
Media	14%	13%	-	9%	**19%**	4%	8%	**18%**	-	**19%**	-
Energy Industry	**29%**	**20%**	**22%**	**55%**	**15%**	**40%**	**21%**	**41%**	**60%**	8%	**7%**
Electric Utility	14%	4%	-	9%	7%	2%	4%	9%	-	-	-

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Is Wave Energy Comparatively Sustainable in Oregon?

Yao Yin
Oregon State University, 2009

Summary

This report is abstracted from a MS Thesis. It provides a snapshot of sustainability and acceptability of wave energy and eight other electricity-generating energy sources in Oregon by looking at all of the current or available data / print or electronic resources. It should be stated that in some cases, this is not much.

The project was centered around "sustainability" because it is an important point of view in decision-making. Although there is no consensus on the definition of sustainability in the academic world, three dimensions of sustainability have been widely accepted: economic sustainability, ecological sustainability, and social sustainability.

Above these three dimensions of sustainability sits political institutions that shape the "overall" aspect of sustainability. We approach political institutions by discussing energy policy typology and developmental stages of the U.S. energy politics. Then we develop three sets of indicators to characterize or operationalize sustainability. Using this framework, we have generated sustainability matrices to summarize what has been found for all energy sources.

Although more research is needed to determine how sustainable wave energy would be versus other sources, this report provides a snapshot of the current important facts, data and framework to inform energy evaluation, policy formulation and decision-making.

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Introduction

The word "sustainability," or the phrase "sustainable development," has been a buzz word since the late 20th century and is part of the mission of infinite international organizations, national institutions, cities and locales, transnational corporations, and nongovernmental organizations (Gutman 2003; Parris and Kates 2003; Speth 2003; Schnoor 2002). The origins of "sustainability" and "sustainable development" can be traced back to 1983, the time when the World Commission on Environment and Development, also known as Brundtland Commission, was constituted by the UN General Assembly (Keeble 1987). In 1987, the Brundtland report *Our Common Future* was published by the Commission in which the terms "sustainability" and "sustainable development" were coined to emphasize the interdependence of economic growth and environmental preservation and the equity between inter- and intra-generations (Osorio, Lobato et al. 2005). Sustainable development, by the definition given by the Commission, is the one that satisfies the needs of the present generation without endangering the future generations' capacity to satisfy their own (WCED 1987).

Indeed, the definition is so inclusive that proponents of sustainable development can differ in terms of opinion of what is to be sustained, what is to be developed, how to balance environment and development, and for how long a time (Parris and Kates 2003). Despite this complexity, a combination of three key elements can be found in most attempts to describe "sustainability" or "sustainable development": economy, society and environment. For example, the Oregon Sustainability Act, House Bill 3948, states that sustainability means "using, developing and protecting resources in a manner that enables people to meet current needs and provides that future generations can also meet future needs, from the joint perspective of environmental, economic and community objectives" (Oregon Legislative Assembly 2001). The triple bottom line is essential to keep in mind that "to refuse the challenge implied by it [triple bottom line] is to risk extinction" (Arup 2008). This level of thinking about sustainability is important because it can help us with decision-making on all scales; making us more "competitive, resilient to shocks, nimble in a fast changing world and unified in purpose" (Arup 2008). This report, therefore, utilizes this overarching sustainable framework and examines the comparative sustainability of wave energy in Oregon in comparison to other energy sources.

Energy is one of the most complex concerns in the dialogue of sustainability because of two reasons. First, energy availability and access is closely related to economic and social freedoms. An unprecedented expansion in industrialization in the 20th century is built on a foundation of fossil energy, a finite energy resource. Today, one-third of primary energy use is from oil; 80% comes from oil, coal and natural gas combined. Dependence on the volatile Middle East is tightly intertwined with national and international security. Continuing population growth and rapidly rising affluence in some parts of the world are driving up the consumption of energy even higher (Holdren 2007). Therefore, energy, an essential good in constrained supply, could severely limit the public and private aspirations of individuals and nations (Simon 2007). The second reason is that many serious environmental problems are caused by the use of energy. For example, almost all carbon dioxide generated by the combustion of fossil energy goes into the atmosphere and contributes to the greenhouse effect and climate change. These two reasons make the impact of energy on the three dimensions of sustainability complicated.

There are many forms of energy, such as light, heat, sound and motion, and all of them can be characterized into two major groups: kinetic and potential. Kinetic energy is generated by the motion of waves, electrons, atoms, molecules, substances and objects, whereas potential energy is stored energy and the energy of position gravitational energy (DOE 2008). Table 1 shows how energy is categorized.

Table 1: Forms of Energy (DOE 2008)

Potential Energy	**Kinetic Energy**
Chemical Energy (e.g. biomass, petroleum, natural gas and propane)	Electrical Energy
Stored Mechanical Energy (e.g. compressed springs and stretched rubber bands)	Radiant Energy (e.g. visible light, x-rays, gamma rays and radio waves)
Nuclear Energy (e.g. fission of uranium and fusion of hydrogen)	Thermal Energy (e.g. heat)
Gravitational Energy (e.g. hydropower)	Motion Energy (e.g. wind and wave)
	Sound

Electricity is one of the most important energy forms in our daily life. One can hardly imagine a life without electricity in today's world: lighting, heating, powering computers, charging cell phones, etc. Yet electricity is a secondary energy source; it is generated by the conversion of other sources such as coal, natural gas, oil, nuclear power and natural sources. Because of the huge significance of electricity to human society, this report is focused upon comparing what source is most sustainable in terms of electricity generation rather than supply of transportation fuel.

In 2005, Oregon's electricity mainly came from hydropower (42%) and coal (41%). Natural gas was used to generate 10% of the electricity; nuclear, wind, and geothermal contributed to the rest of electricity supplies (See Figure 1) (State of Oregon 2008). However, electricity generation at the national level differs in terms of percentages and importance. In 2007, nearly half (49%) of the U.S. electricity came from coal, 21% came from natural gas, and 19% was provided by nuclear power. The rest was supplied by hydropower, biomass, geothermal, solar photovoltaic systems (PV), wind, etc. (See Figure 2).

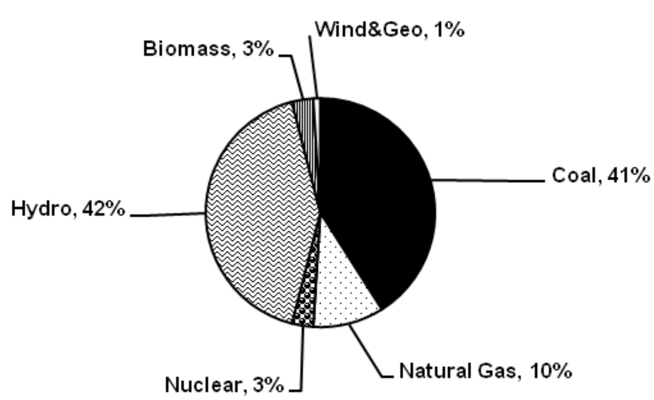

Figure 1: Oregon's Electricity Mix in 2005 (State of Oregon 2008)

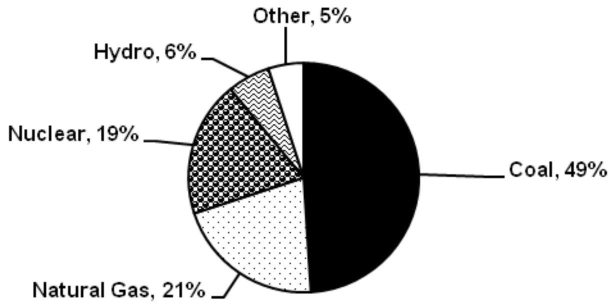

Figure 2: 2007 US Annual Electricity Generation (Energy Information Administration 2008)

In order to explore potential sources for Oregon's electricity generation and to examine the relative sustainability of wave energy, we are focusing on the following energy sources for our comparative research: liquefied natural gas (LNG), petroleum, nuclear power, hydropower, geothermal power, solar power, wind power, biomass and, last but not least, wave energy.

Political Institutions in Energy Issues

However, before we can compare these sources of electricity, it is important to recognize that above the economic, social and environmental dimensions of sustainability lies institutions, and thus, a discussion of institutions is important when we approach sustainability issues (GOSD 2008) (See Figure 3).

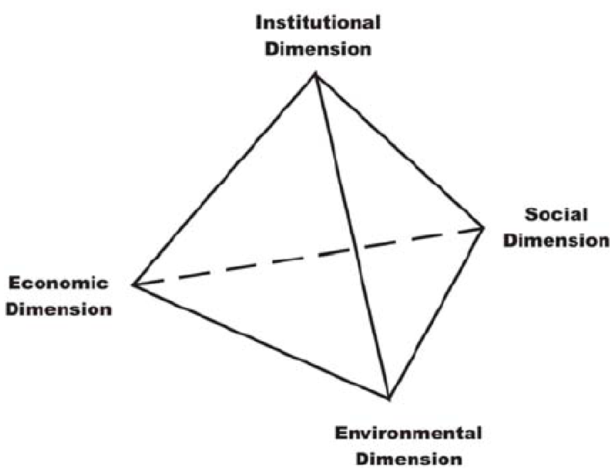

Figure 3: Role of Institution in Sustainability (GOSD 2008)

Since the institutional dimension can help or hinder the pursuit of economic, social and environmental sustainability, it sits above … profoundly influencing and interacting with the three legs, as seen in Figure 3.

The definition of an "institution" is "a persistent, reasonably predictable arrangement, law, process, custom or organization structuring aspects of the political, social, cultural or economic transactions and relationships in a society. Institutions allow organized and collective efforts toward common concerns and the achievement of social goals" (Dovers 2001, p. 5).

Although by definition persistent, institutions constantly evolve, there are many types of institutions, whether formal, informal, local, national, global, legal, customary, scientific, political or economic, but our discussion below mainly focuses on formal political institutions.

Operationalizing Sustainability

Having conceptualized sustainability in terms of environmental, economic and social dimensions and providing an overall institutional framework for national and international governance of sustainability in energy context, we now need to explore what indicators should be used to assess and operationalize sustainability from the three dimensions: environmental, economic, and social (Assefa and Frostell 2007). There have been over 500 projects undertaken to develop quantitative indicators. However, indicators serve different communities and have different purposes; some might be used for political reasons, while others for research and analysis. Since there is no consensus on which set of indicators is optimal, we seek to establish our own measurement system to better characterize the sustainability in energy issues.

Technology Development

Any challenge facing our society, including energy issues, cannot be fully understood without a discussion of technological development, because there is a synergistic relationship between technology and society. Technology utilizes environmental resources in production; it can help improve environmental conservation, but also generates pollution. Technology needs funding; it can also stimulate or hinder economic growth. Technology needs social acceptance; its development can enhance or lower social well-being. The three dimensions of sustainability are closely intertwined with technological development, and thus we'll discuss technological development for every energy source before sustainability dimensions are presented.

Environmental Sustainability

The environment is our life-support system; without a healthy environment humanity couldn't exist. Goodland (1995) defines environmental sustainability as maintenance of natural capital both as a provider of inputs (sources) and as a sink for wastes. This definition is further broken down into three basic rules: output rule, input rule and operational principles. Output rule requires that waste emissions be "kept within the assimilative capacity of the local environment without unacceptable degradation of its future waste absorptive capacity or other important services." Input rule is two-fold: 1) For renewable resources, harvest rates of resource inputs should be "within regenerative capacities of the natural system that generates them," and 2) For nonrenewable resources, depletion rates of resource inputs should be "set below the rate at which renewable substitutes are developed by human invention and investment." Operational principles include three aspects: 1) The scale of the human economic subsystem should be limited within the environmental carrying capacity, 2) "Technological progress for sustainable development should be efficiency-increasing rather than throughput-increasing," and 3) Renewable resources should be used on a "profit-optimizing, sustained-yield, and fully sustainable basis" (Goodland 1995).

There have been many ways to measure or characterize environmental sustainability, one of which is ecological risk assessment that "evaluates the likelihood that adverse ecological effects will occur as a result of exposure to stressors related to human activities" (Norton, Rodier et al. 1992). EPA's framework for ecological risk assessment has three phases: problem formulation, analysis and risk characterization. The core of the assessment is the characterization of exposure and ecological effects. Due to time constraints, our paper only focuses on the qualitative analysis of ecological effects to examine risks or adverse effects imposed by use of each energy source. Analysis is conducted from the four perspectives on which humanity depends: the geosphere (land), the atmosphere (air), the hydrosphere (water and ice), and the biosphere (plant and animal life) (University of Nebraska-Lincoln 2008).

Economic Sustainability

Economic sustainability can be defined at two levels: macro and micro. At a macro level, it is widely accepted that definition of economic sustainability constitutes maintenance of capital, which concentrates mainly on the portion of the natural resources that provide physical inputs into the production process (Goodland 1995). Four types of indicators are often utilized to measure economic sustainability at the macro level: (1) augmented income measures such as Gross Domestic Product; (2) equity measures that focus on distributional concerns such as family income distribution; (3) resilience measures like job growth; and (4) supplementary indicators such as life expectancy at birth (Mittelsteadt, Adamowicz et al. 2001).

In the case of electricity-generating energy, we are more interested in businesses at a micro level where economic sustainability, from a business perspective, refers to the ability to extract revenues that outweigh the costs of operating the business and thereby securing the future of it (Found, Beale et al. 2006). We crafted three financial questions to measure or operationalize economic sustainability of energy sources: (1) What is the cost of the energy in the market?; (2) What are the financial incentives for energy at the federal level?; (3) How about incentives at the state or local level (Simon 2007)?

Incentives are important in energy markets, especially for renewable energy, which would hardly exist without them. Incentives identified include EPAct 2005, Renewable Energy and Production Tax Credit, Solar Energy Technology Program, Wind Powering America, and many more at the state and local levels. Our economic considerations are focused on market cost of a certain type of energy, federal incentives, and state and local incentives to see how market and government would affect economic sustainability of each electricity-generating source we are interested in.

Social Sustainability

Social sustainability deals with how people or communities make choices and how the choices affect others. It is also related to people's happiness, safety, freedom, dignity and affection. These aspects of social sustainability are closely intertwined with community well-being, the ultimate goal of all the various processes and strategies that endeavor to meet the needs of people living together in communities (Rural Assist Information Network 2008). This definition of community well-being is based on how members view or feel about their community. There has been much research on social sustainability that endeavors to improve the community well-being (Campbell 2006).

How is community well-being measured? There is a lack of consensus. Social impact assessments (SIAs) utilize social indicators to predict and assess the consequences of technical projects (e.g., hydroelectric projects, waste-dump siting, etc.) (Kusel 1996). Social acceptance has also been used to address similar questions (Paul A. Alcorn 2003) because something socially sustainable should, at minimum, enjoy wider social acceptance (Assefa and Frostell 2007).

Social acceptance would help shorten the time between the first discussion of a system and its implementation (Assefa and Frostell 2007). Researchers often use three major indicators affecting social acceptance to measure social sustainability: knowledge, perception and fear (Becker and Vanclay 2003). "Knowledge" asks "what does the public know?" "Perception" asks "what does the public think?" "Fear" asks "what does the public feel?" Gathering information on those three questions often involves, but is not limited to, observations, interviews, questionnaires, and surveys (Assefa and Frostell 2007). Answers to these questions provide information on the degree of community well-being that the members feel they have. To better serve the purpose of characterizing energy sustainability, we have replaced "fear" with "risk" in our report and asked "what is the risk of each energy source perceived by people?"

In this report, the way we operationalize sustainability is to first introduce technological development and then to select "adverse effects on the four spheres" for environment, "cost and incentives" for economy, and "knowledge, perception and risk" for social dimension (Figure 7). We apply this format to each energy source with a brief statement of overall acceptability for Oregon.

Sustainability of Wave Technology

Technology

People have been exploring wave energy to generate electricity and solve energy issues both nationally and internationally. About 0.2% of the ocean's untapped energy could be used to provide power to our world. Types of ocean energy include tidal, current, temperature gradient, salinity and wave, among which wave energy might be the best source with its higher availability and predictability (Brekken 2007). Wave energy technology can be categorized into four major types: oscillating water column, attenuators, overtopping and point absorbers (Nelson 2008).

Design category	Example manufacturer	Placement	Principle of power generation
oscillating water column (OWC)*	Oceanlinx	Ocean surface (floating) or fixed to ocean bottom	Rise and fall of a water column forces air through a turbine that generates electricity
attenuators	Pelamis	Ocean surface (floating), anchored to prevent drifting	Elongated, multi-segment, floating device is oriented parallel to wave travel; flexing action of segments drives generators (similar to an hydraulic ram)
overtopping	Wave Dragon	Ocean surface but tethered offshore or built out from shoreline	Waves fill a basin creating a pressure head; water is released back into ocean, driving a turbine
point absorbers	AquaBuOY	Ocean surface (floating), anchored to prevent drifting	Floating structure; absorbs wave energy (e.g., hydraulic turbine, direct acting) from any direction as the device rises and falls

Figure 4: Major Categories of Wave Energy Technology (Nelson 2008)

Since Oregon's wave energy has become particularly interesting because of the abundant ocean resources and strong transmission capacity, researchers from Oregon State University and engineers of Columbia Power Technologies have worked closely to develop wave energy in Oregon, using point absorber technology (Brekken 2007).

How does it work? First of all, the buoy is tethered to the sea floor. Then, as it floats over a wave, the magnets are moved over the electric coil inside a float, leading to a changing magnetic field. The coil experiences the field and generates voltage.

Environmental Sustainability

- *Impact on the Geosphere:* Drawing electricity out of the ocean would cause a decrease of energy in wave, resulting in many changes on the nearshore zone. One would be changes in the profile of the beach and decreases in the cross-shore and longshore transport of sediment, which in turn affects sediment deposition, beach mixing, estuarine processes, morphology of lagoon inlets, etc. (Nelson 2008)
- *Impact on the Atmosphere:* Most of the literature indicates that wave energy doesn't cause air pollution or contribute to climate change, and is often considered a clean carbon-free alternative (Demirbas 2006).
- *Impact on the Hydrosphere:* Wave energy devices can extract three to fifteen percent of the incident wave energy and create triangle-shaped wave shadows on their side towards shore, affecting wave shoaling (wave height changes due to shallower water depths), wave breaking, current generation, turbulence levels, and many other wave driven physical processes (Nelson 2008). Such changes might impose adverse effects on the ocean.
- *Impact on the Biosphere:* Wave energy buoys can act as artificial reefs attractive to reef-associated fishes and serve as hard substrate for algae and invertebrates, leading to a net gain of fish and other marine life (Hatfield Marine Science Center 2007; Nelson 2008). However, wave energy could harm marine birds and mammals. Major concerns for seabirds include disturbance to local breeding colonies, noise pollution from operation,

risk of collision with buoy during foraging, accidental contamination from device failures (Maunsell and Metoc PLC 2007). For mammals, major concerns include risk of collision, disruption of migratory pathways, chemical fouling, food availability, disruption of sensory systems, and disturbance to haul-outs and local rookeries (Maunsell and Metoc PLC 2007; Nelson 2008).

Economic Sustainability

- *Market Cost:* Costs of wave energy vary from site to site. According to *The Economist* it costs at least 18 or 20 cents per kWh (The Economist 2005). For Oregon, researchers estimate the costs to range from 20 to 30 cents per kWh (Brekken 2007). But with improving technology, wave energy is likely to produce electricity at approximately 4.5 cents/kWh (Ocean Energy Council 2008). The following nine factors should be considered when calculating the costs of a wave farm (Vining and A. Muetze 2008):
    1. Siting and permitting
    2. Initial and ongoing capital costs
    3. Installation.
    4. Operation and Maintenance.
    5. Taxes
    6. Depreciation schedule
    7. Financing costs: debt management
    8. Project life time.
    9. Average annual energy production
- *Federal Incentives:* Renewable Energy Production Incentive (REPI) is a federal program promoting renewable production in the U.S. It offers 1.5 cents per kWh produced (1993 dollars, indexed for inflation) to not-for-profit electrical cooperatives, public utilities, state governments, Commonwealths, territories, possessions of the United States, the District of Columbia, Indian tribal governments, or a political subdivision thereof and Native Corporations for a ten-year period. Eligible technologies include solar thermal electric, photovoltaics, landfill gas, wind, biomass, geothermal electric, livestock methane, tidal energy, wave energy, ocean thermal, fuel cells with renewable fuels (U.S. Department of Energy 2008).
- *State and Local Incentives:* The Energy Trust of Oregon is an independent, nonprofit organization dedicated to energy efficiency and renewable energy development in Oregon, who created the Open Solicitation Program in 2002. The program tries to fund renewable energy projects with two million dollars annually. Eligible technologies include hydroelectric, geothermal electric, wave energy, fuel cells, etc. (DSIRE 2008).

Social Sustainability

- *Risk:* Concerns do exist among the public regarding wave energy. Surfers see the risk of drawing energy out of ocean, which leads to reduced size of waves breaking on the shore, would spoil their sport (Morris 2007). Fishermen, both recreational and commercial, are concerned about installations in prime crab or salmon trolling areas, with wave energy affecting the crabbing or fishing (AP 2007).

- *Perception:* In the Oregon Energy Policy survey, people were asked about their attitudes toward the development of wave energy off the Oregon coast. Results show that fifty-four percent of Oregonians state-wide are very positive or positive about wave energy, and only three percent are negative or very negative (Table 2). There are thirty-two percent of Oregonians who don't have enough information to form an opinion (Steel and Stefanovich 2008).

Table 2: People's perceptions of wave energy (Steel and Stefanovich 2008)

Wave Energy	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Very positive	26%	22%	28%	29%
Positive	28%	27%	33%	30%
Neutral	11%	16%	7%	12%
Negative	2%	1%	1%	3%
Very negative	1%	0%	2%	3%
Do not have enough information to form an opinion.	32%	35%	29%	23%

- *Knowledge:* As is seen from above, a large number of people don't have enough knowledge regarding wave energy. This is confirmed by another survey question in the same study. In answering "how familiar are you with wave energy", only twenty-four percent chose "familiar" or "very familiar with the technology." A breakdown table below shows how percentage changes across the state (Table 3).

Table 3: People's familiarity with wave energy (Steel and Stefanovich 2008)

Wave Energy	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Not Familiar	38%	44%	30%	27%
Somewhat Familiar	39%	35%	50%	40%
Familiar	19%	18%	15%	26%
Very Familiar	5%	4%	5%	7%

Acceptability for Oregon

Oregon has been considered an ideal location with tremendous opportunity for wave energy development because of its abundant ocean resource and large transmission capacity (Oregon.Gov 2008). Acceptability of wave energy in Oregon, however, is a different subject than opportunity. Environmentally, the ocean still remains unknown to us in many aspects in Oregon context (Portland State University 2008). Compared to many other places like Scotland, Ireland, California, etc. which have gained better environmental knowledge of the ocean for their wave energy development, we still need more research and science done locally to develop Oregon acceptable plans.

Economically, more incentives might need to be created to support wave energy. "In general, renewable energy projects would not exist if it were not for government subsidies" (Vining and A. Muetze 2008). Four categories of incentives should be taken into account in creating incentives for wave energy: customer choice, direct cash assistance, indirect cash assistance and low-cost debt financing (Table 4).

Table 4: Four Categories of Incentives and Examples (Vining and A. Muetze 2008)

Incentive Category	Incentive	Brief Description
Customer Choice Incentives	Renewables Portfolio Standard (RPS) Tradable Renewable Energy Credits (TREC)	TRECs are allocated to renewable energy suppliers for each kWh generated and may be used to fulfill the RPS.
	Utility Green Pricing Program	A special pricing program for renewables set up and managed by utilities.
Direct Cash Incentive	Fixed Tariffs	Utility providers are required to purchase renewable energy at fixed prices, set by some regulating agency.
	Direct Production Incentive	Renewable generators are given cash payments based upon the amount of electricity generated by the facility.
	Direct Investment Incentive	A generator receives cash for investing in renewable energy much like a grant.
Indirect Cash Incentive	Production Tax Credit	The developer receives an annual tax credit linked to the amount of electricity produced.
	Investment Tax Credit	The developer receives a one-time tax credit for renewable energy investments.
	State and Local Sales Tax Reduction	Reduced sales tax on the components of a renewable energy facility reduces the installation and overall levelized cost of the project.
	Property Tax Reduction	This reduces the overall cost of land for a renewable energy installation.
	Accelerated Depreciation Schedule	This allows companies to claim the loss of asset value as a noncash expense which may be deducted from taxable income and thus decrease annual income tax.
Low-Cost Debt Financing	Government Subsidized Loans	The lower interest rates of these loans help project developers finance their projects.
	Project Loan Guarantees	The government guarantees that a loan will be repaid to the lender, consequently making it easier to obtain project financing.

Socially, it appears from the Oregon Energy Policy Survey that there are more people for wave energy than those who are against it. However, public knowledge of wave energy and of its potential impacts will still need to be advanced. Europe encountered a similar situation several years ago, and in order to promote the public's knowledge and social acceptability of wave energy they proposed three general strategies and two specific recommendations. Generally, (1) public knowledge could be increased through information campaigns directed at press, public and politicians, (2) Networks should be built to help share information between developers and authorities, and (3) Developers should pay attention to the benefits of direct public involvement. In terms of the specific projects it recommended that (1) Each developer should aim at the highest positive level of openness and information during the preplanning phase, and (2) Developers should also keep the high information level during and after construction by providing the progress of the work to the public (Hansen, Hammarlund et al. 2003).

Conclusion

To conclude the report, we have created four comparison matrices to contrast all energy sources examined: an Environmental Sustainability Matrix (Table 5), an Economic Sustainability Matrix (Table 6), a Social Sustainability Matrix (Table 7), an Overall Sustainability Matrix (Table 8) and an Acceptability Matrix (Table 9).

In interpreting the Environmental Sustainability Matrix, please note that our research, due to time constraints, characterized ecological effects qualitatively without discussing the exposure of certain effects. It would be wise to consider assessing the exposure in the future depending on financial resources, analyzing magnitude, duration, frequency, etc. of the environmental stressors.

Table 5: Environmental Sustainability Matrix

Environmental Sustainability	Impact on Geosphere	Impact on Atmosphere	Impact on Hydrosphere	Impact on Biosphere
LNG	LNG pool fires damage land	Contributes to greenhouse effects	Pollutes ocean, groundwater, surface water.	Harms marine organisms and habitats
Petroleum	Could harm soil and ground due to petroleum exploration	Contributes to air pollution and green house effects	Could contaminate ocean, ground water and surface water by improper disposal of wastes	Harms wildlife by damaging the habitat
Nuclear Power	Radioactive waste can contaminate local soil.	Radon as a radioactive gas in atmosphere can cause cancer.	Wastewater discharged back into river could cause water pollution	Radioactive substances can cause many diseases.
Hydropower	Could result in more use of fertilizers in farmland	No air pollution or greenhouse gas	Affects acidity of water	Blocks salmon's way upstream. Turbines could injure fish. Acid-related bacteria releases harmful metals.
Geothermal Power	Exploration may damage resources in the geosphere.	Could contaminate atmosphere by releasing hydrogen sulfide, ammonia, methane, etc.	Could affect groundwater quality	Release of mercury, arsenic, etc. could harm biological organisms
Solar Power	Tin oxide and industrial solvents used by PV cells could contaminate soil.	A catastrophic release of toxic gases used in producing PV devices may cause serious atmospheric pollution.	Disposal of solar cell modules could cause contamination of ground water and surface water.	Carcinogenic chemicals used to produce PV cells could harm organisms
Wind Power	Could cause soil erosion	Believed to reduce carbon dioxide	Could adversely affect local hydrology and ocean.	Could damage local flora and fauna on land or ocean.
Biomass Power	Could reduce soil quality.	Carbon-neutral but may release toxic chemicals into atmosphere	Could cause water depletion and water pollution	Could introduce invasive species
Wave Energy	Could change beach profiles, decrease transport of sediment, etc.	Could be considered a clean energy.	Might impose adverse effects on the ocean by changing physical attributes of waves.	Could harm marine organisms including birds and mammals

In the Economic Sustainability Matrix, we summarized information on market cost, federal incentives, and state and local incentives, from our discussion section. Please note that market cost we draw from different literature is calculated based on various economic assumptions. Readers might want to go back to the original papers to see if the assumptions involved match their situations before using the data to make any decisions. Federal Incentives and state and local Incentives listed in this matrix are not exhaustive, but serve as examples to give readers a sense of what kinds of incentives are available.

Table 6: Economic Sustainability Matrix

Economic Sustainability	**Market Cost**	**Federal Incentives**	**State & Local Incentives**
LNG	Regular natural gas ranges from \$8.55/Mcf to \$14.53/Mcf; LNG might be more expensive than regular	Energy Policy Act of 2005	N/A
Petroleum	West Texas Intermediate Spot Average is \$43.14/barrel in 2009; \$99.57/barrel in 2008.	N/A	N/A
Nuclear Power	\$.03-.046/kWh	Nuclear Production Tax Credit, Regulatory Risk Insurance, Loan Guarantees, etc.	N/A
Hydropower	\$.006/kWh	Clean Renewable Energy Bonds, Hydroelectric Production Incentives, etc.	Business Energy Tax Credits, Energy Loan Program, etc.
Geothermal Power	Range from \$.0008 /kWh to \$1.75/kWh	Renewable Energy and Production Tax Credit, etc.	Oregon Small Scale Energy Loan Program, etc.
Solar Power	\$1/kWh	Solar Energy Technology Program, etc.	Residential Solar Electric Tax Credits, etc.
Wind Power	\$.051 /kWh if optimum	Wind Powering America, etc.	Business Energy Tax Credits, etc.
Biomass Power	\$.029/kWh to \$.054/kWh	Renewable Electricity Production Tax Credit, etc.	Biomass Energy Tax Credit, etc.
Wave Energy	\$.18/kWh to \$.30/kWh	Renewable Energy Production Incentive	Open Solicitation Program

As we can see in the Social Sustainability Matrix, there’s a great deal of uncertainty on people’s fears, perceptions, and knowledge of the energy sources. The results presented are based on the best available data we were able to obtain. At this point, a combination of qualitative and quantitative sociological research would be very helpful to characterize social sustainability.

Table 7: Social Sustainability Matrix

Social Sustainability	Risk	Perception	Knowledge
LNG	Could be a terrorist target. LNG explosions and fires. Disturbance to salmon migration.	Could harm salmon, forests, Farmlands; Fire threats.	Comparatively familiar to the public
Petroleum	High prices	An aging, dirty energy source	The public is aware of petroleum and its negative environmental impacts.
Nuclear Power	Nuclear radiation, plutonium, and nuclear waste disposal	Negative perception	Comparatively familiar to the public
Hydropower	Environmental concerns such as mercury contamination, bioaccumulation, etc.	A massive, landscape-altering, history-flooding, fish-blocking energy source	People are well informed of hydropower's low cost, efficiency, reliability and its environmental concerns.
Geothermal Power	Not too much risk.	It's considered environmentally friendly, but could cause trouble as well.	28% of Oregonians are familiar or very familiar with geothermal power.
Solar Power	Not much risk.	Quite positive	More than half of Oregonians are familiar or very familiar with solar energy.
Wind Power	Viewshed obstructions.	People's perceptions differ on wind energy.	58% of Oregonians are familiar or very familiar with wind energy.
Biomass Power	Could harm agriculture, reduce soil quality, be affected by drought or pestilence	Needs further research on the public's perceptions of biomass energy	Research on biofuel indicates that 44% of Oregonians are familiar or very familiar with biofuel.
Wave Energy	Wave depletion; impacts on fisheries.	Mixed.	24% of Oregonians are very familiar or familiar with the technology.

Based upon our findings, we assign numbers one to nine to all the electricity-generating energies, with one being least sustainable and nine most sustainable. Then, we add up scores each energy receives from three dimensions and rank them all in order of overall sustainability (See Table 15). As we can see from the far right of the table, the overall sustainability order is geothermal > solar power > hydropower > wave energy > wind power > LNG > petroleum > biomass power > nuclear power. This ranking is not conclusive because of two reasons. First of all, every area or location has its own environmental, economic and social characteristics with its individualized political agenda, that is, what is sustainable for Columbia River Gorge can be different from what is sustainable for Willamette Valley. Finding out a one-size-fits-all ranking is not likely. Secondly, in terms of wave energy development, there are many unknowns and more research is needed to determine how sustainable it could be versus other sources. Despite this, our preliminary results still provide a snapshot of comparing sustainability.

Table 8 Overall Sustainability Score

Energy Type	**Environmental Score**	**Economic Score**	**Social Score**	**Overall Sustainability Score**
Geothermal Power	**8**	**7**	**8**	**23**
Solar Power	**9**	**1**	**9**	**19**
Hydropower	**5**	**6**	**6**	**17**
Wind Power	**7**	**3**	**5**	**15**
Wave Energy	**6**	**2**	**7**	**15**
LNG	**3**	**9**	**2**	**14**
Petroleum	**2**	**8**	**3**	**13**
Biomass Power	**4**	**4**	**4**	**12**
Nuclear Power	**1**	**5**	**1**	**7**

The Acceptability Matrix is Oregon-oriented and briefly discusses the challenges and opportunities that might be experienced in developing each type of energy in Oregon.

Table 9: Acceptability Matrix

	Acceptability
LNG	Environmentally, it's likely to receive opposition. Economically, not as feasible as regular natural gas from Rocky Mountains. Socially, Oregonians are concerned about its environmental impacts.
Petroleum	Supply can be difficult for Oregon.
Nuclear Power	Not acceptable in Oregon.
Hydropower	Growing need for surface water supply, aging infrastructures and public's knowledge determines the acceptability of hydro in Oregon.
Geothermal Power	Geothermal in general has been considered a promising energy source for Oregon, but acceptability still depends on how the development would be managed locally.
Solar Power	Oregon's abundance in solar resources and several hundred solar systems would be the basis for future development.
Wind Power	Transmission capacity between eastern and western Oregon and the cost of a small wind farm affect the acceptability of wind energy.
Biomass Power	Biomass can enhance economy, while we'll need to take into consideration environmental pros and cons. Social acceptance is not certain.
Wave Energy	Oregon has tremendous ocean resources and large transmission capacity to develop wave energy. Environmentally, we need more research locally to inform decision-making. Economically, more incentives might need to be created. Socially, the public's knowledge of wave energy needs to be advanced.

In crafting energy policy for Oregon, we highly recommend from examining Low's typology model that policy-makers limit unsustainable and unacceptable energy by using regulatory policy (such as Oregon Statutes 469.595 and 469.597 for nuclear plants), but encourage sustainable and acceptable energy by using distributive policy (such as Business Energy Tax Credits).

In order to increase the sustainability and acceptability of wave energy, we suggest policy makers encourage research on local environmental impacts of wave energy, provide local economic incentives targeted on wave, and promote the public's knowledge of wave energy.

Through the process of completing this project, data limitations and time constraints have been major obstacles. However, as a snapshot in time, this report presents important facts, data and a framework to inform energy evaluation, policy formulation and decision-making. At last, we highly recommend that "sustainability-thinking" should be utilized at all levels of decision-making.

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Appendix 1

List of Abbreviations

ANWR	Arctic National Wildlife Refuge
BETC	Business Energy Tax Credits
CAFE	Corporate Average Fuel Economy
DOE	Department of Energy
EC	European Commission
EEC	European Economic Community
EPAct	Energy Policy Act
EU	European Union
FERC	Federal Energy Regulatory Commission
Mcf	Thousand cubic feet
PUHCA	Public Utility Holding Company Act
PV	Photovoltaic Systems
SELP	Oregon Small-Scale Energy Loan Program

Appendix 2

Sustainability of Geothermal Power

Technology

The center of our Earth reaches 6000 degrees Celsius, and the heat underground can be used to heat houses and to generate electricity. If holes are drilled down to a hot region, and water is pumped down an "injection well," the water goes through the cracks in the rocks and comes back up the "recovery well" under pressure. When it reaches the surface, the water has become steam, capable of driving turbines and producing electricity, as seen in Figure 12 (Darvill 2009). Heat pumps, direct use, flash steam power, and binary steam power are four major geothermal technologies. The first two are thermal, while flash steam power and binary steam power are primarily used to produce electricity. Geothermal resources above 200 degrees Celsius are considered high-grade, and they are found abundantly in the American west. Medium-grade resources (150-200 degrees Celsius) are mostly found in the west and southwest. Low-grade resources (100-150 degrees Celsius) are found throughout the U.S. (Simon 2007).

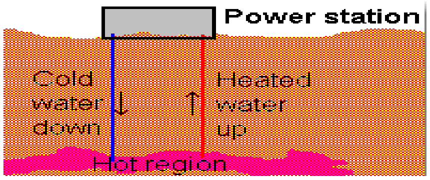

Figure 5: Geothermal Power Technology (Darvill 2009)

Environmental Sustainability

- *Impact on the Geosphere:* When the cooler-injected water meets the hotter rocks underground, it causes rapid decline in temperature, potentially reducing the quality of geothermal resources, especially when the geological formation surrounding the resource does not have a strong heat source (Kumagai, Tanaka et al. 2004). Poor quality of geothermal resources might limit our future use of the underground heat.
- *Impact on the Atmosphere:* Two operational systems can be used in a geothermal power plant: an open-loop system and a closed-loop system. When an open-loop system is used, the superheated water being extracted may contact surface soils and air, contaminating the atmosphere by its harmful components, such as hydrogen sulfide, ammonia, methane, toxic sludge, etc. However, a well-designed closed-loop system can minimize this effect. Generally speaking, geothermal power does not contribute much to the greenhouse effect (Simon 2007).
- *Impact on the Hydrosphere:* Availability of adequate geothermal water resources has become a problem. Some geothermal power plants inject waste water into geothermal reservoirs and generate impurities in the geothermal brine, which may affect the quality of ground water (Simon 2007; Pryfogle 2005).
- *Impact on the Biosphere:* Geothermal power plants would release elements like mercury, Arsenic, Boron and antimony, which could in turn be absorbed by mosses, higher plants and organs of small mammals living close to geothermal installations (Bargagli, Cateni et al. 1997). Research on the ability to scrub these toxins out so as to keep them from being released was difficult to find.

Economic Sustainability

- *Market Cost:* The estimated costs of geothermal power depend on the quality of the resource, location, demand level and type of project development (Tester, Herzog et al. 1994). Total capital costs of small plants (< 5MW) are between $1, 858 and $3,484/kW, while those of large plants are between $1,336 and $2,255/kW. Operations and maintenance costs range from 0.5 cents/kWh to 1.5 cents/kWh. Generally the average cost of geothermal power is between 0.08 cents and $1.75 per kWh (Simon 2007).
- *Federal Incentives:* One example of federal incentive is Renewable Energy and Production Tax Credit, which provides an incentive for geothermal power at the federal level. Corporations that invest in or utilize solar or geothermal energy property in the U.S. are given a ten percent tax credit and an additional twenty-five percent tax credit of the remaining total tax (Database of State Incentives for Renewable Energy 2008).
- *State and Local Incentives:* The Oregon Small Scale Energy Loan Program (SELP) offers low interest loans for projects that produce renewable energy, such as geothermal. Loans can pay for capital costs and related costs such as engineering and design, permits, loan fees, and project management. Loan rates are fixed; tax-exempt rates may be available.

Loan terms can vary from five to fifteen years (Oregon.Gov 2008). Other geothermal incentives include: BEF - Renewable Energy Grant, Business Energy Tax Credit, Energy Trust - Open Solicitation Program, Mandatory Utility Green Power Option, Oregon Energy Trust, Portland - Green Building Policy and LEED Certification, Portland - Green Power Purchasing and Generation, Renewable Energy Systems Exemption and Renewable Portfolio Standard (DSIRE 2008).

Social Sustainability

- *Risk:* Unlike nuclear power or other renewable energies, geothermal energy hasn't drawn much public attention due to limited exploitation of resources. Hardly any literature has indicated serious risks for geothermal energy, though specific public concerns about it do exist (see Perception section).
- *Perception:* Generally, geothermal energy is considered environmentally friendly and benign judging from experiences of small-scale developments in the UK and of large-scale projects in France and Italy (DiPippo 1988). However, the case of Hawaii provides a situation in which local land use conflicts and substantial public protest arose from geothermal energy developments. In 1972, Hawaii began its massive exploration of geothermal potential. As a large 500MV plant project proceeded, public opposition grew due to its "violation of religious and spiritual sites by drilling, the noise and smells from test programs and the operation of a pilot plant, the destruction of lowland rainforest areas, safety from lava inundation, the disturbance of rare flora and fauna, the damage to tourist trade, and the unwanted industrialization of a largely agricultural and service-based island economy." Since then, the public protest had continued for 18 years, hindering the development of geothermal energy. Therefore, there is a mixed feeling or perception among the public (Walker 1995). In future research, it would be good to find more examples in the mainland of the U.S. dealing with the perception of geothermal energy.
- *Knowledge:* Researchers from Oregon State University recently conducted a survey regarding Oregon energy policy and the public's knowledge and perceptions (Steel and Stefanovich 2008). In answering the question "how familiar are you with geothermal energy", only twenty-eight percent of people state-wide are familiar or very familiar with the technology. Numbers vary slightly between Portland Metro, Willamette Valley and coastal areas (Table 10).

Table 10: The public's familiarity with geothermal energy (Steel and Stefanovich 2008)

Geothermal Energy	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Not Familiar	27%	25%	29%	30%
Somewhat Familiar	44%	55%	38%	39%
Familiar	21%	17%	22%	20%
Very Familiar	7%	3%	11%	11%

Acceptability for Oregon

The Cascades, central and southeast Oregon, and parts of northeast Oregon are abundant in high heat flow. Areas outside the Newberry National Volcanic Monument can be commercially feasible for high-temperature geothermal electricity production in the Pacific Northwest. Lake and Malheur counties also have potential in geothermal energy development. Geothermal energy is included as an important renewable energy source in the Oregon Renewable Energy Action Plan, created by the Oregon Department of Energy. In 2006, Governor Kulongoski created the Renewable Energy Working Group focusing on wind, geothermal, biomass and ocean power. Thus, geothermal energy has been considered a promising energy source for Oregon. The acceptability of geothermal energy, however, depends considerably upon how the development would be managed locally (State of Oregon 2008). The Hawaii geothermal experience could be a lesson here.

Appendix 3

Sustainability of Solar Power

Technology

There are three ways to use solar technology: solar cells, solar water heating, and solar furnaces. Solar cells, or photovoltaic cells, convert light into electricity. Solar water heating systems heat water in glass panels on your roof. Solar furnaces can produce very high temperatures by concentrating the Sun's energy into a small space (Darvill 2009). In discussing sustainability of the solar power, our focus is on the first technology that generates electricity: solar cells.

First, the energy of photons from the Sun is absorbed by photovoltaic systems (PV) cells, causing the movement of electrons to create electrical voltage. Then the electrons travel through an electrical circuit to drive an electrical device, or can be stored in a battery for future use (see Figure 6) (Simon 2007). Solar cells are used for both consumer and commercial applications. Emergency call boxes along state freeways and solar-powered electronic devices are major applications (EPRI 2003). In 2001, approximately thirty-one percent of the PV solar cells nationwide were manufactured in California.

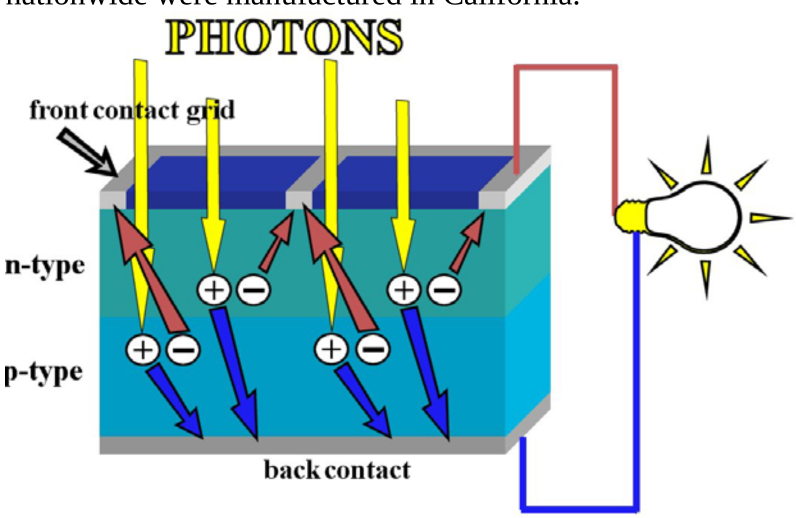

Figure 6: How Solar Cells Work (Specmat.com 2008)

Environmental Sustainability

- *Impact on the Geosphere:* Tin oxide used in electron collector grids could contaminate soil (and water), and industrial solvents used to clean solar collectors can cause soil contamination at a high concentration (Simon 2007).
- *Impact on the Atmosphere:* Although the greenhouse gas is not a problem in solar energy generation, toxic and explosive gases are involved in producing PV devices, such as silane, arsine, phosphine, hydrogen sulfide and hydrogen selenide. A catastrophic release of those toxic gases may result in serious atmospheric pollution (EPRI 2003).
- *Impact on the Hydrosphere:* Disposal of solar cell modules in a landfill could result in contamination of local ground and surface water through many pathways. For example, toxic chemicals from solar cells can reach a drinking water well or river through groundwater seepage (EPRI 2003).
- *Impact on the Biosphere:* The PV industry uses carcinogenic chemicals to produce solar cells. For example, cadmium compounds are used to produce thin-film solar cells. Arsine is a doping gas used in producing polycrystalline silicon cells and gallium arsenide solar cells. Major carcinogenic chemicals include arsenic, arsine, cadmium, dichloromethane, trichloroethylene, etc. (EPRI 2003).

Economic Sustainability

- *Market Cost:* The world market for solar PV is doubling every 2 years, and the manufacturing cost has fallen approximately twenty percent with each doubling (State of Oregon 2008). Domestically, the demand for PV cells has increased since 1994, while their prices have decreased (Simon 2007). Most PV cells produce electricity for approximately $1 per kilowatt hour, but it is predicted that with technological advances the cost would be reduced to 3-25 cents per kilowatt hour (Bronstein 2008; Bullis 2008).
- *Federal Incentives:* At the federal level, the Solar Energy Technology Program (SETP) seeks to promote efficient solar energy systems. The program attempts to streamline market processes, to encourage R&D in solar industry, and to promote the use of solar energy by commercial enterprises. SETP also provides grant opportunities and collaborative projects to universities (U.S. Department of Energy 2008). The majority of the SETP budget contributes to promoting solar PVs, and the rest of it focuses on solar heating, lighting, etc. (See Figure 7) (U.S. Department of Energy 2008).

Solar Energy	FY 2007 Budget Appropriation*
Photovoltaic Energy Systems	$106,235
Concentrating Solar Power	$7,582
Solar Water Heating	$4,685
Cross-Cutting	$5,953
Total, Solar Energy	$124,455

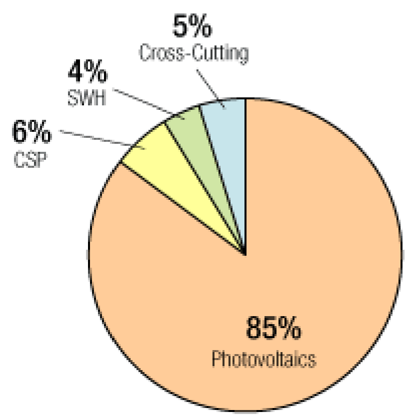

Figure 7: Budget Appropriation for SETP (U.S. Department of Energy 2008)

- *State and Local Incentives:* Residential Solar Electric (PV) Tax Credits is an example of solar incentives statewide, which provides a tax credit for PV systems of $3 per peak watt of installed capacity with a maximum credit of $6000 (Oregon.Gov 2008). Other solar incentives include Ashland - Solar Access Ordinance, BEF - Renewable Energy Grant, Business Energy Tax Credit, Eugene - Solar Standards, Interconnection Standards, Mandatory Utility Green Power Option, Oregon - Net Metering, Oregon Energy Trust, Portland - Green Building Policy and LEED Certification, Renewable Energy Systems Exemption, Renewable Portfolio Standard and Solar Access Laws (DSIRE 2008).

Social Sustainability

- *Risk:* Since sunlight is free, clean and accessible, people are quite in favor of solar energy. Although some toxic chemicals are involved in producing solar PV cells, user safety issues in PV systems are minimal. One of the concerns about potential dangers of solar energy is falling off of the roof when installing or maintaining solar facilities (Simon 2007).
- *Perception:* The public perception of solar energy is quite positive. A survey conducted by an independent polling firm, Kelton Research, shows that ninety-four percent of Americans say it's important for the U.S. to develop and use solar energy. More than seventy percent of Americans favor extension of Federal tax credits for solar energy. Seventy-seven percent of Americans feel Federal government should make solar power development a national priority (SCHOTT 2008).
- *Knowledge:* The Oregon Energy Policy Survey results indicate that more than half of Oregonians are familiar or very familiar with solar energy. Only seven percent are not familiar from a state-wide sample (Table 11). Compared to geothermal, the public are more aware of solar renewable technology. The high percentage could be an indicator for the potential public acceptability of solar energy in Oregon.

Table 9: People's familiarity with solar energy (Steel and Stefanovich 2008)

Solar Energy	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Not Familiar	7%	8%	5%	4%
Somewhat Familiar	32%	30%	41%	29%
Familiar	39%	35%	35%	45%
Very Familiar	23%	27%	19%	22%

Acceptability for Oregon

Solar energy, which consists of solar heat, light and PV, is Oregon's largest renewable energy. Northwestern Oregon receives the same solar resources as the national average, and eastern Oregon and southern Oregon have the same annual solar resources as northern Florida. Now in Oregon, there are several hundred solar systems that are connected to utilities and several thousand "off-grid" systems that have been installed. Also, we are currently able to attract large manufacturers of solar PV technology to Oregon (State of Oregon 2008). Oregon's abundance in solar resources would be the basis for future development.

Appendix 4

Sustainability of Hydropower

Technology

Running water can generate electricity. When water flows through tunnels in a dam, it spins turbines and drives generators to produce electricity (Figure 8). Water can be stored above the dam to cope with peaks in demand (Darvill 2009). Hydropower accounted for six percent of total U.S. electricity generation in 2007. However, more than fifty percent of the total U.S. hydropower is concentrated in three States: Washington, California and Oregon (Energy Information Administration 2008).

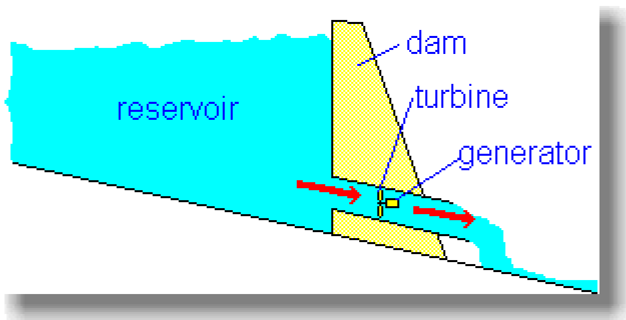

Figure 8: Hydropower Technology (Darvill 2009)

Environmental Sustainability

- *Impact on the Geosphere:* Hydropower dams can prevent nutrient-rich silt from reaching the downstream land, which may result in more use of fertilizers in agriculture along the river, allowing for more pollution (Bowyer 2008). It is estimated that twenty-five percent of the sediment flux that is supposed to go downstream can be impounded behind dams (Voromarty, Meybeck et al. 2003). Hydropower dams can affect ecological functions by converting river or land ecosystems into lake ecosystems (Bowyer 2008).
- *Impact on the Atmosphere:* It is widely accepted that hydropower does not produce atmospheric pollution and does not contribute to the greenhouse effect. A study by the International Hydropower Association indicates that emissions from hydropower were to 40 times lower than from thermal power plants, and a hydropower plant can absorb and store more CO_2 than they emit (International Hydropower Association 2003). However, two papers published by the International Rivers Network have proposed that flooded areas may be sources of CO_2 rather than sinks (McCully 2004; Parekh 2004).
- *Impact on the Hydrosphere:* Reservoirs in hydropower plants can act as buffers during flooding seasons and reduce the runoff peaks to prevent flooding downstream (Verbunt, Zwaaftink et al. 2005). However, one the concerns about hydropower is that the rotting vegetation within the dam can cause the water to be acidic (Bowyer 2008).
- *Impact on the Biosphere:* Hydropower also causes biological and ecological concerns. For instance, salmon need to swim upstream along the Columbia River to their spawning

grounds to reproduce, but dams block their way and have been one cause in the decline of salmon. Fish ladders have been built to fix the problem and help salmon swim upstream, but when the small fish try to come down the river, it is very likely that they will be injured by the turbines (Bowyer 2008). Another major biological problem arises from acidic conditions in reservoirs, which may promote the growth of certain types of bacteria. Those bacteria release metals such as mercury, which is in turn absorbed by fish and travels further along the food chain. Such mercury poisoning has been reported in Canada (Hoey and Postl 1998).

Economic Sustainability

- *Market Cost:* Hydroelectricity is among the lowest cost energy, approximately 0.6 cents per kWh in 2006 (the cost per kWh is calculated by dividing total life-cycle costs by the estimated amount of energy in kWh the system will produce over its operating life). Since hydropower dams were built decades ago, capital costs or debt service are minimal. Operational costs and maintenance costs are low (Werner 2006).
- *Federal Incentives:* EPAct 2005 includes a major reform of the licensing procedure for hydroelectric dams. It also provides federal incentives to renewable energies including hydro. For example, renewable generation credit allows hydro to receive 0.9 cents per kWh (Neff 2005). Another incentive would be Clean Renewable Energy Bonds (CREBS), which work as a tax credit bond and can be applied to certain hydroelectric facilities (American Public Power Association 2008). Hydroelectric Production Incentives also offer 1.8 cents per kWh payment to certain hydroelectric facilities (Cornell University Law School 2008).
- *State and Local Incentives:* Two major financial incentives for hydroelectric power in Oregon are the Business Energy Tax Credits (BETC) and Energy Loan Program. The BETC provides tax credits to businesses that invest in hydroelectric systems below 25 megawatts of capacity in Oregon. This credit could be up to 35 percent of the project cost. The Energy Loan Program offers low-interest, fixed rate, long-term loans to businesses that develop any size hydroelectric project in Oregon (Oregon.Gov 2008). Other local relevant incentives include BEF Renewable Energy Grant, Energy Trust Open Solicitation Program, Interconnection Standards, Mandatory Utility Green Power Option, Oregon Net Metering, Oregon Energy Trust Incentives, Portland Green Building Policy and LEED Certification, Renewable Energy Systems Exemption, Renewable Portfolio Standard, etc. (DSIRE 2008).

Social Sustainability

- *Risk:* Unlike nuclear power, hydropower is not associated with much risk. However, many ecological concerns still exist, such as mercury contamination, bioaccumulation, and limitation of biodiversity are sources of anxiety (Rosenberg, Berkes et al. 1997).
- *Perception:* Hydropower is often considered yesterday's technology, and when thinking about renewable energy today, people seem to be more excited about photovoltaics, hydrogen, or other new types of technology. There is also a tendency for the public to relate hydropower to a massive, landscape-altering, history-flooding, fish-blocking energy source (Ballentine 2004), instead of some of the smaller-scale hydropower systems in, say, Alaska.

- *Knowledge:* It is found through a review of literature that the public is aware of both advantages and disadvantages of hydropower. Almost the same amount of literature can be found from two sides. People are well informed of hydropower's low cost, efficiency and reliability, while they quite understand its environmental concerns as well.

Acceptability for Oregon

Since the present availability of water resources in Oregon provides a large capacity for electricity, hydropower is able to meet forty-four percent of Oregon's electricity demand. However, the growing need for surface water supply by irrigation, drinking water, etc. is likely to affect the long term acceptability of hydropower. Aging infrastructure that nears the end of its engineered life is also a challenge to hydropower in Oregon (Achterman 2008). The public's knowledge about its environmental impacts may limit the growth or development of hydropower. On the other hand, some relevant public and private incentives in Oregon could help hydropower to be somewhat competitive.

Appendix 5

Sustainability of Wind Power

Technology

Wind energy comes from moving air as a result of unequal solar heating of the earth. This type of energy is mainly used to generate electricity, although sometimes it can also help to crush grain or to pump water as a mechanical force. As wind blows, the rotor of a wind turbine in wind farms spins and drives the shaft of an electric generator. Figure 9 shows a typical design of a wind turbine (National Renewable Energy Laboratory 2009). Usually, wind turbines with small rotors are used for battery charging, whereas larger rotors facilitate the generation of large amounts of electricity in a regional grid (Massachusetts Technology Collaborative 2008).

At the end of 2006, wind produced just above one percent of world-wide electricity (World Wind Energy Association 2007). A total of 17.8 billion kWh per year of electricity was generated by wind machines in the U.S. in 2005, capable of serving more than 1.6 million households (Energy Information Administration 2007).

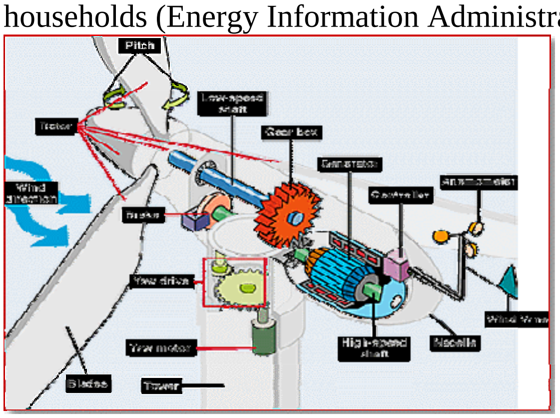

Figure 9: Wind Turbine Schematic Diagram (National Renewable Energy Laboratory 2009)

Environmental Sustainability

- *Impact on the Geosphere:* Wind is one of the prime causes for soil erosion, because it dislodges soil particles and carries them off the land (Pimentel and Kounang 1998). It is possible that development of wind energy projects would result in the deterioration of soil systems. But wind has minimal or no risk of soil contamination (Tuttle 2002).
- *Impact on the Atmosphere:* Wind energy, as a clean energy, contributes to reduction of carbon dioxide emission, which is a major cause for global warming. For example, a 1000MW project called New Wind Power in Montana is estimated by National Renewable Energy Laboratory to reduce carbon dioxide 2.9 million tons a year (National Renewable Energy Laboratory 2009). However, nonmainstream scientists speculate that large-scale wind power systems have the capacity to change local weather (Simon 2007).
- *Impact on the Hydrosphere:* Some wind farms are built offshore, which may affect the hydrology of the ocean. Also, when cables connect to the onshore grid, cable routes could adversely affect the local hydrology (Royal Haskoning 2007).
- *Impact on the Biosphere:* Sometimes in order to build a wind power plant, trees have to be removed in order to accommodate the giant "fans." Transportation of energy production equipment requires huge trucks and can cause enormous disturbance to the local flora and fauna. Wind power plants also impose threats to animals, especially birds and bats, such as loss of habitat, electrocution, and collisions with wind energy machines (Simon 2007).

Economic Sustainability

- *Market Cost:* The cost of wind energy can be produced at approximately 5.1 cents per kWh if an optimum wind of twelve meters per second is sustained on a 24-hour basis. In reality, however, wind does not meet load demands all the time, and housing for power storage devices would be needed to store surplus energy. Storage devices, and resulting buildings, additional wind turbines, a staff of employees, the costs of disposing of worn devices, etc. will impose an additional cost to the optimum 5.1 cents per kWh (Simon 2007).
- *Federal Incentives:* Wind Powering America is a recent federal commitment to increase the use of wind energy in the U.S. Instead of being a top-down policy that imposes rigid regulations on states, local governments, and businesses, Wind Powering America seeks to promote cooperation and collaboration among them. This policy takes into consideration American farmers, Native Americans, and other rural landowners, attempting to provide new sources of income for them (U.S. Department of Energy 2008).
- *State and Local Incentives:* Business Energy Tax Credits is one of the major incentives for wind energy in Oregon, which provides an incentive of thirty-five percent of the cost of wind systems to commercial developers. The credit is taken over five years: ten percent in the first and second years and five percent each year thereafter. Trade, business or rental property owners who pay taxes for a business site in Oregon are eligible to apply (Oregon.Gov 2008). Other wind energy incentives in Oregon include Ashland Electric - Net Metering, BEF - Renewable Energy Grant, Energy Trust - Small Wind Incentive Program, Interconnection Standards, Mandatory Utility, Green Power Option, Northwest Solar Cooperative - Green Tag Purchase, Oregon - Net Metering, Oregon Energy Trust,

Portland - Green Building Policy and LEED Certification, Portland - Green Power Purchasing and Generation, Renewable Energy Contractor Licensing, Renewable Energy Systems Exemption, Renewable Portfolio Standard, Residential Energy Tax Credit, Small-Scale Energy Loan Program, Tax Credit for Renewable Energy Equipment Manufacturers (DSIRE 2008).

Social Sustainability

- *Risk:* It is found that visual aesthetics is of most concern to the public, while other aspects including noise and disturbance to wildlife are of lesser importance. Two factors associated with visual aspect are the nature of the location (e.g. hilltop, coast, protected area) and the characteristics of the turbines per se (such as size, color, orientation and layout) (Walker 1995).
- *Perception:* The public's perceptions of wind farms are complex. Some people think the disadvantages of wind turbines can be balanced by their broader benefits, while others don't believe so. In the U.S., some proposals, such as the Zond Systems Development near Los Angeles, in the Altamont Pass, and Palm Springs area, have been turned down due to vigorous public opposition. Therefore, the public's positive perceptions are vital to the success of the wind energy industry (Walker 1995).
- *Knowledge:* Results from the Oregon Energy Policy Survey indicate that fifty-eight percent of Oregonians self-identified themselves as being familiar or very familiar with wind energy. This percentage varies with locations: Sixty-six percent for Portland metropolitan area, forty-eight percent for Willamette Valley, and sixty-five percent for the coastal area (Table 12).

Table 12: People's familiarity with wind energy (Steel and Stefanovich 2008)

Wind Energy	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Not Familiar	5%	3%	4%	6%
Somewhat Familiar	37%	30%	48%	29%
Familiar	42%	45%	38%	49%
Very Familiar	16%	21%	10%	16%

Acceptability for Oregon

Large and small wind projects in Oregon can provide a total capacity of about 450 MW, and development of new projects is carrying out primarily in the central and eastern Columbia River area and in northeastern Oregon. One of the major concerns in terms of large-scale wind energy development is the transmission capacity between eastern and western Oregon. It is more difficult to run a small wind farm due to a relatively higher cost, but it may benefit the local economy more than a big farm does (State of Oregon 2008).

Appendix 6

Sustainability of Liquefied Natural Gas

Technology

Natural gas is underground deposits of gases consisting of 50 to 90 percent methane (CH_4) and small amounts of heavier gaseous hydrocarbon compounds such as propane (C_3H_8) and butane (C_4H_{10}) (EPA 2008). Unlike other fossil fuels, natural gas is often considered clean energy because it emits lower levels of harmful byproducts into the air. Natural gas can be used for producing heat, operating engines and generating electricity. Although compared to other fossil energy it is a small part of the electricity market, natural gas is still considered important because of its low emissions. Sometimes, the gas is cooled to approximately -260° F at ambient air pressure and stored in a liquefied form for transportation purposes known as liquefied natural gas (LNG). Special ships are used to transport the LNG. After it reaches its destination, LNG is converted back to the gas state by vaporization at 35° F (Oregon Pipeline 2008). Now there are about 113 active LNG facilities in the United States, with more than 64 million Americans using it to heat and cool their homes, and more than 280,000 miles of natural gas transmission pipelines are available nationwide (Dominion 2008; Oregon Pipeline 2008).

Environmental Sustainability

- *Impact on the Geosphere*: There are concerns about LNG spills. A spill over land may result in local LNG pool fires, burning and damaging land (G.A.Chamberlain 2006).
- *Impact on the Atmosphere:* LNG is odorless, non-toxic, non-corrosive and non-carcinogenic per se. The combustion of re-gasified LNG for electricity generation is much cleaner than other fossil energy, because it contains virtually no sulfur and can reduce carbon dioxide emissions by 65 percent (Foss 2003; Oregon Pipeline 2008). However, methane, the primary component of LNG, can still contribute to the greenhouse effect due to its carbon elements. Also, compared to the current piped natural gas, LNG has more greenhouse gas emissions because of the energy used in shipping, liquefying and re-gasifying. In 2007, researchers at Carnegie Mellon University found that LNG can be equivalent to coal in terms of the greenhouse gas emissions if it is shipped over long distances (Oregon Department of Energy 2008).
- *Impact on the Hydrosphere:* LNG spills or pipeline breakages can cause severe pollution of water (Eden 1981). There are limitations in existing data that approach this issue in detail.
- *Impact on the Biosphere:* LNG projects may cause mortality and injury of marine organisms due to impingement, entrainment, ship strikes, etc. Other adverse impacts could include damage to marine habitats due to vessel operation, construction, disposal, water use, etc. (National Oceanic and Atmospheric Administration 2005)

Economic Sustainability

- *Market Cost:* There were 647,635 residential and 74,683 commercial customers in Oregon, 2006, who consumed 41 and 28 billion cubic feet of natural gas, respectively. The average prices of natural gas paid by residential and commercial customers were $14.53 and $12.94 per thousand cubic feet, respectively (Energy Information

Administration 2008). On an annual basis, the Henry Hub spot price of natural gas is expected to average $9.71 per thousand cubic feet (Mcf) in 2008 and $8.55 per Mcf in 2009 (Energy Information Administration 2008). Compared to regular natural gas, LNG operations are not cheap. Upfront costs have to be spent on construction of liquefaction facilities, purchase of specially designed LNG ships, and development of re-gasfication facilities. It will also take time and money to liquefy, transport and re-gasify natural gas (Foss 2003; State of Oregon 2008). Internationally, there are two major LNG markets: the Atlantic Basin and the Pacific Basin, both of which supply LNG in the U.S. at a higher price than the natural gas from North America. For Oregon, 100% of the natural gas is imported; major supply sources are Canada and the Rocky Mountain states (Oregon Pipeline 2008). It is estimated that traditional pipelines from the Rocky Mountains are more economic and environmentally friendly than the LNG terminals proposed in Oregon (Oregon Department of Energy 2008).

- *Federal Incentives:* President George W. Bush has proposed the expansion of LNG port facilities, and the EPAct of 2005 gives FERC exclusive jurisdiction over where LNG facilities should be sited. There are some federal incentives for LNG as a motor vehicle fuel, such as the Safe, Accountable, Flexible, Efficient Transportation Equity Act, which provides $0.50 per gallon incentive for businesses, individuals and tax-exempt entities that sell or use the fuel (Natural Gas Vehicles for America 2008). Since we are focused on the LNG used for electricity generation, the LNG fuels are not further discussed.
- *State and Local Incentives:* Currently, there is no state incentive for the LNG projects, and the State of Oregon is not in favor of building LNG terminals in the state. Since FERC has exclusive control for siting, construction, expansion and operation of LNG terminals, the state siting process is pre-empted where the Oregon Energy Facility Siting Council makes decision about siting and Oregon Department of Energy coordinates all permits. In order to influence FERC and protect Oregon's environment, Governor Kulongoski appointed Oregon Department of Energy as the State's lead agency to work with FERC to adopt Oregon's rules (State of Oregon 2008).

Social Sustainability

- *Risk:* People are concerned about LNG facilities being a potential target for terrorism (Parformak 2003). LNG explosions and fires are also major concerns (Foss 2003). In addition, other concerns can be raised. For example, people in Astoria, Oregon are concerned about a proposal to locate a LNG facility and its potential impact on salmon habitat (Profita 2008). Oregon House Bill 2015 LNG Public Protection Act in the 2009 Legislative Session gives the public the power to minimize LNG in Oregon, which can also reflect the Oregonians' fear of LNG in some way (75th Oregon Legislative Assembly 2009).
- *Perception:* There's a tendency for Oregonians to relate LNG to severe harm on salmon, new pipelines running through forests and farmlands, and inherent fire threats of LNG technology (Register-Guard 2008). Hardly any positive perceptions have been formed among the public, although LNG companies in Oregon have insisted that benefits brought by LNG include investment in the local and regional economy, creation of family wage jobs or construction jobs, etc.
- *Knowledge:* There isn't much data available regarding the public's knowledge of LNG. But compared to new emerging technologies, such as wave energy, people are more

familiar with this conventional energy form. Nevertheless, more research is needed to examine how much the public know about the technology and its pros and cons.

Acceptability for Oregon

For Oregon, LNG is likely to receive opposition due to its potential adverse impacts on the environment. Economically, natural gas from Rocky Mountains appears to be more feasible and economically beneficial. Socially, Oregonians have expressed fear and concern about the possible negative impacts on Oregon's environment, and with little research results or knowledge and understanding of this energy source, it appears that LNG remains disapproved by the public.

Appendix 7

Sustainability of Petroleum

Technology

Petroleum can serve as a fuel and a source for electricity. In researching petroleum, we find it difficult to obtain data or information of petroleum used specifically for electricity. Nevertheless, a general discussion of petroleum is presented below without distinguishing its two uses.

Consumption of petroleum in the U.S. has risen steadily since 1950. Now approximately 20 million barrels are consumed daily, and there is an increasing dependence on foreign suppliers of crude petroleum. 21.3 billion barrels of crude petroleum have been found in proven reserves in the U.S. and the U.S. protectorates (Simon 2007).

How does petroleum produce electricity? In a steam power plant, petroleum is burned in gas turbine generators to heat water, which in turn becomes steam and goes through a turbine to generate electricity (The Electricity Forum 2008). From January through April 2008, petroleum fired plants contribute to 1.1 percent of the U.S. electric power, with 0.7 percent coming from petroleum liquid and the remainder from petroleum coke (Energy Information Administration 2008).

Environmental Sustainability

- *Impact on the Geosphere:* Exploration for and production of petroleum can have harmful impacts on soil, surface and groundwater, and ecosystems due to improper disposal of saline water produced both with petroleum from accidental hydrocarbon and produced-water releases and from abandoned oil wells (Veil, Puder et al. 2004; Kharaka and Hanor 2003; Kharaka, Thordsen et al. 1995; Richter and Kreitler 1993).
- *Impact on the Atmosphere:* Petroleum coke has a high sulfur and nitrogen content, leading to undesirable emission characteristics (Wang, Anthony et al. 2004). Emission of mercury can also occur from processing petroleum (Wilhelm 2001). Also, carbon dioxide emitted from petroleum-fired electricity generation contributes a lot to the national total of the greenhouse gas (DOE and EPA 2000).

- *Impact on the Hydrosphere:* Offshore drilling for oil can pollute the ocean by discharging 735,000 gallons of oil every year into the ocean (National Research Council 2003). Also, ground water and surface water can be contaminated by improper disposal of wastes (EnviroTools 2008).
- *Impact on the Biosphere:* Oil exploration may cause many biological and ecological problems. For example, drilling in the Arctic National Wildlife Refuge is predicted to have major effects on caribou and musk oxen and moderate effects on wolves, wolverines, polar bears, snow geese, seabirds and shorebirds, arctic grayling and coastal fisheries (Kotchen and Burger 2007).

Economic Sustainability

- *Market Cost:* Crude oil prices in the U.S. had been skyrocketing in the past few years until early 2009 when the price was dropping dramatically (see Table 13) (Energy Information Administration 2008). Recently, we see the price increasing again. It's been difficult to predict oil prices now.

Table 103: Crude Oil Prices in the U.S. (Energy Information Administration 2008)

Crude Oil Prices (dollars per barrel)	2004	2005	2006	2007	2008	2009
West Texas Intermediate Spot Average	41.44	56.49	66.02	72.32	99.57	43.14
Imported Average	35.89	48.90	59.05	67.13	92.57	40.80
Refiner Average Acquisition Cost	36.96	50.25	60.26	68.09	94.97	41.82

- *Federal Incentives:* Historically, there have been a large number of incentives that target the petroleum industry until the late 1970s when Congress started enacting incentives to encourage alternative energy sources (Hymel 2008). However, the George W. Bush Administration has focused on petroleum production again. For example, in 2005, Congress decided to open a small area of the Arctic National Wildlife Refuge to explore oil (Simon 2007).
- *State and Local Incentives:* No incentives targeting petroleum are found at the state level in Oregon. In contrast, instead of incentives, some local regulations are available for petroleum programs. For example, Oregon Petroleum Load Fee Program, passed by the Oregon Legislature in 1989, imposes a fee on: (1) the initial withdrawal of petroleum products from a bulk terminal facility; and (2) the import of petroleum products into a storage tank other than a tank connected to a bulk facility in Oregon. The current fee is $2.50 per load on withdrawal from a bulk terminal facility and $2.50 per load on products imported into the state (Revenue 2006).

Social Sustainability

- *Risk:* Concerns mostly come from unreliable foreign sources, increasing domestic demand, and the resultant high prices of petroleum. Such risk is partly reflected by how people think about the petroleum market. A survey conducted by CNN/Opinion Research Corp shows that seventy-eight percent of the respondents believe gasoline price will hit $5 a gallon, and fear that they will have to pay more are strong. Sixty percent said high fuel prices have caused hardship for them or their household (Joyner 2008).

- *Perception:* People in the U.S. and Europe tend to perceive petroleum as an aging, "dirty" industry with questionable long-term prospects (Hermanmiller 2008). A study in Canada confirmed this tendency with citizens having negative perceptions of petroleum refineries and the effects of the refinery on their health (Luginaah, Martin Taylor et al. 2002). From a historic perspective, the current generation of Americans is not like earlier generations who emphasized materialism and economic self-interest. Now postmaterialists, such as the "Baby Boomers," are more concerned with quality of life issues including environmentalism. With such value changes, this generation has been attempting to free the country from the yoke of international petroleum producers (Simon 2007).
- *Knowledge:* A survey about the public's attitudes on energy use and environmental concerns done by the Carbon Capture and Sequestration Technologies Program at MIT showed that generally the public is aware that automobiles, factories, and power plants emit carbon dioxide and contribute to climate change, and people are increasingly willing to take action to "go green" even at a higher cost (Curry 2004).

Acceptability for Oregon

Oregon is not abundant in petroleum resources and does not have internal crude oil resources. All the petroleum in Oregon is imported, and no refineries are available here. Ninety percent of Oregon's refined petroleum products come from four refineries in the Puget Sound area of Washington via Olympic Pipeline and barges. More than eighty percent of the crude oil at the Puget Sound refineries originates in the Alaska North Slope oil fields. The Port of Portland receives the refined oil and distributes statewide from there (State of Oregon 2008) (see Figure 10). As demand for petroleum increases, the supply system is pressured more. Supply difficulties can come from natural disaster, unexpected infrastructure failure, or maintenance of aging system (State of Oregon 2008). Therefore, other energy sources and energy technologies have long been encouraged in Oregon to meet energy demand and mitigate environmental concerns.

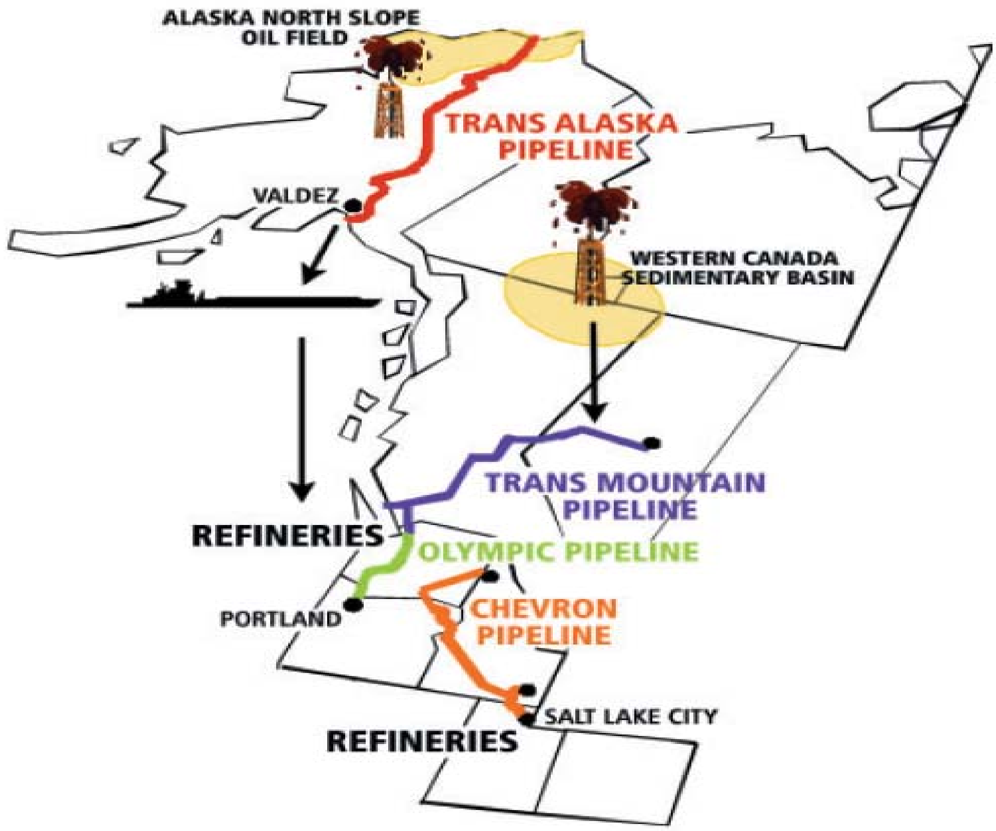

Figure 10: Oregon's Petroleum (State of Oregon 2008)

Appendix 8

Sustainability of Biomass Technology

Technology

Generally speaking, biomass is composed of forestry resources and agricultural resources, depending on where the feedstocks come from. Both of them have three levels of resources-the primary level (direct from photosynthesis), the secondary level (residues from central processing), and the tertiary level (salvage after secondary use as post-consumer residues) (See Figure 11) (Clark and Yin 2007).

Forest Resources

Primary
- Logging residues from conventional harvest operations and residues from forest management and land clearing operations
- Removal of excess biomass (fuel treatments) from timberlands and other forestlands
- Fuelwood extracted from forestlands

Secondary
- Primary wood processing mill residues
- Secondary wood processing mill residues
- Pulping liquors (black liquor)

Tertiary
- Urban wood residues – construction and demolition debris, tree trimmings, packaging wastes and consumer durables

Agricultural Resources

Primary
- Crop residues from major crops – corn stover, small grain straw, and others
- Grains (corn and soybeans) used for ethanol, biodiesel, and bioproducts
- Perennial grasses
- Perennial woody crops

Secondary
- Animal manures
- Food/feed processing residues

Tertiary
- MSW and post-consumer residues and landfill gases

Figure 11: Biomass Sources (U.S. Department of Energy 2005)

These various sources of biomass can be used for electricity generation, heat production, or transportation fuel supply. Since electricity generation is the focus of this report, technology translating biomass into electricity, which is similar to that of wind energy, is discussed in this section.

First, biomass is burnt to provide heat, which in turn makes water into steam. The steam turns the turbines and generates electrical power (see Figure 12). According to the Energy Information Administration, 590 million wet tons of biomass are available annually in the U.S. (Haq 2002).

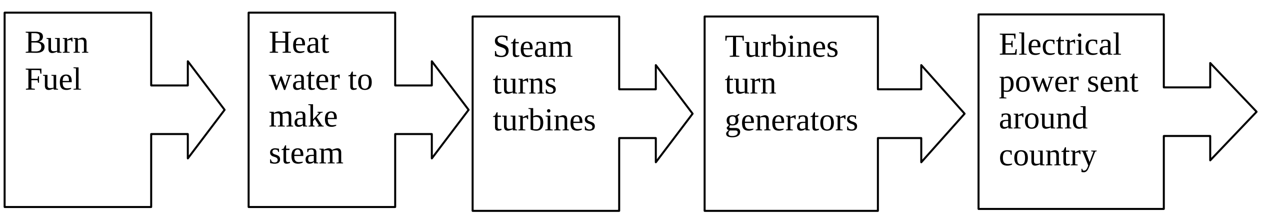

Figure 12: How Biomass Generates Electricity (Darvill 2009)

Environmental Sustainability

- *Impact on the Geosphere:* Biomass plays an important role in preventing soil erosion, maintaining organic nutrients, and keeping beneficial soil organisms. First, biomass residues can protect soil from water and wind erosion and maintain the water content and air content of soil by reducing runoff/sediment and air-borne particulates. Second, removal of biomass residue would result in decreased organic matter and nutrients, and thus increased fertilizer is required to provide more nutrients, leading to more pollution by fertilizer. Third, biomass residue removal can affect the existence or living of soil organisms, disrupting the balance of the ecosystem. Experiments performed in Olympic Peninsula revealed that forest harvesting practices for biomass production, such as clear cutting, would influence organisms to varying degrees (Clark and Yin 2007).

- *Impact on the Atmosphere:* Although biomass is able to absorb CO_2, when it is burnt to generate electricity, the carbon dioxide is released, making biomass CO_2 neutral (CAN Europe 2008). Also, growing biomass plants might involve using more fertilizers, which may release additional toxic chemicals into the air (Clark and Yin 2007).
- *Impact on the Hydrosphere:* Water depletion and water pollution are the two major problems caused by biomass electricity generation. In many cases fresh water (groundwater and surface water) is being depleted by agriculture than it is being recharged, which has threatened current food supplies, not to mention biomass crops. As for water pollution, agricultural chemicals are inevitably applied to protect biomass crops from weeds, plagues and diseases. Common agricultural chemicals are herbicides, fungicides, insecticides and other pesticides. At this point, biomass feedstocks should be sought that require low chemical inputs (Clark and Yin 2007).
- *Impact on the Biosphere:* Ideal ecological traits of biomass energy plants are often found among invasive species. Examples of invasive biomass energy plants in the United States are *Arundo donax, Phalaris arundinacea, hybrid grass Miscanthus* × *giganteus, Panicum virgatum*, etc. Ecological risks must be assessed before planting certain species to avoid ecological disorders (Clark and Yin 2007)

Economic Sustainability

- *Market Cost:* Biomass transportation, storage and handling costs are a major part of the costs of biomass electricity generation. Designing the facility to handle multiple biomass types is also an extra cost compared to using conventional technology. The estimated cost of generating electricity from landfill gas is 2.9 to 3.6 cents per kWh. Producing electricity from anaerobic digestion of animal manure is about 3.7 to 5.4 cents per kWh. Digester gas from a farm-site manure digester can help reduce farm energy costs (Oregon.Gov 2008). How much biomass electricity costs depends on what type of biomass would be used for electricity generation.
- *Federal Incentives:* One of the federal incentives for biomass electricity generation is the Renewable Electricity Production Tax Credit, which provides tax credit for electricity generated by renewable sources and sold by the taxpayer to an unrelated person during the taxable year. Table 7 below shows the in service deadline and credit amount for biomass resources (DSIRE 2008).

Table 14: Renewable Electricity Production Tax Credit (DSIRE 2008)

Resource Type	**In Service Deadline**	**Credit Amount**
Closed-loop Biomass Facilities	December 31, 2010	2.1 cents/kWh
Open-loop Biomass Facilities	December 31, 2010	1.0 cents/kWh
Landfill Gas	December 31, 2010	1.0 cents/kWh

- *State and Local Incentives:* Incentives for biomass electricity at the state and local levels in Oregon include Business Energy Tax Credit, Interconnection Standards, Mandatory Utility Green Power Option, Oregon - Net Metering, Oregon Energy Trust, Portland - Green Building Policy and LEED Certification, Portland - Green Power Purchasing and Generation, Renewable Energy Systems Exemption, Renewable Portfolio Standard, Residential Energy Tax Credit, Small-Scale Energy Loan Program, Tax Credit for Renewable Energy Equipment Manufacturers (DSIRE 2008).

Social Sustainability

- *Risk:* Land is not infinite and therefore producing biomass energy might jeopardize access to agricultural land that would otherwise provide food for the world. Removal of waste and residues can also deprive the soil of nutrients, leading to unsustainable and infertile soil. Biomass energy dependence can be greatly affected by drought or pestilence. These risks should be taken into account when we consider the sustainability of biomass energy (Schiermeier, Tollefson et al. 2008).
- *Perception:* A study on public perceptions on woody biomass utilization in Oregon identifies that there is "widespread support for removing excess biomass from Oregon forests by means of mechanical thinning", but it is not clear how the public sees producing electricity from the biomass. Also, further research is needed to determine the public's perceptions on other biomass feedstock (Oregon Departments of Energy and Forestry 2007).
- *Knowledge:* The Oregon Energy Policy Survey also examines people's familiarity with biofuel technology. Although biomass electrical energy and biofuel are not the same thing, we are still able to have a sense of the public knowledge regarding bio-products from the survey. Thirteen percent of Oregonians are very familiar with biofuel, and thirty-one percent are familiar, while about half of the people are not familiar or somewhat familiar with the technology (Table 15). The numbers vary a little across the state as is shown in the breakdown.

Table 15: People's familiarity with biofuel (Steel and Stefanovich 2008)

Biofuel	**State-wide Sample**	**Portland Metro**	**Willamette Valley**	**Coastal Sample**
Not Familiar	12%	12%	12%	9%
Somewhat Familiar	44%	42%	47%	47%
Familiar	31%	35%	26%	31%
Very Familiar	13%	11%	15%	13%

Acceptability for Oregon

In Oregon, more than ninety percent of biomass energy is generated by forest or urban woody biomass (forty percent) and paper mill pulping liquor (forty-six percent). A study done in Wallowa, Union and Baker counties assessed that six jobs would be created for each megawatt of biomass energy with a fifty megawatts potential in these three counties (State of Oregon 2008). On top of the economic considerations, ecological pros and cons need to be taken into account. For example, as we are running risks of affecting soil quality by removing biomass, it might help restore Oregon's forest health by reducing fire hazards (Bowyer 2006). Socially, the public acceptance of biomass energy is not certain with approximately fifty percent of Oregonians not familiar or somewhat familiar about the technology.

Appendix 9

Sustainability of Nuclear Power

Technology

Not only can complex compounds of fossil sources generate electricity, but small atoms, such as Uranium, can produce electricity as well. There are two types of Uranium involved in this process: U-238 and U-235. Most of the uranium in use is U-238, but U-235 splits more easily. When a U-235 atom splits, neutrons are released and hit other uranium atoms, causing more uranium atoms to split. This chain reaction is called fission, which produces a huge amount of heat that can turn water into steam for energy production by driving turbines (Figure 14).

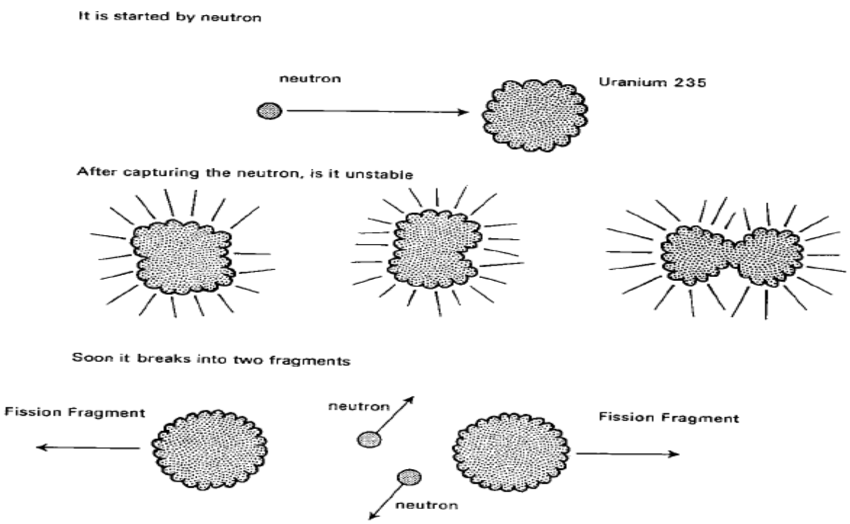

Figure 14: Chain Reaction (Hodgson 1999)

Figure 15 illustrates how this works. Now there are approximately 104 nuclear power plants in the U.S. that contribute twenty percent of the national electricity (Nuclear Energy Institute 2008).

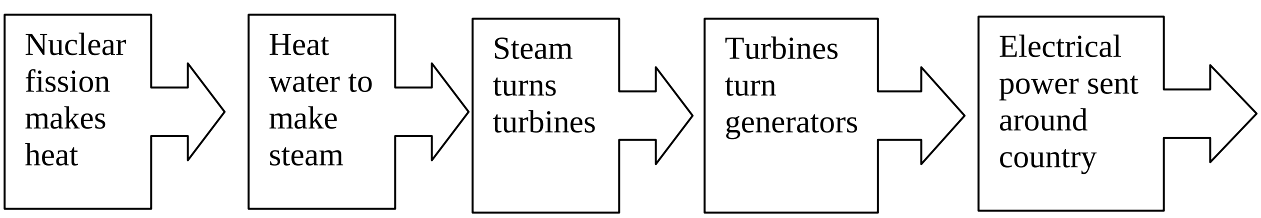

Figure 15: How Nuclear Plants Generate Electricity (Darvill 2009)

Environmental Sustainability

- *Impact on the Geosphere:* There are some cases showing that radioactive waste leaking from a nuclear power plant contaminated the local soil. Once the radionuclides enter the soil, it can transfer from soil to plants through the food chain and go further along the chain (New York Times 1981; Zhu and Shaw 2000).

- *Impact on the Atmosphere:* Nuclear power production does not generate smoke or carbon dioxide, and thus the greenhouse effect would not increase. Although a nuclear power station releases radioactive substances into the atmosphere, the radioactivity is even less than that of substances emitted from coal power stations (Hodgson 1999). However, during the decay of uranium, radon can be produced, which is known to cause cancer in humans (Connexions 2008).
- *Impact on the Hydrosphere:* Nuclear power reactors are often located near rivers, lakes or oceans, because they require a large amount of cooling water. A powerful intake of water into nuclear reactor and an equal amount of wastewater at a higher temperature discharged back into the river may disturb the hydro system and the marine life within the system (Energy Justice Network 2008).
- *Impact on the Biosphere:* Radioactive substances can be introduced through the food chain, causing tissue damage, loss of appetite, illness, cancer and even death (Hodgson 1999; Connexions 2008).

Economic Sustainability

- *Market Cost:* Nuclear power is cost competitive with fossil fuel for electricity generation, although capital costs are relatively higher and decommissioning and waste disposal costs, which are often externalized for other electricity-generating technologies, are internalized in nuclear power production. However, building nuclear power plants costs more than constructing coal- or gas-fired plants due to the need for special materials, safety facilities and back-up control equipment (World Nuclear Association 2008). The Energy Utility Cost Group showed that nuclear utility generation costs on average 2.866 c/kWh in the U.S. in 2007. The electricity generation cost projected for 2010 is shown in Table 16.

Table 16: Electricity Generating Cost for Nuclear Power

	5% discount rate	**10% discount rate**
Electricity Generating Cost for Nuclear Power (the U.S. 2003 cents/kWh, 40 year lifetime, 85% load factor)	3. 01	4.65

- *Federal Incentives:* In the EPAct of 2005, three types of federal incentives were included for nuclear power production: Nuclear Production Tax Credit, Regulatory Risk Insurance, and Loan Guarantees. The Nuclear Production Tax Credit provides a 1.8 cents/kwh tax credit for up to 6,000 megawatts of new nuclear capacity for the first 8 years of operation, up to $125 million annually per 1,000 megawatts. Regulatory Risk Insurance, called "Standby Support," covers some of the costs of licensing delays. The first 2 new reactors that meet certain criteria will be reimbursed for all such costs, up to $500 million apiece, whereas each of the next 4 reactors will receive fifty percent reimbursement of up to $250 million. Loan Guarantees will cover up to eighty percent of a nuclear power plant's estimated cost (Parker and Holt 2007).
- *State and Local Incentives:* No incentives are found at state or local levels in Oregon, and voters approved an initiative in November 1980 to limit the licensing of new nuclear power plants. See details in Acceptability for Oregon section below.

Social Sustainability

- *Risk:* There are three major risks associated with nuclear power: nuclear radiation (which can cause deaths or serious harm to people), plutonium (an inevitable by-product of nuclear power production and the most toxic element known) and nuclear waste disposal (Rossin 2003).
- *Perception:* Many people were affected by events such as the Three Mile Island (U.S.) and Chernobyl disasters (Russia), and the general public's perception of nuclear power tends to be negative. Polls conducted before and after Chernobyl confirmed this point. 11,819 people in twelve European Economic Community (EEC) countries were asked if the risks associated with nuclear power stations are "worthwhile," "of no concern" or "unacceptable." Results changed from forty-three percent, seven percent, and thirty-eight percent in 1984 to twenty-nine percent, seven percent and fifty-six percent in 1986 after Chernobyl (Hodgson 1999).
- *Knowledge:* Apparently, the public became more aware of the risks of nuclear power after the Three Mile Island and Chernobyl disasters. But how much people know about the benefits of nuclear power is still in question, which to a great extent determines the acceptability of nuclear power in our society.

Acceptability for Oregon

Nuclear power production is not quite acceptable in Oregon mostly because in November 1980 Oregon voters approved an initiative, which limits the licensing of new nuclear power plants. Only with voter approval and a permanent repository may a new plant be licensed (State of Oregon 2008). Oregon Statute 469.595 and 469.597 describe the two, respectively (Statelawyers 2008).

> *469.595 - Condition to site certificate for nuclear-fueled thermal power plant*
>
> Before issuing a site certificate for a nuclear-fueled thermal power plant, the Energy Facility Siting Council must find that an adequate repository for the disposal of the high-level radioactive waste produced by the plant has been licensed to operate by the appropriate agency of the federal government. The repository must provide for the terminal disposition of such waste, with or without provision for retrieval for reprocessing.
>
> *469.597 - Election procedure; elector approval required*
>
> (1) Notwithstanding the provisions of ORS 469.370, if the Energy Facility Siting Council finds that the requirements of ORS 469.595 have been satisfied and proposes to issue a site certificate for a nuclear-fueled thermal power plant, the proposal shall be submitted to the electors of this state for their approval or rejection at the next available statewide general election. The procedures for submitting a proposal to the electors under this section shall conform, as nearly as possible to those for state measures, including but not limited to procedures for printing related material in the voters' pamphlet. (2) A site certificate for a nuclear-fueled thermal power plant shall not be issued until the electors of this state have approved the issuance of the certificate at an election held pursuant to subsection (1) of this section.

Marine Spatial Planning and
Lessons Learned in the Early Phase of Ocean Energy Development

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Summary

As a major shift in attention to alternative energy sources and modernized energy infrastructure unfolds around the world, marine and hydrokinetic energy prepares to take its place in the array of renewable energy options.

The Energy Act of 2007 defines marine and hydrokinetic energy:

> For purposes of this subtitle, the term ''marine and hydrokinetic renewable energy'' means electrical energy from—
> (1) waves, tides, and currents in oceans, estuaries, and tidal areas;
> (2) free flowing water in rivers, lakes, and streams;
> (3) free flowing water in man-made channels; and;
> (4) differentials in ocean temperature (ocean thermal energy conversion).

The term ''marine and hydrokinetic renewable energy'' does not include energy from any source that uses a dam, diversionary structure, or impoundment for electric power purposes.[i]

The two major institutions that collect data and track the development of marine and hydrokinetic renewable energy worldwide are the International Energy Agency and the United States Department of Energy (USDOE)[ii]. These sources indicate that twenty-eight countries now possess some form of ocean energy technology within their waters. These countries represent a wide variety of systems of government and law, including environmental and marine statutes and regulations. The database maintained by the USDOE indicates that currently MHE projects are in various stages of development from very early planning through commercial power stages.

Why are some technologies and projects more advanced than others? Is there a particular pattern or mixture of ingredients – of engineering, policy, governmental and public participation, and capital investment – that predict a shorter time horizon and success in proving these technologies? In advance of deployment, what are some early, key characteristics of emerging best practices for siting these technologies, including using new methods of marine spatial planning and public involvement?

Looking beyond existing ocean energy laws and regulations, this project seeks to point toward answers to these and related questions. It seeks out approaches from other ocean resource laws and regulations that may be applicable to ocean energy development in Oregon --these could be international, as well as regional and national examples related to other uses of the coastal ocean. Although many of the details are constantly changing, this work asks what are the best management practices within the US and internationally for permit streamlining and expedited roll-out of emerging energy technologies?

Table of Contents

Introduction and Rationale

The Challenges

Although some forms of hydrokinetic energy (such as tidal energy) have been around for a while, they are new to the United States. From 2000-2009, design, engineering, testing, and small scale deployment has taken place of tidal and in-river current devices (in the eastern U.S.) but also wave energy (along the U.S. west coast).

As with many new technologies, the challenges to development and commercialization are tremendous. The past decade has been a time when most attention and funding have been placed on design and engineering. At present, over a hundred device designs have been proposed for ocean energy. Over time and within each technology category, the numbers will narrow down to the most promising and efficient designs.

Meanwhile, an ocean energy developer in any nation courting ocean energy must jump through numerous hoops in order to get its technology permitted for testing, licensed, in the water, maintained, and monitored. Apart from seeking millions of dollars in funding for a single venture alone, among the most challenging issues for developers are mastering the laws and steps required in order to launch a test prototype through to completion as a commercial-ready product.

Most state and regional governments lack expertise in marine science and marine law, and lack personnel experienced in licensing novel devices to be placed in the ocean. Moreover, environmental impacts of ocean energy technologies are not understood; what little data exist are closely guarded as the device designs themselves, as confidential company property. However, by contrast, the oceans are public property and are managed by governments on behalf of all people, including future generations. There are already several layers of activities occurring on and in the oceans, including commercial and recreational fishing.

Citizens within and outside of coastal communities feel a strong attachment to the ocean and coast. Many express the desire to contribute to decision making alongside government representatives and other ocean users. In such a complex context, the key to success is proactive planning and the employment of strategies that include citizen and stakeholder engagement and visual planning aides such as geographical information systems and science (GIS).

Therefore, the problem that ocean energy (OE) represents has many facets: OE is expensive, its devices must be tested in a strenuous environment, at every phase OE touches on a long list of laws, regulators do not have many licensed and deployed examples to go by, the ocean has many other users including historically invested, traditional users and other energy extraction industries, the public has a right and a desire to be involved in decision making about the ocean and coast, and many of the nation’s marine waters are not yet mapped, in particular the twenty-two coastal state’s coastal waters (0-3 nautical miles) nm.

The Opportunities

Worldwide, concerns that include the end of cheap oil (labeled loosely as "peak oil"), greenhouse gas emissions (GHG) from burning fossil fuels, global climate change, and population growth are stimulating possibly an unprecedented amount of research and investment in alternative energy supplies, particularly renewable energy.

The Example of Oregon

Although each of the above concerns is significant and important, for an arguably sufficient single example let's examine population and electricity use and generation in the state of Oregon.

Fuel Sources for Electric Power[iii] Generation in Oregon in 2005 (trillion Btu)
Coal: 35.4 (8%); Natural Gas: 89.8 (20%); Petroleum: 1 (0%); Nuclear: 0 (0%); Hydroelectric: 309.5 (69%); Biomass, Geothermal, Solar, and Wind: 14.8 (3%).

Fuel Sources for Electric Power Generation in the United States in 2005
Coal: 20,736 (50%); Natural Gas: 6,935.8 (15%); Petroleum: 2469.1 (6%); Nuclear: 8,149.1 (20%); Hydroelectric: 2,670.1 (6%); Biomass, Geothermal, Solar, and Wind: 1,018 (2%).

Rationale for This Study

The population of Oregon in 2040 (only thirty-four years away) will have increased from that of 2006 by roughly 46%. How will current supplies of coal, natural gas, and hydropower keep up with electricity demand of an expanded population? The required solution will be multifold, including conservation and diversification of the overall energy supply. Oregon's waters have been characterized as featuring a wave climate that is attractive for extracting energy. Hydrokinetic energy can play an important role in helping meet present and future needs and in moving Oregon's electricity consumption away from nonrenewable sources, a goal formalized in Oregon's Renewable Portfolio Standard.[iv]

The next few decades will require a significant shift in our habits, scientific and technological knowledge base, our energy infrastructure, regulatory paradigms, and public involvement mechanisms. We would be wise to examine the emerging "best" practices that other nations and states have used, in order to devise an effective roadmap and strategy. Because energy is a requirement and not a luxury in the United States, the solution to meeting future needs is everyone's concern. Therefore, this brief report should be of interest to citizens, developers and industry advocates, government representatives, regulators, lawyers, stakeholders (such as fishermen), utilities, educators, students, and coastal communities.

Background

As of summer, 2009, the United States Department of Energy's Marine and Hydrokinetic Technology Database[v] indicates that twenty-eight countries have some form of ocean energy in development.

Among the most advanced projects, are there any patterns that contributed to deployment? Why are some technologies and projects more advanced than others? Is there a particular pattern or mixture of ingredients – of capital investment, national engineering capacity, policy, governmental and public participation – that predict a shorter time horizon and success in proving these technologies? In advance of deployment, what are some early, key characteristics of emerging best practices for siting these technologies, including using new methods of marine spatial planning and public involvement?

International Research and Development Context and Status

In any era, new technology of the size and scope of OE is impacted by risk and cost. During the early 2000s, there was a tremendous investment and media attention surrounding OE. During 2007-2008, the world economy entered recession and simultaneously fossil fuels hit record highs. As banks and investment firms were affected, much capital disappeared, including some previous commitments by government. Many economists expect markets to begin to recover at the end of 2009 or during 2010. Still, many projects are moving forward, more slowly than even before (in a world where projects normally move at a cautious pace).

During this lull, many activities related to marine spatial planning, public outreach, and citizen and stakeholder education and involvement, policy and decision-making are steadily moving forward in parallel with the technological design, engineering, and proving. Regarding the technology side, two major efforts by the IEA-OES and the USDOE yielded important resources that provide a snapshot of the status of OE today.

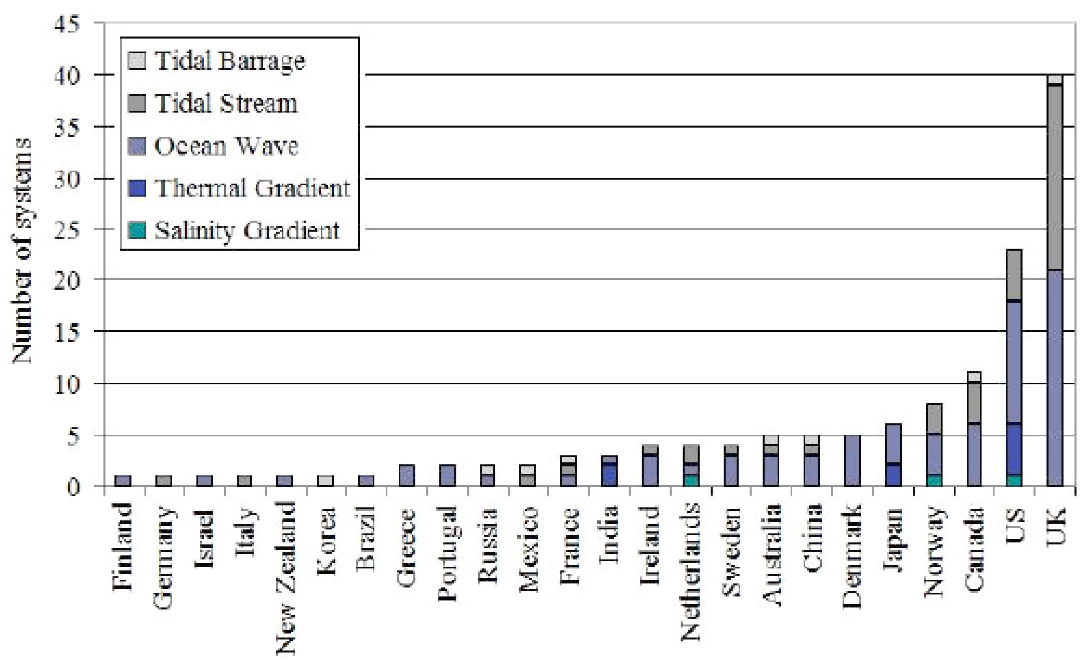

Figure 1 from *Ocean Energy: Global Technology Development Status*,[vi]

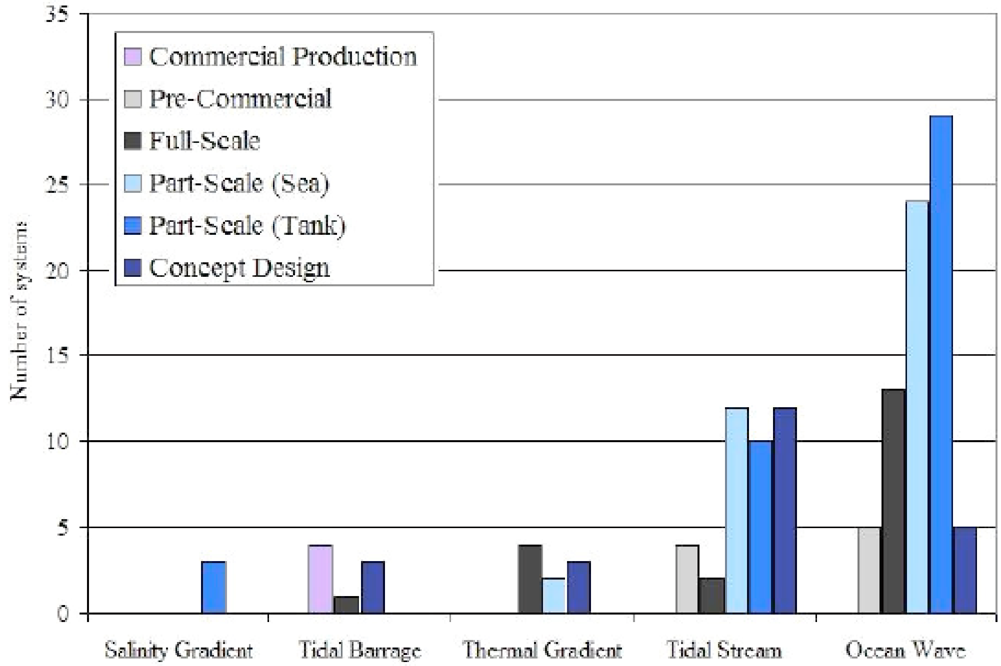

Figure 2 from *Ocean Energy*, HEK Technology Maturity as of March 2009.

For Figure 2, above, the explanation of the development stages is as follows:

Phase 1 is Siting or Planning,
Phase 2 is Site Development,
Phase 3 is Device Testing,
Phase 4 is Partial Deployment, and
Phase 5 is Full Deployment.

Full Deployment means that all devices are in the water, whether or not they are connected to the grid, but also refers to past pilots where devices were removed and remediation of the environment was undertaken or is in process.

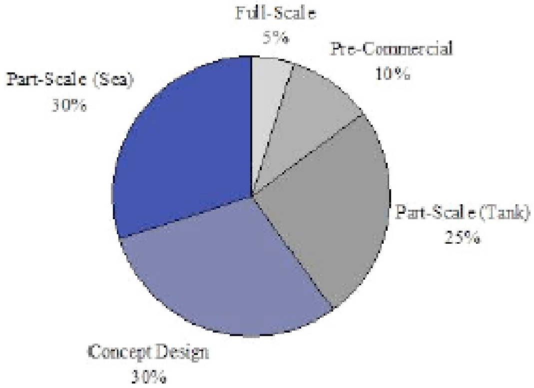

Figure 4.1: Percentage of tidal current systems in each maturity category

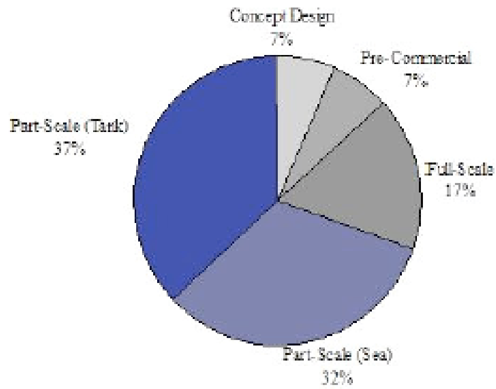

Figure 4.2: Percentage of wave energy systems in each maturity category

From *Ocean Energy*, March 2009.

The IEA-OES Report explains the status of development in 2009:

> The development of ocean energy systems is spread widely across a number of countries, with the United Kingdom and the United States each representing a substantial portion. The UK is leading the development effort, with a significant lead over the US in number of systems. Canada, Norway, Australia and Denmark also have a significant number of systems in development. Although only a limited number of systems are under development in Portugal, it should be noted that many more systems, including the Pelamis and the Archimedes Wave Swing, have undergone deployment and testing there. Overall, 25 countries (including Portugal and Denmark for the archipelagos of the Azores and the Faroe Islands, respectively) are participating in the development of ocean power.
>
> As shown in Figure 2, there are more wave systems than tidal current systems, and wave and tidal current systems significantly outnumber other system types. The large number of wave devices is likely due to two factors: Firstly, the potential resource available is much higher for wave than it is for tidal current. Secondly, there is a wide variety of different methods for extracting wave energy, whereas tidal current systems have mostly converged on a few different turbine designs. The number of tidal current systems is likely due to the simplicity of the

technology, which is very similar to the technologies and techniques used in wind power. Overall, wave energy and tidal current energy are the focus of current ocean power development efforts.

A large number of prototypes have been developed in the UK, with only a few amongst the other countries. However, systems at various stages of development are present in almost every country, demonstrating the wide distribution of technological progress.[vii]

In 2006, IEA-OES commissioned a sixty-page report from Energy Ireland to determine the status of technology development for OE with particular attention to individual countries' policies, support, and barriers that were helping or impeding the industry,[viii] and attempted to link policies with development trends where possible. The report, Review and Analysis of Ocean Energy Systems Development and Supporting Policies (hereafter Policy Report) set forth several key findings.

The Policy Report found that the policies that were in place fit three main categories:

1) "Research and innovation policies that help to develop emerging and improved technologies (eg government RD&D programs).

2) Market deployment policies that underwrite the cost of introducing technologies into the market to improve technical performance and to encourage development of an industry (eg market deployment support mechanisms).

3) Market-based energy policies that provide a competitive market framework, and may internalise externalities in terms of energy security, environmental protection and economic efficiency."

The Policy Report strongly recommended that governments create an energy policy that featured an integration of all three features or characteristics.

Predictably, government funding for research and innovation during 1974-2004 had an inverse relationship to trends in oil prices; in other words, when there was an oil "crisis," innovation investment flowed. When oil prices fell, innovation investment dried up. Notably, OE only received 0.3% of funding, the total of which was around 24 billion dollars (US) from 1974-2002. Arguably, although (as the report points out) OE could not compete with wind and other renewables, it is limited as a competitor because it is not proven, shown to be reliable, or shown to be a reasonable risk in proportion to cost. This is a circular dilemma that has obviously been made worse by the current recession. Particularly during an economic downturn, countries are apt to invest in technologies that are proven and cost-effective, with ready-to-deploy projects.

During this period, the clear leaders in investment were: The United States (53% of reported research and development funding), followed by 41% spent by the United Kingdom, Japan, Canada, and Norway.

Notably, the 2006 Policy Report mentions the new ocean energy strategy of the Irish government, overseeing one of the greatest European wave energy resources. More recent sources indicate a possible stalling with this investment, most likely due to the economic downturn.[ix] Hopefully, this interruption is only temporary.

The chart below, from the Policy Report, was presented in the report to help convey the findings for the second recommendation above (market deployment policies). This chart underscores the lack of similarity that OE has with other renewables in regard to support.

Figure 3.4. National policies that support the market deployment of ocean energy systems compared to other renewable support mechanisms

		Australia	Austria	Belgium	Canada	Denmark	France	Germany	Greece	Ireland	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden	United Kingdom	United States	Brazil	China	India	Mexico	South Africa	Finland
OCEAN ENERGY SYSTEMS	Capital Grants																x			x							
	3rd Party Finance																										
	Investment and Production Tax Credits							x													x						
	Obligations																			x						x	
	Tradable Certificates																			x							
	Guaranteed Prices/feedin tariffs							x									x			x							
	Regulatory and Administrative Rules																x			x							
OTHER RENEWABLES	Capital Grants	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x		x				x
	3rd Party Finance			x	x		x	x					x	x				x			x	x					x
	Investment and Production Tax Credits			x	x		x	x		x			x	x			x	x	x		x				x		x
	Obligations	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x		x	x	x	x			x	x
	Tradable Certificates	x		x							x		x	x		x			x	x		x					
	Guaranteed Prices/feedin tariffs		x		x	x	x	x	x	x	x		x	x			x	x	x		x	x	x				
	Regulatory and Administrative Rules	x	x	x		x	x	x	x	x	x		x		x	x	x	x	x				x		x		x

X – Denotes policy instrument set up in country.

The Report provides a significant amount of detail on these types of support. A highlight is seen in the United Kingdom's Marine Renewables Deployment Fund which was set up to confer up to GBP 50 million that was intended to fill the gap in investment between the R&D stage and the ultimate commercial phase. The scheme appears intended to enhance testing, deployment, data capture, performance measures, and environmental assessment in a way that allows cross-comparison of all technologies in a consistent manner.[x] Other reports have frequently commented that lack of electrical power infrastructure (grid connectivity) is a real barrier to ocean energy in many locations. Notably, the UK's Marine Renewables Deployment Fund makes eligible applications to fund grid connection.

Many readers are already familiar with the Energy Policy Act of 2005 (or EPAct) and other American incentives, so they will not be covered here.

The policies that support deployment (such as streamlining permits or leases, or making environmental standards temporarily less harsh) are termed "consenting procedures or exemptions" in the Policy Report, which describes countries' efforts in this, the third category of recommended support (refer back to page 12 herein). The Report's coverage of this subject is extremely brief, and the note on United States procedures is now out of date. Despite this, the

Policy Report states that "regulatory and administrative policies can accelerate the rate of technology deployment by streamlining consenting arrangements, clearly instructing developers how to secure permits for demonstration projects, and enabling information to be gathered to improve understanding (eg on environmental impacts)…"

Next, the Report outlines four other types of support for OE.

1) R&D support services and facilities provide practical support in the form of design facilities, and laboratories for simulated testing of models and prototypes. Here, the Report mentions such facilities in Korea, Portugal, Canada, and various public university partnerships, such as SUPERGEN. Oregon State University would fall under this category.

2) Ocean testing facilities provide grid-connected sites to enable demonstration at sea. This includes EMEC, and the eventual facility in Newport, Oregon: the Northwest National Marine Renewable Energy Center.[xi]

3) Professional services provide expert and specialist consultancy based upon experience in areas such as hydrodynamics, composites, engineering, power electronics and marine structures.

4) Other supporting organisations may perform a range of non-technical support (ie not directly involving the development of a technology). Under this heading fall the Coordinated Action on Ocean Energy (CA-OE) and IEA-OES itself.

The Policy Report saw (in 2006) the main barriers to OE in terms of:

- Insufficient demonstration of full-scale prototypes of the technologies
- Demonstration of multiple full-scale prototypes in a pre-commercial farm for years, not months, because what would be learned would directly improve design and function and enhance investor confidence
- Cost of grid connection demonstration systems because of the distance from shore and from populated areas apt to have sufficient grid capability
- Lack of understanding of environmental impacts
- Lack of understanding of the ocean energy resource (uncertainty, inefficiency)
- Ability to accurately predict energy production performance, metrics, and design tools
- Absence of standards ("internationally recognized metrics or standards for development, testing, and measurement…standards must be valid across technologies and independent of test sites")

In order to overcome inertia, OE technologies would benefit from all of the recommendations listed in the IEA Policy Report. One other report, released in August 2008, makes additional recommendations. The report is the Status of Wave and Tidal Power Technologies for the United States, by Walter Musial of the National Renewable Energy Laboratory (NREL). A relevant excerpt of the report is provided in Appendix A.

The NREL report is specific only to perceived barriers to OE in the United States. Many of these will be addressed in the short term under the resolution of jurisdiction between the

Minerals Management Service and the Federal Energy Regulatory Commission, and the new testing centers for the east and west coasts funded by the USDOE. The regulatory maze has been made more tractable by a plethora of private enterprises emerging that serve as the "one stop" shop for which some developers had expressed a desire.

Results and Discussion

A startling omission in both reports is the lack of any reference to planning or to public process whatsoever, as if OE would just be a simple negotiation between an industry entrepreneur and a government representative.

The process as it has unfolded so far has often indicated a severe lack of understanding of the ocean, the law, and the ancient place the oceans hold in the law. There are signs of a persistent ignorance of process or respect for process, consultation and collaboration. There are around nineteen federal laws and nine federal agencies overseeing their application, and that have legal responsibilities in, on or over the ocean. In addition, each of the twenty-two U.S. coastal states has management responsibilities in state waters (0-3 nm). Federal responsibilities are not mere trivialities. They include those of the United States Navy, Coast Guard, and National Oceanic and Atmospheric Administration (and National Marine Fisheries Service). The government is the steward of the oceans on behalf of ordinary citizens: coastal communities, and fishermen all have rights in the ocean and in marine resources generally.

As a vehicle for both planning and process, the contemporary state of the art in tool in ocean management that perfectly accommodates energy (or any new use) is marine spatial planning, with the use of Geographic Information Systems and Science (GIS).

There are over two-dozen literature sources known to date on the topic of marine spatial planning,[xii] with several currently in press. Over the past decade, the concept has been known (as it continues to be) by different names. Ocean zoning and place-based management are two common names. UNESCO attributes the origin of the term "marine spatial planning" (or MSP) to the team that led the effort to create the Great Barrier Reef Marine Park.

UNESCO produced a report[xiii] on the topic (Visions for Sea Change, 2006) following a workshop. The purposes of the workshop were to:

- Identify best practices;
- Develop an international community of scientists and planners;
- Share information and experience;
- Forge new partnerships, and;
- Identify priorities for future action.

The UNESCO report rests on the assumption that ocean space is a valuable but increasingly over-used resource that is poorly managed in most places. The UNESCO authors sought to transition the models that brought about poor management to a contemporary ecosystem-based management approach. UNESCO defines this new approach as one that comprehensively manages human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity" (citing Helcom-Ospar, 2003).

Justification to the public is achievable because the ocean is their resource. A public that has been involved early on in a meaningful way will be informed and educated about the need for coastal mapping and planning. Here, "meaningful" means more than on an "ad hoc" basis.[xiv] As pointed out by UNESCO in 2006 and St. Martin and Hall-Arber in 2008, the "community" is the "missing layer" of GIS because it is so often consulted prior to an environmental impact, for the sole reason of checking it off the to-do list of a task-oriented agency working on an individual project. The authors state:

> Impact analyses…do not represent a comprehensive integration of the social landscape of the marine environment into a planning process. They may, importantly, demonstrate community linkages to offshore areas but they do so only relative to the development or management plan in question. MSP will require a comprehensive mapping of the social landscape comparable to that being developed for the biophysical landscape. *While both are important tools for impact analyses, they are essential layers of information for MSP*. (St. Martin & Hall-Arber, 2008, emphasis added)

Recommendations / Considerations

In general, in the United States and around the world, capacity must be built in every aspect of OE from engineering, environmental science and monitoring and management, law and policy—and particularly in developing professional capacity. This will occur in tandem with deployment. At this time, the only thing that can aid deployment is greater capital flow, provided not just by the private sector but especially by government as the IEA-OES Policy Report and others have recommended. This will also ensure that the greater body of science of OE is advanced and that environmental data remain public and accessible as a foundational resource from which to improve OE. However, while all of these things can help assure success, the main thing that must be achieved is sound planning that includes mapping. The relationships between data sets and maps are accomplished by slow, patient, and usually hidden work by dedicated people, without fanfare. The maps produced are critical for purposes beyond energy siting—purposes that include emergency preparedness, habitat conservation, and planning for sea level rise. The adage that those who fail to plan, plan to fail, is especially true in demanding, harsh environmental systems that we poorly comprehend. Money and time spent on planning and mapping ahead of the introduction of new uses will save billions of dollars over the long term.

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Available from United States Department of Energy – Energy Efficiency and Renewable Energy, EERE State Activities and Partnerships, at http://apps1.eere.energy.gov/states/electricity.cfm/state

Oregon's goal is to have 20% of its energy come from renewable sources by 2025. 74th OREGON LEGISLATIVE ASSEMBLY--2007 Regular Session, Senate Bill 838, available at Oregon Department of Energy website http://www.oregon.gov/ENERGY/RENEW/RPS_home.shtml.

Supra, note 2.
http://www.ferc.gov and scroll down to Hydrokinetic Energy Technologies link.

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Portions of this manuscript are taken from Campbell, *Scoping the New Horizon: Using Geographic Information Systems and Science to Foster Public Involvement in MarineSpatial Planning and Ocean Energy Siting*, in revision for publication 2009

Appendix 1

Excerpt from *Walter Musial, Status of Wave and Tidal Power Technologies for the United States, National Renewable Energy Laboratory (NREL) , Technical Report NREL/TP-500-43240, August 2008 Regulatory and Environmental (page 6)*:

In general, marine energy systems will have to be at a higher state of maturity than wind energy systems in the early stages of development in the early 1980's, because siting will take place on public waterways and oceans where there will be a higher level of scrutiny over design function and performance, and a lower tolerance for failures. Any developer today could attest to the costly and timely process that is currently imposed upon the deployment of full-scale prototypes. This is largely due to deeply entrenched regulatory paradigms from the conventional hydro-electric industry, which were designed to limit or deter construction of new dams and impoundments but are now hindering the development of new clean energy technologies. Resource and regulatory agencies would cite the high degree of uncertainty associated with these technologies and, in particular, the potential cumulative impacts. However, imposing high-cost barriers to prototype deployments only discourages further deployment and prevents us from assessing the actual risk associated with the technologies. All would agree that actual field data is needed to evaluate the real environmental impacts and develop a balanced regulatory framework. Before an informed and balanced strategy can be developed, detailed monitoring of the first installations by third party evaluators must be conducted with the goal of assessing the ecological risk associated with each technology-type and to help establish mitigation strategies.
When new scientific findings become available, regulators must be flexible enough to adapt their rules. Technology developers do not have additional resources or objectivity to embark on such monitoring campaigns, to make the uniform judgments about what should be measured, or to make the necessary interpretations of the data. Field data collection should be encouraged and supported through strong government leadership. Several countries in Europe have already established monitoring protocols for prototype deployments, and through our international collaborations, some of the uncertainty can be reduced quickly. Experience from wind energy has taught us that seemingly small environmental consequences that are ignored during the early stages of development can lead to unfounded long-term negative public perceptions that are more difficult to dismiss if they are not addressed proactively. A good example is noise. Wind turbines are quiet compared to other common machinery, but because some early wind machines were loud, many people still perceive wind turbines to be obnoxious noise makers.

From Conclusion (page 8):
In the past decade, new technologies have been introduced to harness the energy of the oceans waves, currents, and tides. Nearly 100 companies worldwide have joined this effort but most companies struggle to deploy their first prototypes and not all can be funded from the public sector. A viable strategy to help mature the marine renewable

energy industry is needed. One approach is to characterize technology status, performance, limits, and cost, and to develop and validate design tools and standards to facilitate a fair and equitable means for funding the most promising technologies. Performance, cost, and reliability metrics should be established to guide the process. New ocean testing facilities should be developed to facilitate rapid prototype deployment and testing. Finally, international cooperation can accelerate the development and to achieve the critical deployment capacity needed to bridge the gap from prototype to commercial maturity. Marine energy resources have global significance and should be developed as part of a diverse clean energy portfolio that will be necessary to reach expected future carbon reduction targets. No single energy source will be able to achieve these reductions independently, and these resources can make a significant contribution. [end of NREL Excerpt]

Understanding Organized Interests Groups and Their Preferences toward Wave Energy

John Stevenson and Zack Covell
Oregon State University, 2009

Summary

Since 2006, Oregon has promoted the development of wave energy off its coast. The state appears to be well suited for the technology because of an abundant wave resource and supporting coastal infrastructure. However, there remain potential barriers to implementing this policy including, but not limited to, uncertainties about the technology and concerns for impacts to the local environment and existing ocean users.

Among many studies commissioned to help the industry proceed in a responsible manner, this research project builds on other studies included in the OSU Human Dimension of Wave Energy Research Program. This study provides a more complete understanding of the social and political context by focusing specifically on Oregon's "organized interest groups" who are in a position to influence state decision-making but may not be engaged in wave energy development at this time.

Key findings from this study indicate that organized interest groups generally have a low familiarity with wave energy development yet they tend to be supportive of the industry at this time. If the energy industry or others wish to increase the knowledge about the technology among these organized interest groups, this study provides information that suggests targeting their primary information sources: the Internet and local media (newspapers and radio). The results of this study also suggest that building on scientific credibility and continuing to fund research aimed at moving the industry forward in a responsible manner could be beneficial in building support among Oregon's organized interest groups.

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Introduction

In 2006, Oregon's governor advocated developing renewable energy to combat global warming and stimulate the state's economy with green jobs. In the following year, the state legislature passed the Oregon Renewable Portfolio Standard (RPS) that required electricity providers to supply 25% of state's electricity from renewable resources by the year 2025. Included in this 2007 – 2009 package was a suite of tax incentives and funding for research and development of emerging technologies. The wave energy industry benefited from this policy in particular with just over $4 million to fund the Oregon Wave Energy Trust (OWET) for the purpose of promoting the technology's development off Oregon's Coast. Technical assessments indicate that the coast of Oregon is well suited for the technology because of the abundant wave resource and supporting coastal infrastructure to transmit the electricity to coastal populations.

However, the wave energy industry is only in its infancy and some 20 years behind wind technology, which is considered the most market competitive of the renewable energy resources. Major technical considerations for wave energy development include its ability to withstand a harsh ocean environment and efficiency for extracting energy from the resource, both of which are considered key to its economic success. Other considerations include impacts that the technology may have on the surrounding marine environment including concerns for migratory grey whales, and changes to sediment transport in near-shore coastal processes.

Social, economic, and political concerns have also been raised. Concerns have been voiced about the loss of commercial and recreational fishing grounds and other recreational activities including surfing and kayaking. The legal framework managing wave energy has also complicated efforts to develop the resource. When this study began in late 2007, an on going federal jurisdictional dispute – between the U.S. Federal Energy Regulatory Commission (FERC) and the U.S. Minerals Management Service (MMS) – about who would regulate wave energy loomed over this developing industry and created uncertainty about permitting and licensing processes for developers, state resource agencies and public stakeholders. This overlaid Oregon's own coastal management frameworks, which are currently undergoing modification to identify appropriate areas for wave energy development in its Territorial Sea Plan (TSP). Cumulatively, these factors may have influences the degree of support or opposition among policy stakeholders and the public. This, in turn, could have an effect on the state's efforts to foster wave energy development and the RPS implementation more generally.

Among many studies commissioned to help the industry proceed in a responsible manner, this research project builds on other studies included in the OSU Human Dimension of Wave Energy Research Program. This study provides a more complete understanding of the social and political context by focusing specifically on Oregon's "organized interest groups" who are in a position to influence state decision-making but may not be engaged in wave energy development at this time. By understanding these groups' perceptions of wave energy, information sources, and strategies for influencing decision-making, this study can provide information helpful in the development of communication strategies and efforts to build support among these groups to help the industry move forward.

Background and Purpose of this Study

This study provides a characterization of attitudes about wave energy development among organized interest groups in Oregon; groups who may be in a position to influence state political decision-making but may or may not be engaged in the issue at this time. In particular, this study answers the following research questions:

1. How is wave energy perceived by organized interest groups, including what do they know about it and what is their position?
2. Where do organized interest groups get their information?
3. What role is science playing in organized interest group decision-making?
4. What types of strategies are being used to promote interest group preferences?

In answering these questions, this study provides a more complete understanding about perceptions of wave energy development in Oregon. This study builds on the work done in other parts of the OSU Human Dimensions of Wave Energy Research Program. For example, it builds upon Stevenson's stakeholder analysis and Stefanovich's survey of Oregon households. Specifically, Stevenson's stakeholder analysis focused narrowly on the specific "policy actors" involved with wave energy development at the time of these studies; whereas Stefanovich looked more broadly at public opinion across all of Oregon. Using this information, the Oregon Wave Energy Trust could develop a more effective strategy for engaging the state's interest groups – and their members – as it attempts to facilitate the responsible development of wave energy in the ocean off Oregon's coast.

Methods

This study used two primary research techniques: in-person ethnographic interviews and mail surveys. From September through December 2008 fifteen interviews were conducted with representatives from the following five categories of organized interest groups:

- Energy Industry (developers and utilities)
- Workforce (unions, workers, management)
- Environmental / Conservation
- Commercial Fishing, and
- Recreational Users.

With the help of these interview informants a larger sample was generated for the survey. Surveys were sent to individuals / members falling within one or more of the categorized organized interest groups listed above.

In total 289 surveys were mailed out in May 2009 (with a second mailing in June). Seven surveys were returned with a refusal to participate. A total of 108 surveys were completed, yielding a 36.2 percent response rate.

Key Findings

How is wave energy perceived by organized interest groups?

Familiarity and Support:

Responses to the mail survey indicate that organized interest groups have a low familiarity with wave energy compared to other renewable technologies. When asked to rate their familiarity with renewable technologies, using a four point scale with 1 ‘not familiar’ and 4 ‘very familiar’, respondents had the highest familiarity with wind (79%); wave energy came in third (45%). See Figure 1.

When we break this out by organized interest group individually, respondents from the commercial fishing interest group category and the energy industry interest group category (60% respectively) indicated they had a high degree of familiarity with wave energy. Fewer respondents from the workforce interest group category (44%), environmental / conservation interest group category (43%), and the recreational users interest group category (42%) had a high familiarity with wave energy. See Figure 2.

The survey also indicates a general degree of support for developing wave energy in the ocean along the Oregon coast. Survey data suggests a degree of support for wave energy development, followed by a sentiment of neutrality, and a small minority of respondents who are unsupportive of wave energy development (see Figure 3). Support was greatest among those respondents within the energy industry and recreational users interest group categories, and, to a lesser degree, the environmental / conservation interest group category. This is similar to what Stevenson found in his stakeholder analysis, which indicated that those policy actors within environmental groups were generally in support of developing renewable energy; although they were more divided on wave energy (on that study) because of concerns for potential impacts to the local environment.

Respondents from the commercial fishing organized interest group category were more divided; 35% agreeing that wave energy should be developed, 27% disagreeing and 38% indicating that they were neutral. The divide among this group is likely a result of concern for loss of fishing grounds.

Lastly, respondents from the workforce organized interest group category indicated that they were neutral on the topic (67% of responses), while another 33% indicate support. This neutrality of respondents from the workforce organized interest group category may be partially explained in the interview data. For example, one interview informant noted that their colleagues were excited about possible jobs in the near-term for making wave energy installations, but that they were also interested in what kind of jobs the industry would have in the future for their children (although this is difficult to evaluate at this stage in the industry’s development).

Where do organized interest groups get their information?

When asked about particular sources of information used to learn about wave energy development, organized interest group respondents indicated they most frequently used the Internet, followed by local newspapers, environmental groups, Oregon Public Radio, and the Oregonian newspaper (see Figure 4). Conversely, the least frequently-used sources of information were legal entities, state/local/federal government, electric utilities, fishing groups, and television.

These survey results are similar to what was found during interviews. For example, in the absence of resources to hire legal consultants, some members of organized interest groups rely on the Internet:

> *We can't afford a team of lawyers or consultants, so we spend a lot of time doing research and reading articles on the Internet* - Commercial fishing organized interest group member

Similarly, information found on the Internet is then used and circulated to colleagues:

> *I set up my auto-task filter reader to filter stories to my relevance and issue and by [news]paper in Oregon. [Then] I'll circulate that around and give people tidbits of what's in the news in Oregon* – Environmental / conservation organized interest group member

What role is science playing in organized interest group decision-making?

Results from survey data indicate a general role for science in decision-making for organized interest groups. Respondents from all categories of organized interest groups more frequently agreed (than disagreed) with the statement: 'science is the best method understanding the natural world' (see Figure 5). This was most pronounced among those respondents within the energy industry organized interest group category (100% agreed with the statement); followed by the environmental / conservation organized interest group category (92%) and the recreational users organized interest group category (92%). Sixty-five percent of respondents from the commercial fishing organized interest group category agreed with the statement, while 23% disagreed. Respondents from the workforce organized interest group category were also in agreement with the statement 56% of the time, while the other 44% were neutral.

The mail survey also presented participants with the statement: 'scientists look for data which supports their own personal values.' Respondents gave a more mixed response to this question (see Figure 6). The greatest agreement with this statement came from those respondents from the commercial fishing organized interest group category (68%), followed by those from the workforce (67%) and recreational (62%) organized interest group categories. However 31% of those responding from the recreational users organized interest group category disagreed with the statement, as did 40% of energy industry and 43% of the environmental / conservation organized interest group categories.

Overall the data indicates some cynicism for scientists. However, there appears to be overall agreement that science is the best way to provide information about the natural environment.

What types of activities/strategies are being used to promote organized interest group preferences?

Lastly, members from organized interest group categories were asked to rate how frequently they used a particular strategy to communicate their policy preferences. These are presented in Figures 7 - 8. Overall, the most common strategies among all groups were presenting information to elected officials and presenting information to government agency managers (Figure 7). These venues were followed by communicating via the Internet, participation in professional and local meetings, and at public hearings (Figure 8). The least common strategies for communicating policy preferences were through expert testimonies, radio and T.V., and field trips. Looking at activities by group, energy developers and environmental groups were most likely to use any of these strategies, but especially in targeting elected officials and agency managers, meetings and hearings, and using the Internet.

Recommendations

Increase Wave Energy Awareness

There is general support for wave energy in Oregon among organized interest groups, yet they are comparatively unfamiliar with wave energy technologies. This is most pronounced among the workforce, recreational users, and environmental / conservation organized interest group categories. Efforts could be made to engage members of these organized interest groups using the Internet and local media including newspapers and public radio.

Key messages could include information about the state of the technology, its potential for clean electricity generation, and the economic stimulus that could result – not only in the short-term but also over a longer time-horizon -- once these projects have been deployed.

Continued Investment in Scientific Studies

Continued investment in scientific studies may yield social and political benefit. As part of its effort to increase awareness of wave energy technologies among Oregon's interest groups, OWET could build on the credibility of scientific research to provide that information. This is particularly important for members of environmental / conservation organized interest groups who favor renewable energy generation to confront global climate change, but are concerned about what kind of local environmental footprints these projects will have.

By investing in continued scientific research OWET could have additional information to help familiarize Oregon's organized interest groups with wave energy generation and to strengthen the perception that development is moving forward in a responsible manner.

Build Long-term Support

This study builds upon the lessons learned from Stevenson's policy actor stakeholder analysis and Stefanovich's public perception analysis. All indicate that there is evidence that the wave energy industry is young and that the social and political context surrounding it has yet to fully develop. The disadvantage of these findings is that there are a number of political players that may not have yet developed positions for or against wave energy development and could eventually become opponents of the industry. The promising news is that early evidence suggests most organized interest groups are supportive of the industry at this point in time, even if they do not know very much about it.

Looking forward, the industry could build on the above recommendations to foster continued support. However, findings in this study also suggest that there are some organized interest groups that are less supportive of the industry, most notably members of organized commercial fishing interest groups. As suggested earlier, Stevenson's stakeholder analysis indicates that this may be a result of conflict over fishing grounds and to date stands as the most visible example of opposition to the wave energy development. It will be important to address these concerns in order to maintain the perception that the industry is moving forward in a responsible manner.

Figure 1.

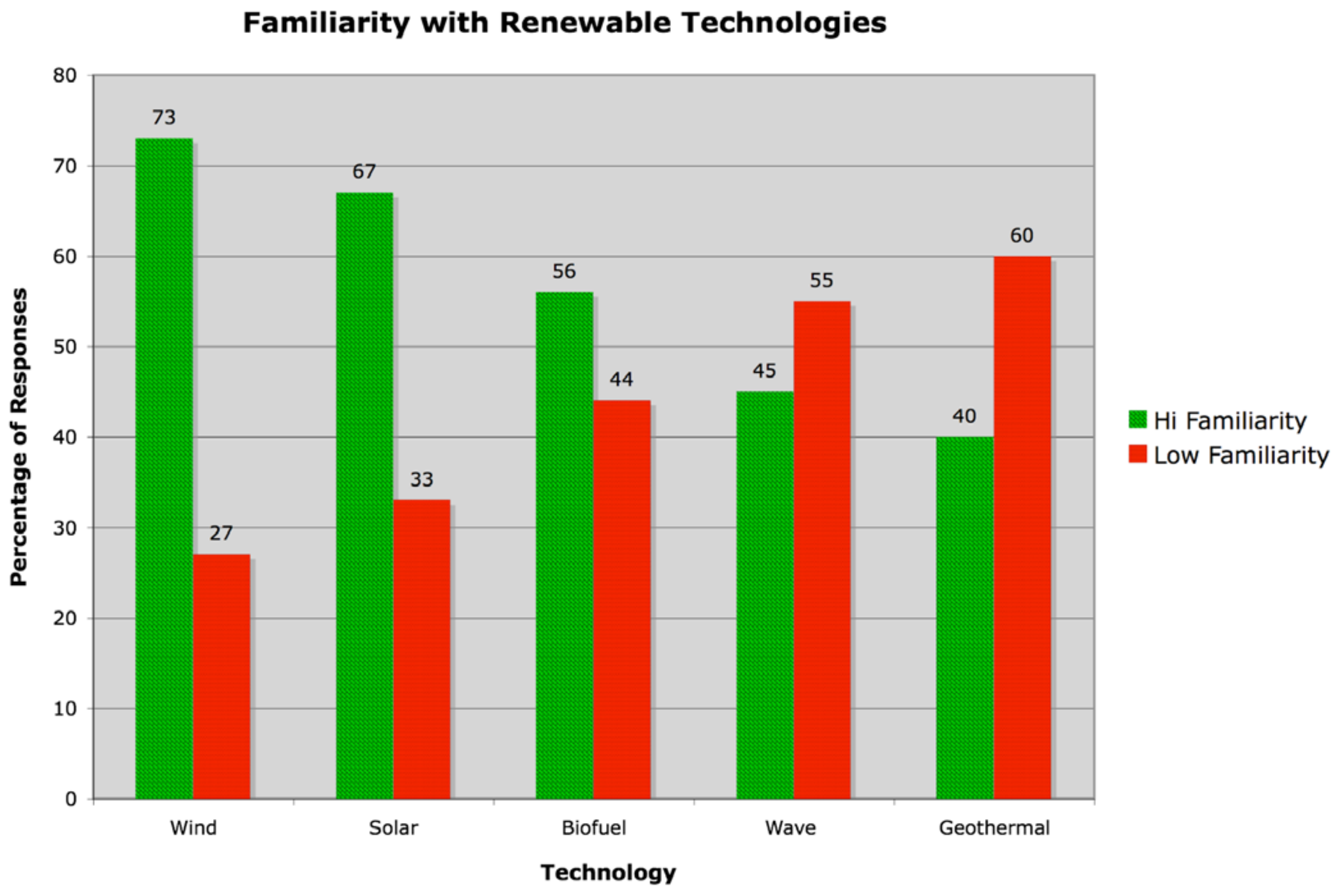
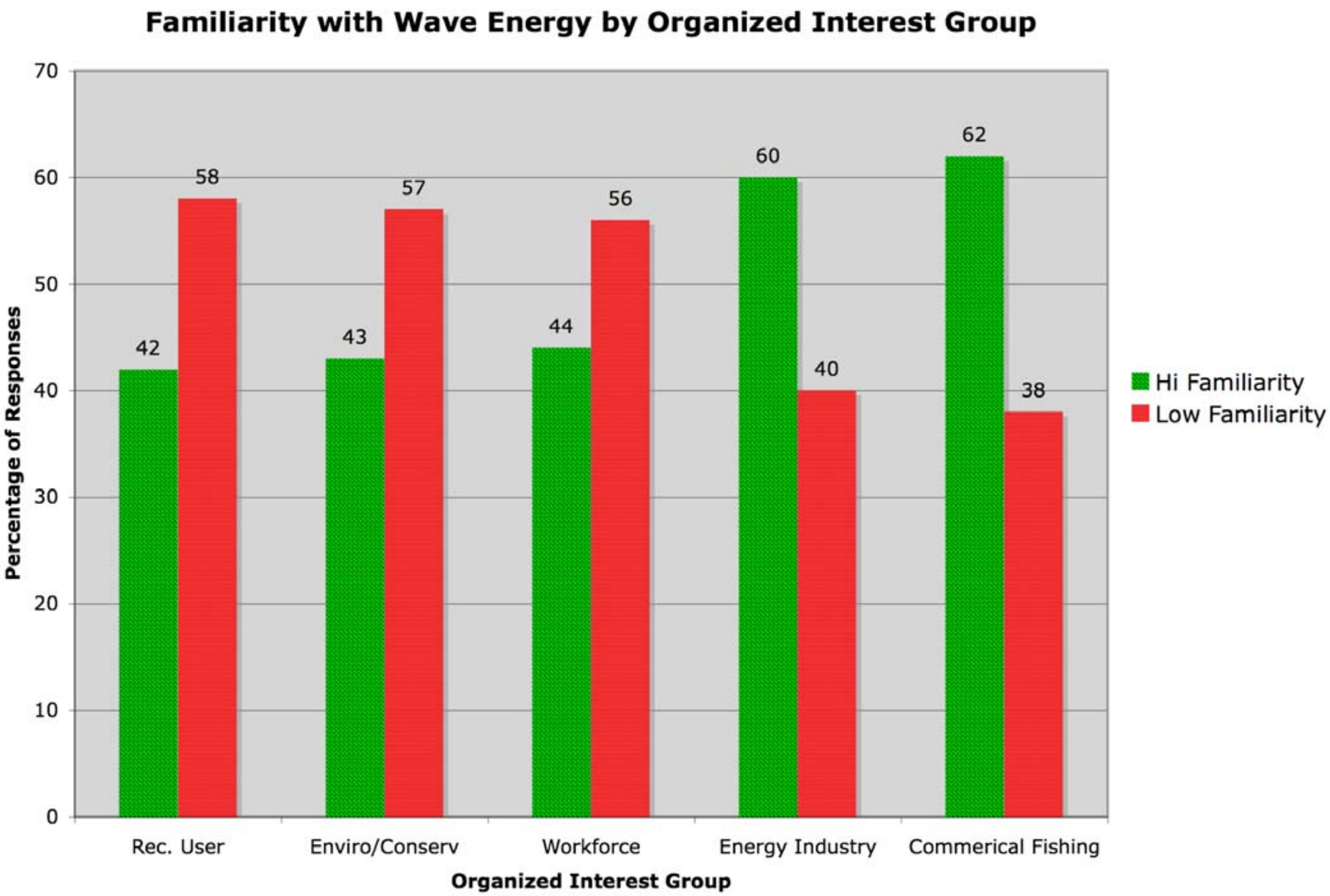
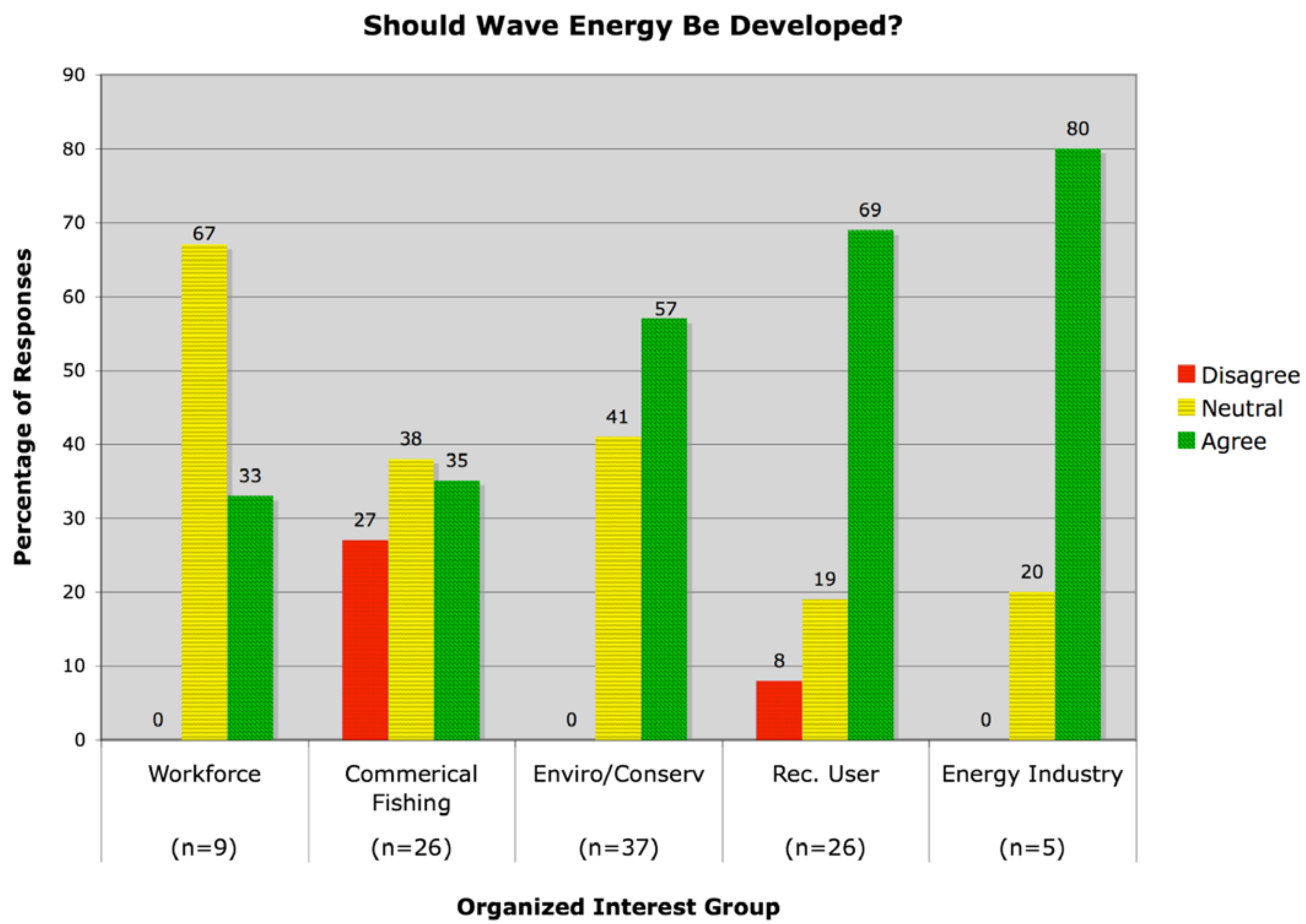

Familiarity with Renewable Technologies
Percentage of Responses
80
70
60
50
40
30
20
10
0
73
27
67
33
56
44
45
55
40
60
Wind
Solar
Biofuel
Wave
Geothermal
Technology
Hi Familiarity
Low Familiarity

Figure 2.



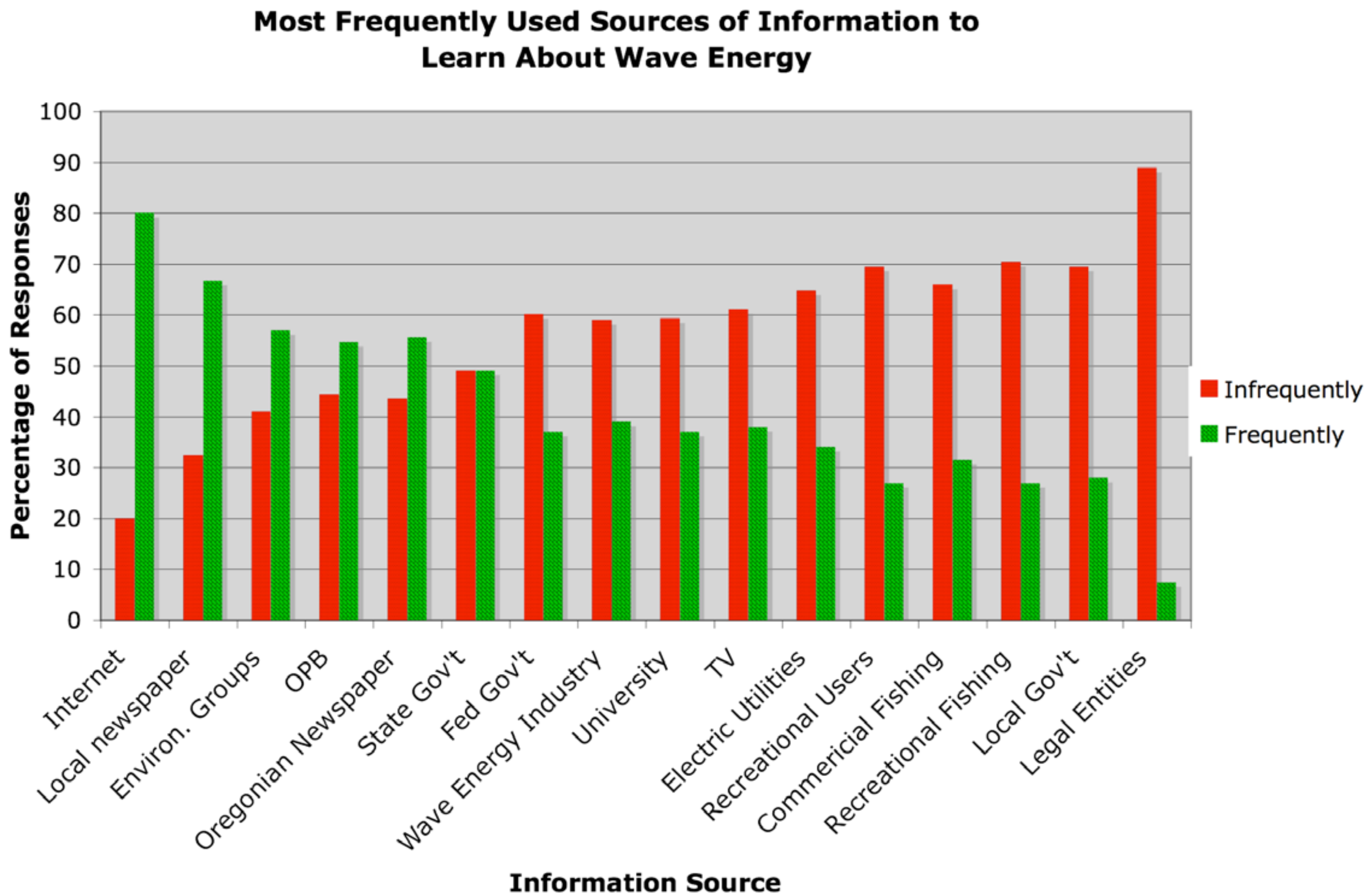
Familiarity with Wave Energy by Organized Interest Group
Percentage of Responses
70
60
50
40
30
20
10
0
42
58
43
57
44
56
60
40
62
38
Rec. User
Enviro/Conserv
Workforce
Energy Industry
Commerical Fishing
Organized Interest Group
Hi Familiarity
Low Familiarity

Figure 3.



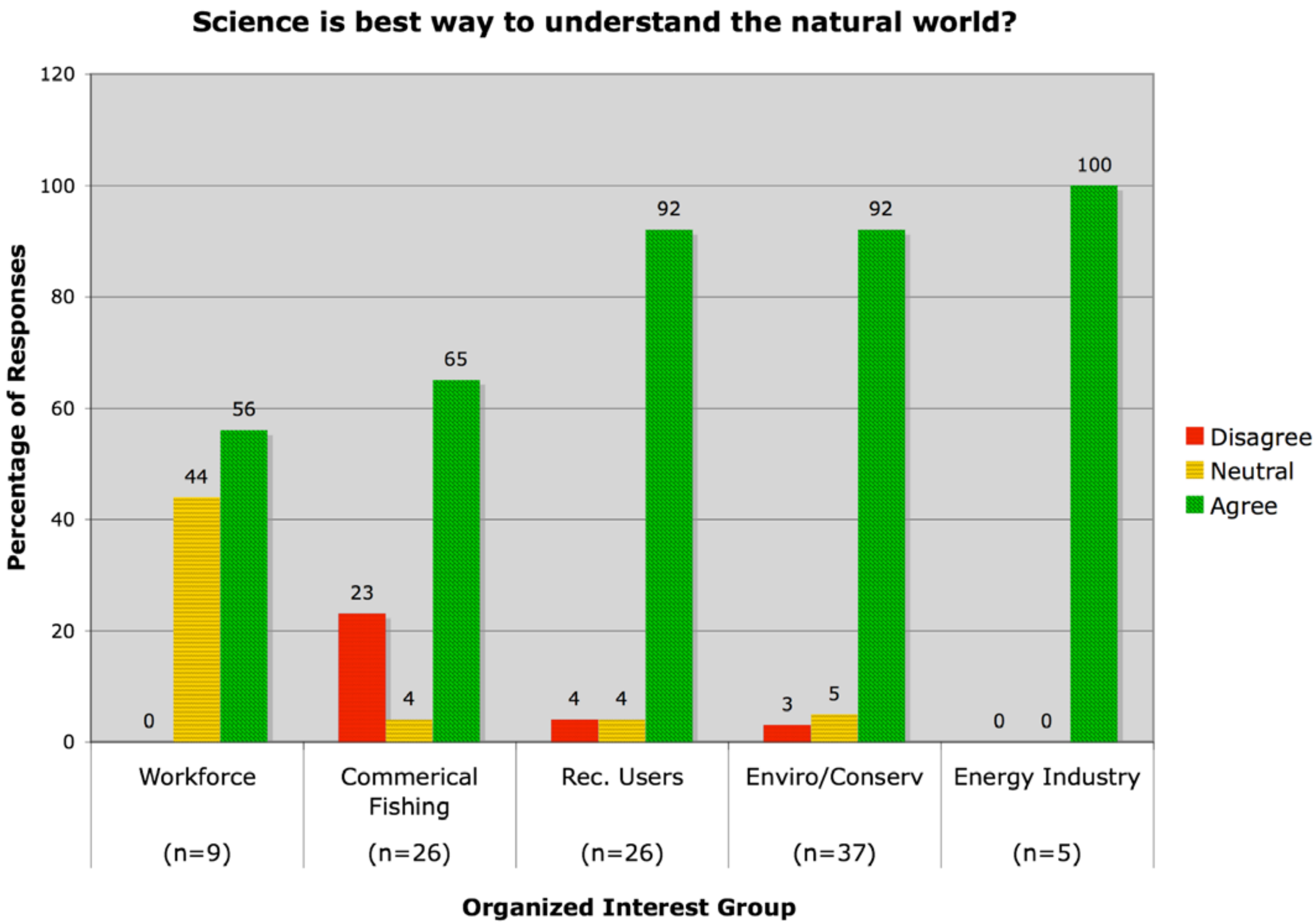
Should Wave Energy Be Developed?
Percentage of Responses
90
80
70
60
50
40
30
20
10
0
67
33
27
38
35
41
57
8
19
69
20
80
Workforce
(n=9)
Commerical Fishing
(n=26)
Enviro/Conserv
(n=37)
Rec. User
(n=26)
Energy Industry
(n=5)
Organized Interest Group
Disagree
Neutral
Agree

Figure 4.



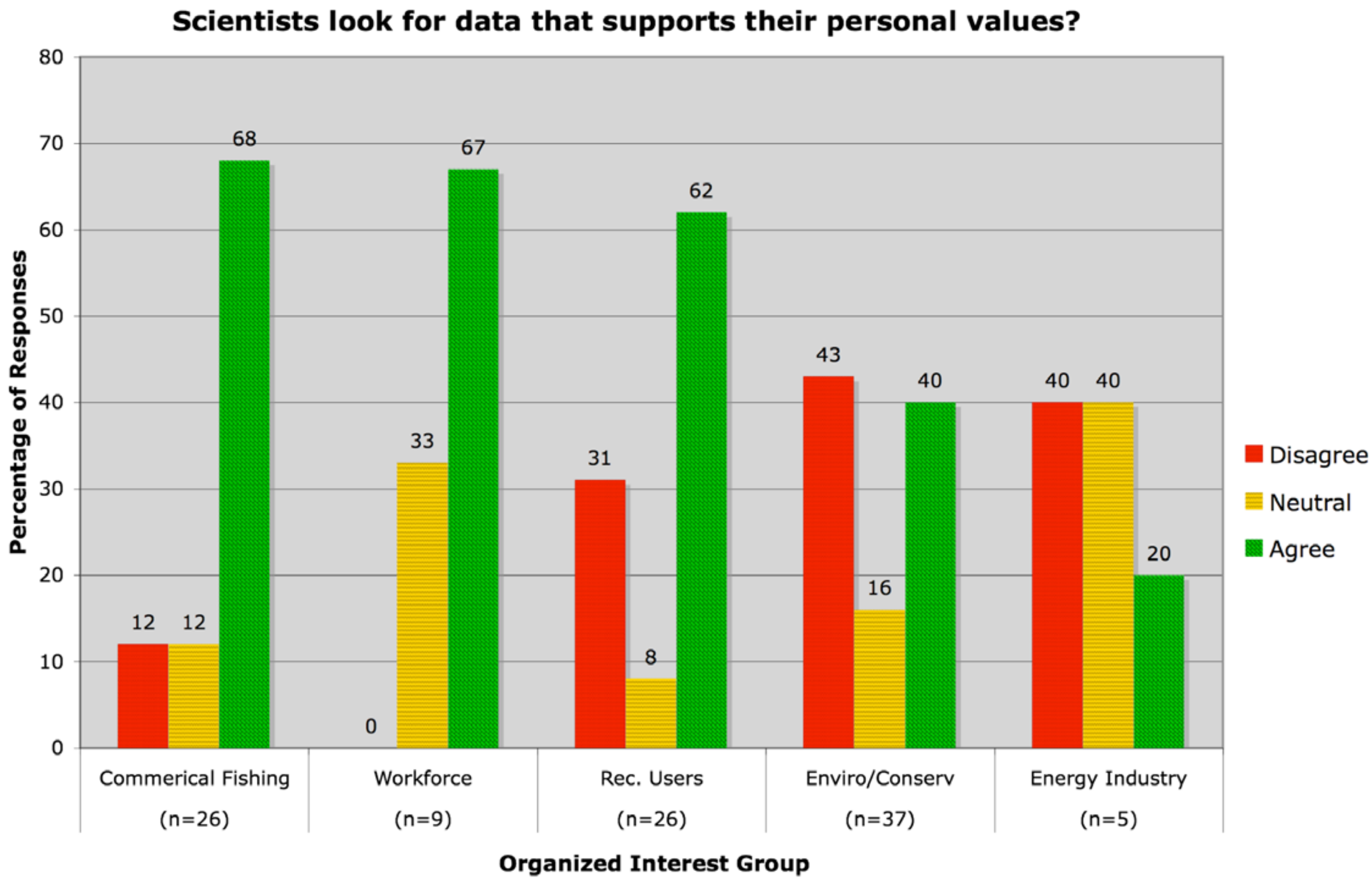
Most Frequently Used Sources of Information to Learn About Wave Energy
Percentage of Responses
100
90
80
70
60
50
40
30
20
10
0
Internet
Local newspaper
Environ. Groups
OPB
Oregonian Newspaper
State Gov't
Fed Gov't
Wave Energy Industry
University
TV
Electric Utilities
Recreational Users
Commericial Fishing
Recreational Fishing
Local Gov't
Legal Entities
Information Source
Infrequently
Frequently

Figure 5.



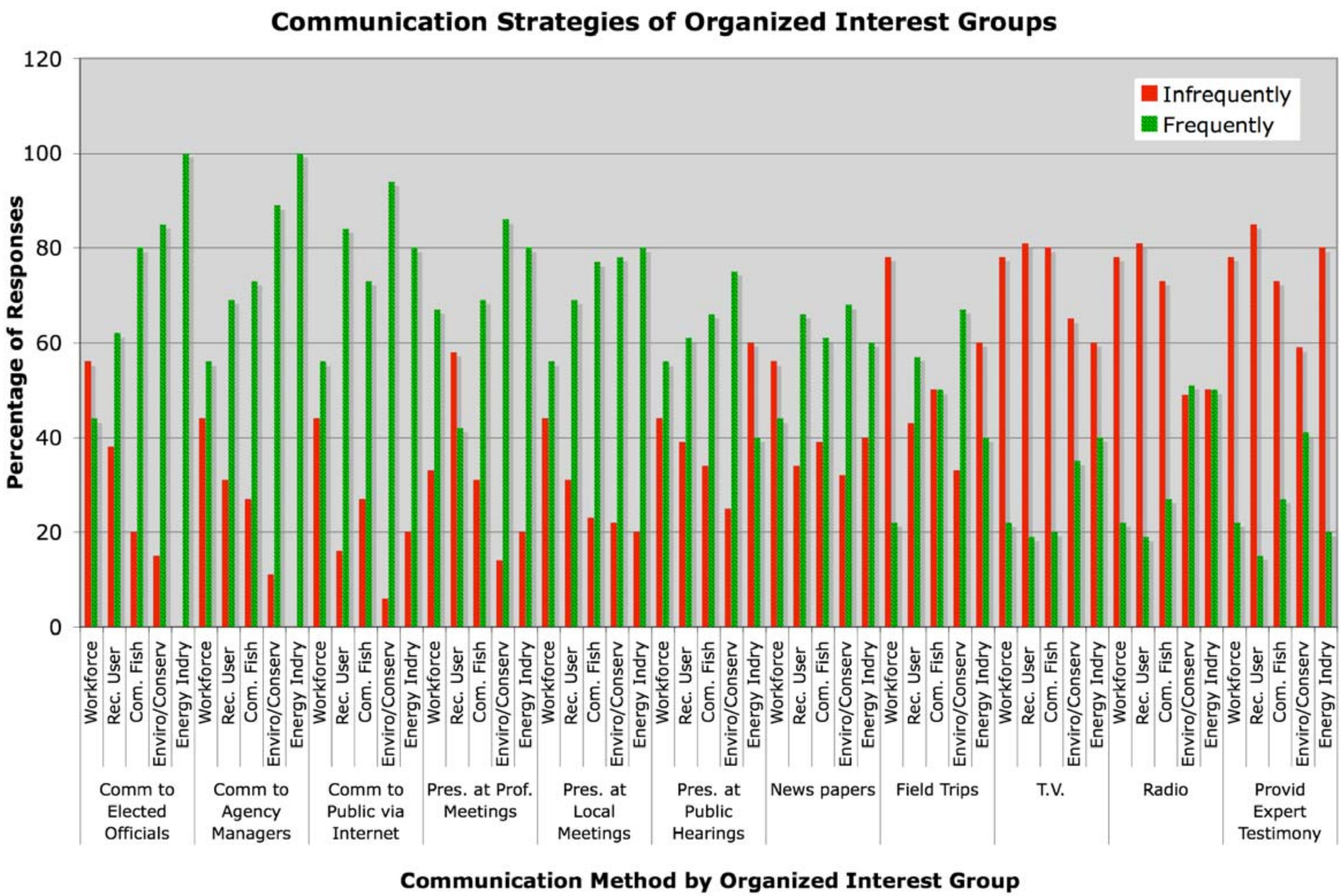
Science is best way to understand the natural world?
Percentage of Responses
120
100
80
60
40
20
0
0
44
56
23
4
65
4
4
92
3
5
92
0
0
100
Workforce
(n=9)
Commerical Fishing
(n=26)
Rec. Users
(n=26)
Enviro/Conserv
(n=37)
Energy Industry
(n=5)
Organized Interest Group
Disagree
Neutral
Agree

Figure 6.



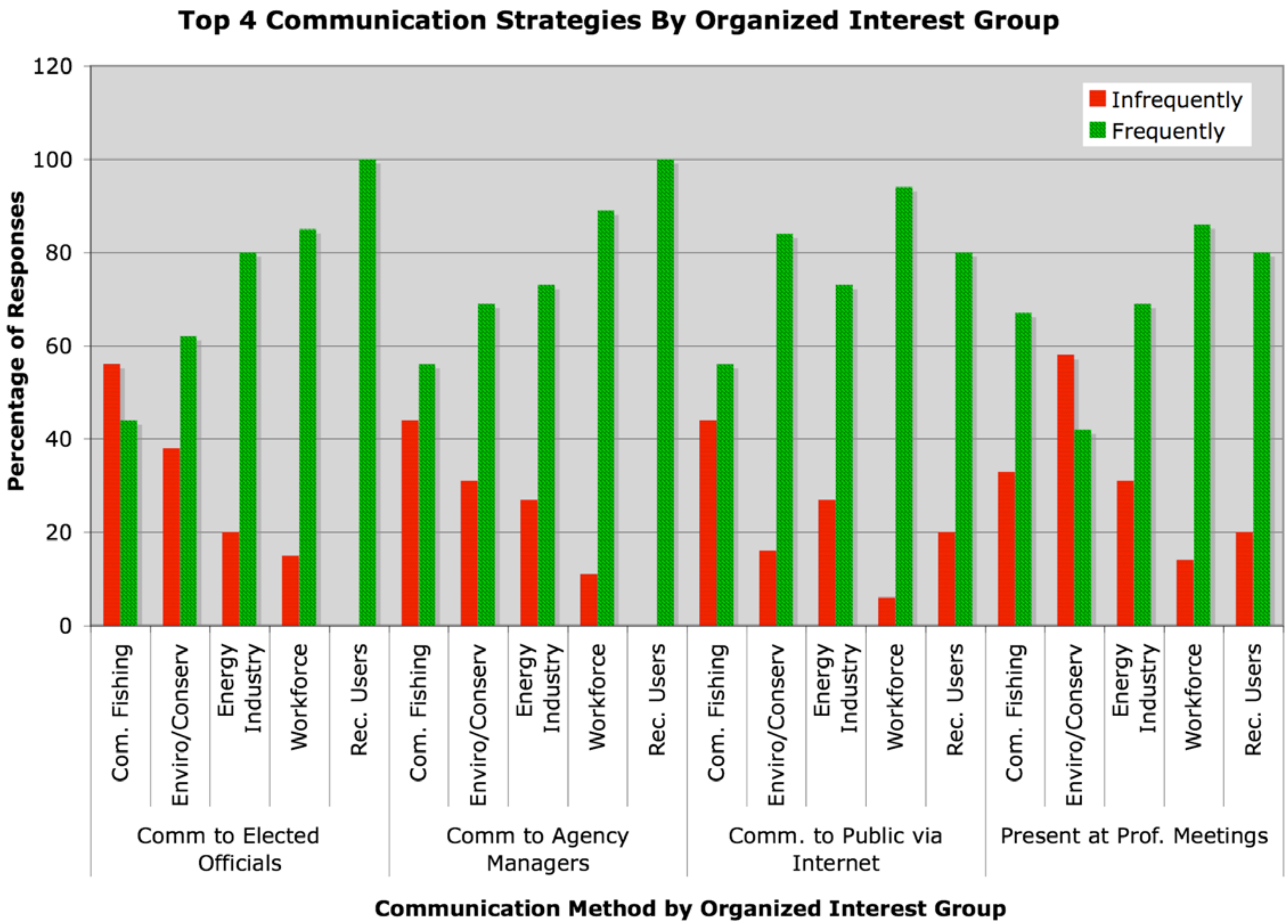
Scientists look for data that supports their personal values?
Percentage of Responses
80
70
60
50
40
30
20
10
0
68
67
62
43
40
40
40
33
31
20
16
12
12
8
0
Disagree
Neutral
Agree
Commerical Fishing
(n=26)
Workforce
(n=9)
Rec. Users
(n=26)
Enviro/Conserv
(n=37)
Energy Industry
(n=5)
Organized Interest Group

Figure 7.



Communication Strategies of Organized Interest Groups
Percentage of Responses
120
100
80
60
40
20
0
Infrequently
Frequently
Workforce
Rec. User
Com. Fish
Enviro/Conserv
Energy Indry
Comm to Elected Officials
Comm to Agency Managers
Comm to Public via Internet
Pres. at Prof. Meetings
Pres. at Local Meetings
Pres. at Public Hearings
News papers
Field Trips
T.V.
Radio
Provid Expert Testimony
Communication Method by Organized Interest Group

Figure 8.


Top 4 Communication Strategies By Organized Interest Group
Infrequently
Frequently
Percentage of Responses
0
20
40
60
80
100
120
Com. Fishing
Enviro/Conserv
Energy Industry
Workforce
Rec. Users
Comm to Elected Officials
Comm to Agency Managers
Comm. to Public via Internet
Present at Prof. Meetings
Communication Method by Organized Interest Group

Addressing Perceived Community Impacts of Wave Energy in Coastal Oregon Communities

Daniel Hunter, MA Applied Anthropology
Oregon State University, 2009

Summary

As a burgeoning new industry, wave energy development promises not only a renaissance of family-wage jobs for residents of coastal Oregon communities but also the opportunity to fulfill the mandate of the state's Renewable Energy Portfolio Standard (RPS) of 2006. However, not all coastal residents express enthusiasm for wave energy, and some feel directly threatened by specific development proposals. This study examines public perceptions of the wave energy development process among six categories of coastal stakeholders including local government, sport and commercial fishermen, tourism enterprises, the recreation community, environmentalists, and the general citizenry including retirees and others.

Forty-seven residents across three coastal counties facing potential wave energy development projects were asked a set of questions during semi-structured interviews to assess: 1) the concept of "community well-being," 2) the nature of residents' knowledge and understanding of wave energy technology and the development process, and 3) the perceived potential impacts of wave energy technology on community well-being.

The degree to which impacts were viewed as either threats or opportunities respectively reflected their personal orientation toward either near-term effects within local systems or long-term effects across global systems. Findings suggest that proponents could channel outreach efforts through local newspapers and online resources to help dispel unrealistic expectations of potential benefits as well as exaggerated predictions of potential negative community impacts. Additionally, proponents could gain community support by building partnerships with local groups to collaborate in the research effort and ultimately share the potential success of wave energy in Oregon.

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Introduction

Developers of wave energy have sought to capture the vertical component of ocean wave kinetic energy in order to convert it to electricity using various technologies, including specialized surface buoys tethered to the seabed. The prospect of multiples of buoys wired together into arrays and connected to electrical substations onshore raises questions regarding: the federally regulated privatization of near-shore waters; the potential loss of productive fishing grounds; possible obstruction of key shipping lanes; and, myriad unknown environmental impacts. Proponents of wave energy hope to offset dependence on conventional energy sources while harnessing local renewable energy to claim regional and global leadership in wave energy development and green-collar job-creation. It is argued that both coastal and non-coastal communities would share in the benefits of electricity consumption derived from wave energy projects. However, potential impacts of development projects of this nature can be perceived as either benefits or risks (Thomas 1981), (Lee 1987). The perceptions of people living in closest proximity to development sites are critical to those charged with developing the technology, the regulatory framework, and the economic distribution regimes that govern it as well (Bennett 1986).

Oregon's Governor Ted Kulongoski has taken an active role to ensure that wave energy contributes to the continued economic development of the Oregon coast (Kulongoski and Bradbury 2008). Development companies as well as county entities have already attained preliminary project permits from the Federal Energy Regulatory Commission (FERC). While the intended purpose of ocean wave energy is to yield a carbon-free renewable supply of electricity both locally and regionally, the potential social impacts of wave energy, like the technology itself, remain largely unproven. This study examined perceptions of wave energy among residents of coastal communities in close proximity to several proposed wave energy project sites. I explored the ways in which people in these communities have interpreted information about the technology, framed the development process as either an opportunity or a threat, and formed adaptive strategies based on personal value systems.

The aims of this study were to provide a detailed conceptual framework guided by three key research questions: 1) How do residents of coastal communities define community well-being? 2) To what extent do they understand wave energy technology and the development process? and 3) How is wave energy perceived in terms of its potential impacts on community well-being? The communities in this study were experiencing a major economic transition, and given the uncertain nature of regional fishery dynamics (exemplified by the 2008 collapse of the spring Chinook salmon run (Franklin 2008)) ocean wave energy could spell either disaster or relief to resource dependent communities on the coast. People here had to weigh key socio-economic factors in order to evaluate the appropriateness of wave energy for their community.

Support for wave energy technology did not necessarily reflect an understanding of technological specificities but rather the particular social constructions of wave energy as a source of either *green renewable energy* and *job creation* or of *hazardous marine debris* and *job loss*. Interview data from three coastal Oregon counties demonstrated conflicting assessments of the requirements and feasibility of the technology, the degree to which it could influence marine ecological dynamics, and the socio-economic value of historic and competing ocean uses. These assessments lead residents to frame issues regarding wave energy development as either *opportunities* or *threats* to one or more economic, political, or social dimensions of community well-being (Gramling and Freudenburg 1992). These served as the basis for key decisions regarding both the role of government as well as the preferred sources of funding for developing wave energy.

Background

It is unproductive to discuss the implications of wave energy development on coastal communities without first understanding the broader economic and regulatory context in which wave energy is a relative newcomer. A total of 47 coastal Oregonians participated in this research study—17 from Tillamook County, 18 from Lincoln, and 12 from Douglas—over a period of four months from July to November of 2008. That year witnessed the longest and most highly publicized presidential election campaign in U.S. history. Given the political climate, pre-existing attitudes toward development may have been uniquely heightened during the interview time period. The summer of 2008 also saw the price of crude oil skyrocket to its highest levels on record, causing gasoline prices to spike to over five dollars a gallon nationally.

Numerous marine reserves had been proposed in Oregon for rocky-bottom habitat where species biodiversity were thought most plentiful and ecosystem dynamics most critical (Jacobson. 2008) (PISCO 2007). While numerous marine protected areas had already been established in Oregon's near shore waters, during the course of this study multiple environmental groups were busy putting together major proposals for specific areas to be considered by the state of Oregon's Ocean Policy Advisory Council for the establishment of a series of marine reserves. These studies involved sampling and interviewing many residents of coastal communities, and likely contributed to a growing awareness of the potential conflicts arising from pending ocean management revisions.

Methods and Materials

I recruited key informants from three coastal Oregon counties including Tillamook County, located on the northern coast, Lincoln County on the central coast, and Douglas County on the south-central coast. The research methodology I employed borrowed techniques from the grounded theory approach where ethnographic data are gathered, analytic categories coded, and major themes exemplified through targeted interview quotes (Bernard 2006). As a result, data can be systematically interpreted in such a way as to allow for the discovery of particularly policy-relevant theory (Corbin and Strauss 2007). Participants included people involved in local sport and commercial fisheries, community organizations, small businesses, environmental groups, local governments and institutions, as well as retirees and second-homeowners. Key informants were asked to nominate others from within their communities whom they believed would also be able to contribute to the study. Some participants were also selected using convenience sampling as I explored each community's fishing, tourism, and recreation sectors in person.

Semi-structured interviews followed a standard interview protocol of open-ended questions with no right or wrong answers. Interviews were recorded using a handheld digital recorder, transcribed on a personal computer, and coded for thematic content using NVivo8 software. As a result, I was able to easily identify and organize major themes upon which various community groups based their attitudes and perceptions in response to each interview question.

Results

In order to gauge the potential impacts of wave energy on coastal communities, I used the concept of *community well-being* as an analytic device to describe aspects of both personal and collective lifestyle preferences. While numerous studies address various aspects of social well-being (Helliwell and Putnam 2004), my goal was to establish a model of community well-being grounded in public perception data collected from the communities themselves. This allowed the most salient aspects of well-being to percolate to the surface and for me to build a relevant dimensional framework through which to articulate the potential impacts of proposed wave energy projects.

Economic Dimensions of Community Well-Being

Growth

Coastal communities confronted with the limitations of timber extraction, seafood production, and agricultural land-use, were seeking new ways to support future *economic growth*. Economic growth, in its capacity to attract investment and generate development, was viewed as an essential component to generating economic well-being. It was generally described in terms of either industrial or private development, establishing and promoting various forms of light industry by way of attracting and retaining professionals and field experts relocating to coastal communities. However, there remains a high degree of uncertainty toward economic growth potential among people in traditionally resource dependent communities who perceive such change with trepidation.

Transition

Perhaps the most visible indicator of economic transition has been the rise of the *tourism industry*. It enjoys significantly higher levels of overall employment rates than either fishing or logging, but does so at the expense of *family-wage* rates of pay. The tourism industry contributes nearly as much to the economic activity of coastal communities as the fishing industry and slightly more than the timber industry (the Research Group 2006). Some expressed concern for the loss of fishing and timber jobs, and lamented the transition to a predominately tourism based economy. Others framed the growth of the tourism industry as a defense mechanism against further industrialization of coastal ecologies. Local government officials noted that both tourism and fishing contributions to county economies fell far short of those made by taxes levied on transfer payments from out of state accounts to predominately retired coastal residents. This may also explain a demonstrated acceptance of the ongoing transition away from natural resource extraction.

Political Dimensions of Community Well-Being

Basic Services

The domains of elected officials (and funded with taxpayer dollars), *durable infrastructure* and *crime prevention* were seen as key services providing a general sense of safety, security, and stability to coastal communities. The *built environment* was cited as a key component in the psychological well-being of residents as abandoned buildings were seen as sources of depression or even anxiety. The ability to construct modern buildings and preserve historic ones was often seen as essential to attracting new residents and investments as well as retaining existing ones.

Balance

While growth was seen as primarily good in most instances, it was also acknowledged that perhaps there are right and wrong ways to go about it. For coastal communities, *planned change* involves maintaining sufficient *control over growth* so as not to disturb or lose those portions of culture that communities value the most. Dramatic alterations in the socio-natural system can jeopardize not just a community's modes of economic production but its *cultural identity* as well. *Balance* emerged a key concept in developing strategies for adapting to potential changes that wave energy development could bring about. The constant weighing of risks against benefits and threats against opportunities defines the discourse of wave energy on the Oregon coast.

A significant example of "planned change" and failure to consider community impacts and opinions is the Ocean Power Technologies (OPT) application for a preliminary permit to the Federal Energy Regulatory Commission (FERC) for an experimental wave energy buoy array of up to 20 devices. They had been working with the Reedsport community in putting together the application, however; on March 7th, just prior to final submission, OPT made a major revision to the application without consulting community stakeholders: they changed the maximum potential number of buoys requested from 20 to 200. Overwhelming public outcry has resulted in a stalled development process, ongoing bitterness, widespread distrust, and outright resentment among people in coastal communities, mostly fishermen, familiar with the case. While OPT has been working to mend fences and foster relationships with community groups and local leaders, the damage to the public trust was clearly demonstrated in a number of participant interviews. The incident probably biased many people against wave energy developers and, by association, with the technology itself.

Administrative Transparency

Participants argued that development projects, in particular those that pose potential hazards to the local environment, should be carefully scrutinized not just by experts but also by the people of the community themselves. Not only did they want to know what their elected officials were doing but also that their representatives understood and carried out the will of their constituencies. Residents often found it difficult to hold captive the attention of their own local governments, let alone those at the state or national levels. The importance of *having a voice in the decision-making process* was a recurring theme throughout the interview process.

Regulatory Justice

Several participants indicated that government regulations have made traditional fishing and logging practices untenable, and many blamed government intervention for the decline of natural resource economies on the coast. Though local governments often have little to do with the drafting of such regulations, they were easy targets for assigning blame. While state and federal agencies claim to use the best available science to help write resource regulations, some resource users already felt adversarial toward the scientific community. Frequently, the science-government relationship was viewed with high levels of frustration and suspicion. By making express efforts to work with existing ocean resource users some local governments have already helped foster their trust and cooperation. *Access to information* and *political autonomy* figured prominently in building a community's sense of regulatory justice.

Sustainability

While traditional industries like fishing and logging remain crucial to coastal communities, there is a growing sense that the future of the coast may depend on its ability to capitalize on alternative resources and institutions. In this sense, the political concerns of certain participants represented a more *progressive* agenda than simply maintaining historic patterns of resource use. While the sustainability of certain fishing and logging practices has been widely disputed (Fluharty 2000), there is a growing debate over the meaning of the concept of *sustainability* as people on the coast seek to ensure long-term economic prosperity. The debate stems from differences over the perceived sustainability of current resource extraction regimes versus [proposed and existing] non-extractive ones. The question of *what actually constitutes sustainability, and who ultimately is allowed to define its dimensions*, may have the greatest impact on what sorts of economic regimes take precedence for coastal communities in the future.

Social Dimensions

Environmental Health

Participants in this study routinely cited the health of the *natural environment* as one of the key factors contributing to community well-being. The natural environment, while exploited commercially for timber and fish, remains a source of pride and fulfillment for many. It is difficult to separate the environmental from the economic when analyzing responses from historically resource dependent communities. There was nonetheless a shared sense of what has and hasn't worked in the past and what communities must do differently to ensure future prosperity. Communities have become stratified along lines of support for or opposition to various proposals regarding new or existing ocean uses, but each was viewed by participants as contributing to a greater sense of collective *ocean awareness*.

Shared Responsibility

Participants cited the importance of feeling connected with one another and of *working together to get things done*. They indicated that in coastal communities financial and municipal resources were less plentiful than in more urban areas. It was therefore more important for people to commit to community involvement with volunteer groups to assist each other as well as the needy. While participants did not agree entirely over political or economic issues like catch restrictions or marine reserves, they nonetheless found *common ground* in their shared interest in working together to define and achieve "common goals" (whatever those might be).

Demographic Shift

Long-time residents often viewed wealthy newcomers as less likely to help pay for city services or school improvements, and felt increasingly powerless to determine the future of their communities. A dramatic *demographic transition* has taken place on the Oregon coast, as tourists, retirees, and second-home owners have gradually and increasingly shaped the character of the region from rugged frontier to luxury destination. Property values and home prices have consistently risen, many well out of reach of existing residents. Real estate developers have capitalized on the increasing desirability of coastal areas as vacation and retirement destinations, and characterizations of retirees as outsiders has contributed to a narrative of resentment and distrust.

Cost of Living

Compounding the difficulties many working families face regarding home prices are the similarly rising costs of healthcare and the relative lack of available healthcare facilities. Given the level of danger entailed in both the fishing and the logging industries (not to mention surfing, kayaking, or riding ATVs), one might expect a high level of social services geared at helping people pay for hospital expenses. However, because hospitals are relatively large institutions that require a great deal of financial and human capital to sustain them, many rural counties find themselves unable to attract health professionals to staff them. Participants indicated that coastal counties have also experienced *declining school enrollment* as young families associated with resource extraction have moved out of the area and retired people have moved in.

Retirees and vacationers drawn to the Oregon Coast for its beauty and charm have prompted the creation of many new jobs in the *services sector*. They may have also contributed to *rising home prices*, *increased healthcare costs*, and an overall jump in the *cost of living*.

Knowledge and Understanding of Wave Energy Technology

Participants in this study demonstrated a wide range of knowledge and understanding regarding wave energy technology, from highly informed to essentially uninformed. While they may not have indicated everything they knew about wave energy, participants likely described what they most recently learned or what seemed particularly relevant to them at the time. Although coastal communities may not have known or understood a great deal about how wave energy technology works, they intuited to a proportionately high degree the threats such industrial projects could pose to existing commercial ocean users. Many indicated that the physical risks to boats, surfers, beachcombers, and marine life posed by large industrial debris were not worth the proclaimed benefits; to whomever they were intended to go.

Of the 47 participants I spoke to, 40.4% made some reference to “BOB” (for “bouy on bottom”) as Finavera’s lost 2007 test buoy was frequently referred to. It represented a major milestone for coastal communities regarding the nature of wave energy development and a blow to its credibility as a viable energy generation tactic. Finavera’s sunken test buoy was usually cited in interviews as evidence that wave energy technology would likely not survive Oregon’s oceans (or at least that its engineers didn’t know what they were doing and should have consulted with locals first).

Information Sources

Most participants indicated that they had first learned about wave energy from either *public meetings* or *word of mouth*. When asked how participants gained new information on wave energy, both *newspapers* (38.3%) and the *internet* (27.7%) were most frequently referenced. The internet had not been previously mentioned at all as an initial source wave energy information. After participants first learned about wave energy the internet was a widely utilized tool for gaining new information, more so than either public meetings or word of mouth.

Table 1 - Sources of Information Regarding Wave Energy Technology

Information Source	% Sample First learned	% Sample Now learn
Newspaper	17.0%	38.3%
Internet	0.0%	27.7%
Public meetings	27.7%	25.5%
Word of mouth	23.4%	23.4%
Presentations	12.8%	10.6%
OSU outreach	10.6%	6.4%
TV news	8.5%	6.4%
Workplace	10.6%	4.3%
FERC website	0.0%	4.3%
Industry conference	8.5%	0.0%
Popular Mechanics	6.4%	0.0%

Note: All % based on n=47 participants.

Local newspapers were cited as reliable and available sources of new information on wave energy, doubling from 17.0% as an initial source to 38.3% as an ongoing source. It is reasonable to expect that most coastal residents actively seek information regarding wave energy on their own after first learning about it from an associate or a presentation.

Feasibility Prediction

Participants were asked to: appraise the feasibility of wave energy technology; predict the most likely location within Oregon for its initial commercial implementation; propose a theoretical timeline for reaching full implementation; and, indicate barriers to developing wave energy in Oregon. The degree to which people appraised the feasibility of wave energy tended to reflect the degree to which they felt it represented either an opportunity or a threat to the well-being of their communities.

Most participants indicated that wave energy would eventually be developed commercially on the Oregon coast, and most of those felt that the development of wave energy was inevitable. The concept of *development inevitability* was often based on a perceived deterioration of local political autonomy and a growing condition of being subject to the agenda of the state. Doubters cited *buoy survivability* as the main reason why wave energy development would not be feasible in Oregon. They doubted the ability of wave energy buoys (and their supporting electrical infrastructure) to withstand the harsh ocean conditions of the Pacific, especially during winter storms and forty-foot swells.

The Role of Government

Participants felt that the federal government should either: fund the development of wave energy technology; regulate the development process; or, stay out the process altogether. In general, the preferred role of the state government was as an intermediary between the federal and local levels of government to: shield the state from overreaching federal agency; to speak out at the federal level on behalf of local governments and communities; and, to aid and assist in conducting critical research studies on the feasibility and practicality of wave energy technology.

Most participants in this study felt that wave energy would be developed within the next ten years in the state of Oregon and that private developers and local PUDs constituted the primary driving forces behind that process. However, most felt that the government, at all levels, should ensure that state and local interests are not compromised or neglected by non-coastal development entities (including federal permitting agencies) along the way.

The local government was generally viewed first and foremost as advocates for coastal communities. Many participants felt that local governments should have the greatest authority over the development process. Some, however, viewing their local governments as well-meaning, thought them incapable of efficiently developing wave energy technology and delivering renewable energy to the power grid: as a matter of national urgency, local governments would only increase inefficiency and get in the way. Two disparate themes emerged for the ways in which participants described the ideal roles of their governments: *protecting communities* and *promoting wave energy*.

Protecting communities emerged as a major theme in its own right, but also served to classify others as well. Promoting wave energy development was a less often cited theme, but also served to classify other more commonly cited themes such as *financing projects* and *expediting the permitting process*. Ultimately, a strong majority of participant responses supported the role of government as protecting communities from the negative impacts of wave energy development.

Table 2 - Preferred Government Roles in the Development Process

Protection Functions	n	%*	Promotion Functions	n	%*
Protect communities	26	55.3%	Find compromise	15	31.9%
Regulate development	17	36.2%	Finance projects	11	23.4%
Conduct research	15	31.9%	Expedite permitting	10	21.3%
Protect environment	14	29.8%	Spearhead development	6	12.8%
Empower locals first	13	27.7%	Promote wave energy	6	12.8%
Site projects	7	14.9%	Empower feds first	5	10.6%
Monitor projects	5	10.6%	Try something somewhere.	4	8.5%
Advise development	5	10.6%	Generate revenue	4	8.5%
Empower feds last	4	8.5%	Empower states first	4	8.5%
Stay out of it	3	6.4%	Why not wave energy	2	4.3%
No federal role	3	6.4%	Distribute power	1	2.1%
Disseminate information	3	6.4%			
Lower taxes	2	4.3%			
Comprehensive planning	1	2.1%			
Total Protection	118	63.4%	Total Promotion	68	36.6%

*% based on total N=47 participants citing multiple government roles.
Note: Total % based on combined number of responses n=186 (118+68)

Permitting Familiarity

Many participants with historic associations with sport and commercial fishing, viewed wave energy development as a direct threat to what they viewed as the single most important sector of local jobs on the coast. They felt it would create navigational hazards, limits to fishing areas, and adverse environmental conditions for target species such as Dungeness crab. Fishermen and local leaders described strategies for defending historical and existing ocean uses from what they had been experiencing as fast-tracked development initiatives in an exceedingly loosely regulated process. Instead they sought to control the development process, and filed for preliminary permits from FERC in advance of developers' attempts to do so. Lincoln County's initial application was denied as too broad in geographic scope, but Tillamook County's application to explore wave energy resource potential in key locations was approved. Both sought to leverage wave energy's vocational potential to their constituency's advantage, unwilling to fully trust private developers and federal regulators to sufficiently provide family-wage jobs to locally impacted communities.

In an effort to gauge the level of public engagement in the wave energy development process as well as the degree to which public outreach has effectively raised public awareness about wave energy and the roles of local, state, and federal governments, I examined levels of familiarity and degrees of understanding of the federal [energy] permitting process involved in wave energy development projects. There was generally a direct relationship between holding office in local government or belonging to a coastal organized interest group and possessing high levels of familiarity and knowledge regarding the permitting process. On the whole, most participants were altogether unfamiliar with the federal permitting process. Because the bureaucracies associated with the federal permitting process where often perceived as cumbersome and expensive—even if only marginally understood in detailed technical terms—supporters offered strategies for promoting wave energy development projects in terms of *expediting the permitting process* and otherwise minimizing the political obstacles hindering the development process.

Discussion

Perceived Impacts of Wave Energy Development on Dimensions of Community Well-Being

Some of the people I spoke to for this project were quite enthusiastic about wave energy and did not indicate a perception of the potential drawbacks to its development on the Oregon coast. For these participants wave energy development represented an *opportunity* worth exploiting. Others had difficulty finding anything positive to say about wave energy development whatsoever, and viewed it as primarily a *threat* to various aspects of community well-being.

Differential Effects of Wave Energy Development

Fishermen were overwhelmingly cited as the group likely to be most affected by wave energy. Dungeness crab was viewed as the most vulnerable fishery to the threats posed by commercial scale wave energy development. This is due to the fact that developers have generally sought sandy or soft-bottom areas where buoy-anchoring systems can be most efficiently installed and maintained. The Dungeness crab lives in this soft-bottom habitat. According to the Oregon Dungeness Crab Commission, Dungeness crab landed values ranged from $5 million to $44 million over the last ten years, and represents “the most valuable 'single-species' fishery in Oregon.”

Other groups also figured prominently in the interview data. The tourism industry was seen as facing a significant amount of change as a result of wave energy development, and participants described both positive and negative ways in which wave energy could potentially impact the tourism industry. They noted the potential for arrays of buoys to alter the aesthetic experience of the western horizon line across the Pacific Ocean, and inferred the eventual negative impact on the values of beachfront properties, including homes and second homes as well as hotels and restaurants. A few people believed that wave energy might also serve as a tourism draw, much the way hydroelectric dams do along the Columbia River.

Participants cited the potential for greater *housing affordability* for low income residents if high-value beachfront properties faced potential devaluation from diminished or otherwise industrialized view sheds. Some mentioned ways in which wave energy could affect the price of electricity, a key commodity for retirees and low-income residents. What the long term affect of wave energy will be on *electricity rates* remains to be seen, but some believed rates would go up while others believed they could go down or disappear altogether. The degree to which people believed their rates would change may have greatly affected their personal preference for, and willingness to pay for, wave energy development in their community.

A significant proportion of people working and raising families in coastal communities claimed to do so because of the particularly excellent opportunities for *recreational ocean use* that exist throughout the region. Surfers in particular were well aware of the potential impacts of various wave energy technologies on their ability to enjoy their local surf spot. One surfer mentioned the potential for wave energy buoys to attenuate incoming swells by removing energy from passing waves. Another mentioned that the oscillating water column (OWC) project proposed by WaveGen for the south jetty at Winchester Bay could easily cause sand and sediment to shift into such a way as to fatally alter the quality of the swell. Many credited Oregon Surfrider Foundation, a local non-profit environmental group, with having kept their members informed regarding wave energy development. Some indicated that prime surf spots had already been lost to various development projects, and viewed wave energy as a major threat to their quality of life.

Differential Costs of Developing Wave Energy

People often suggested that *state and federal governments* should fund wave energy development projects. They cited government roles in: protecting communities from rising energy prices; providing incentives to attract industrial job opportunities; and, leading the world in innovative renewable energy development. For them, the government should provide *tax incentives* to wave energy development companies. They felt that wave energy technology represented too large an endeavor for private industry alone to spearhead and that governments were obliged to step in and help kick start the development process by providing both *financial and bureaucratic assistance* for preliminary project developers. Others indicated that, regardless of who ought to be paying for wave energy, taxpayers would inevitably bear many of the costs, in the form of government subsidies, whether they wanted to or not.

Coastal residents opposed to wave energy did not want to sponsor its development based on low expectations of its capacity for successful commercialization in Oregon's temperamental ocean. As an investment opportunity, it was simply not worth the risk. They felt that private developers should bear the financial costs of starting up projects, even though they also acknowledged that developers would then ultimately be the ones to reap the profits. Others viewed the funding of wave energy development as ideally constituting a shared obligation between governments and industries, taxpayers and stockholders: just as the costs could be shared among governments and corporations, so too could the revenue streams generated by wave energy facilities. While the technical details of an energy tax revenue stream for counties was never clearly articulated in the interviews, there were at least supporting statements from county leaders regarding their intentions to help translate wave energy development into a profitable enterprise for the benefit of local public services.

Public Perceptions and Adaptive Strategies

Participants viewed wave energy development as either an *opportunity* or a *threat* to community well-being. The ways in which they perceived wave energy were influenced by their personal orientation regarding various potential impacts of wave energy on community well-being. Some people described wave energy's impacts on community well-being in terms of local resources and historical or current socio-natural systems; these were associated with the perception of wave energy development as a threat. Others described wave energy's impacts on community well-being in terms of shared global resources, the need for alternative energy sources, and futuristic socio-natural systems; they tended to view wave energy development as an opportunity. Participants from both viewpoints described adaptive strategies which corresponded to five dimensions of potential impacts of wave energy on community well-being.

Table 3 - Adaptive Strategies to Community Impacts by Opportunity (O) and Threat (T)

Dimension	**Opportunity Perception**	**Threat Perception**	**Adaptive Strategy (O)**	**Adaptive Strategy (T)**	**Behavioral Tactic (O)**	**Behavioral Tactic (T)**
Environmental	Greener alternative	Ecological disturbance	Prevent carbon-related climate change	Preserve marine habitat	Endorse renewable energy projects	Oppose marine industrial development
Aesthetic	International recognition	Scenic blight	Gain media exposure	Protect beachfront property value	Establish press and web presence	Petition local leaders to relocate projects
Economic	Economic growth	Media skepticism and developer distrust	Attract professionals and investment	Critique environmental propaganda	Provide incentives and subsidies	Endorse wave energy alternatives
Vocational	Job creation	Lost jobs in fishing and related industries	Promote wave energy development projects	Defend existing ocean use	Expedite permitting process	Control development process
Psychological	Energy security	Social disruption	Produce locally consumed energy	Support community networks	Cultivate public-private partnerships	Endorse existing ocean use

Environmental Impacts

Participants viewed potential environmental impacts of wave energy both locally and generally. Some perceived industrial development in near shore waters as a direct threat to cherished marine ecosystems. They sought to implement a strategy of *preserving marine habitat* by *opposing wave energy* on the grounds of biophysical preservation. Others saw wave energy as an important alternative form of renewable energy production, and have adopted a strategy of preventing the effects of *carbon-related climate change* by *endorsing renewable energy* development projects aimed at displacing fossil-fuel energy systems. Aspects such as *topophilia* (love of place) and a healthy environment were associated with the social dimensions of community well-being, and *threats* to these social values were perceived from a local orientation. In contrast, environmental *opportunities* of wave energy were perceived at a more generalized level, with *global locales* and *future climate systems* forming the basis of key positions.

To the extent that wave energy development was viewed as a threat to local marine ecosystems, the positions of certain environmentally oriented participants resembled those of fishermen who believe themselves a vital component of marine ecologies. The Pacific Northwest has long been considered a major source of renewable energy by way of its extensive system of hydroelectric dams. But, some participants questioned their designation as "renewable" and instead considered them environmentally harmful to fish species. They hoped wave energy would benefit salmon stocks and the fishing community by offsetting the needed flow of water through hydroelectric dams, protecting young smolt headed downstream and eventually helping to reconstitute regional stocks.

Still, the potential for wave energy to *harm local ecosystems* and *diminish incoming swells* constituted major environmental threats to community well-being. Fishermen were particularly aware of the potential threats posed by *electromagnetic frequencies*. Many go to great lengths to minimize their electromagnetic effects on fish from the gear they employ. The potential for wave energy devices to sink, drift, or break free from their moorings was cited as a significant *industrial debris hazard*, both to offshore ocean users as well as people and marine life along the shoreline. Some also mentioned the potential for even properly functioning wave energy devices to create a significant amount of industrial *noise pollution*. They feared driving marine mammals from their habitat and diminishing the quality of life for many coastal residents. The ability for wave energy technology to benefit coastal communities was viewed as a desirable option only if it could be both *locally benign* and *more efficient* than more polluting sources of energy.

Aesthetic Impacts

Wave energy was perceived as a direct threat to *local scenic beauty* and to the appreciation of adjacent beachfront properties. To protect the value of these properties, participants sought to mitigate and diminish the aesthetic impacts of wave energy facilities by petitioning local leaders in such a way as to *prevent project developments* in close proximity to popular residential and recreational beachfront areas. Other participants viewed wave energy as an opportunity for rural coastal communities to achieve *international recognition* as technology leaders, and sought to *gain media exposure* by establishing and expanding their presence in both the mainstream press and on the internet. For these participants, it was important to cultivate an international aesthetic of progressivism and innovation leadership. To the extent that wave energy technology could help publicize coastal communities as vibrant and innovative, gaining notoriety on the global stage could lead to future investments of both financial and human capital.

Others thought that beachfront property owners, including the tourism industry, would suffer economically if the view of the Pacific Ocean were significantly industrialized or otherwise altered by the installation of arrays of wave energy generating buoys. Beachfront property owners felt more personally invested in the Oregon coast than tourists or non-beachfront property owners and expressed deep concerns over the potential impacts wave energy could have on both their *property values* and their *quality of life*. It was generally noted that many visitors are drawn to the coast for its scenic beauty.

Economic Impacts

While some participants mentioned the potential for economic growth through industrial development, others were skeptical of the viability of device technologies and the energy resource potential. Some described the ways in which wave energy development could help to: revitalize coastal ports; increase county and state tax revenues; provision for better schools; and, enrich wave energy investors. It was generally conceded that the ports stood to gain from increased industrial activity involved in the construction, transport, deployment, and maintenance of wave energy buoys and infrastructure. However, some saw the growth potential for ports as insignificant in comparison to the decline that could result from displacing fishermen. Though some questioned wave energy's technological viability, fishermen were hopeful that if it were ever commercialized in Oregon it should be *as cost-effective as possible* producing the most possible electricity from the smallest possible area of ocean.

Participants also believed that state and county governments would benefit from wave energy by receiving tax revenues from the sale of electricity generated in their region. The concept of *generating local revenue* reflects the tendency for some coastal residents to seek to exert *control over the development process* to transform a likely threat into an possible opportunity. Several participants argued that local governments should leverage their natural resource potential for the greatest economic benefit to all coastal residents. The tendency for wave energy to be perceived as an opportunity for growth was also associated with *attracting professionals (*engineers and technical experts) and *global investment*. This reflected a desire to provide incentives to wave energy developers to encourage national and international companies to expand their business interests to the Oregon coast. Many wished to expand Oregon State University's academic research presence in communities on the coast. Even if never commercially implemented locally, wave energy research could provide the coast with rich sources of academic, financial, and social capital. Educational investment was seen as an opportunity for local institutions in both the short and long terms.

The flow of economic benefits from wave energy described in the narratives of mainstream media sources were often viewed with high levels of local skepticism. They were framed as either *environmental propaganda* or simply as deliberate misinformation aimed at enriching only a small number of powerful vested interests. These participants viewed claims of economic growth through a lens of *developer distrust*. They countered with a rational critique of the perceived propaganda by *endorsing wave energy alternatives* to wave energy including wind, nuclear, and other more allegedly benign forms of ocean energy such as the oscillating water-column and offshore wind.

Vocational Impacts

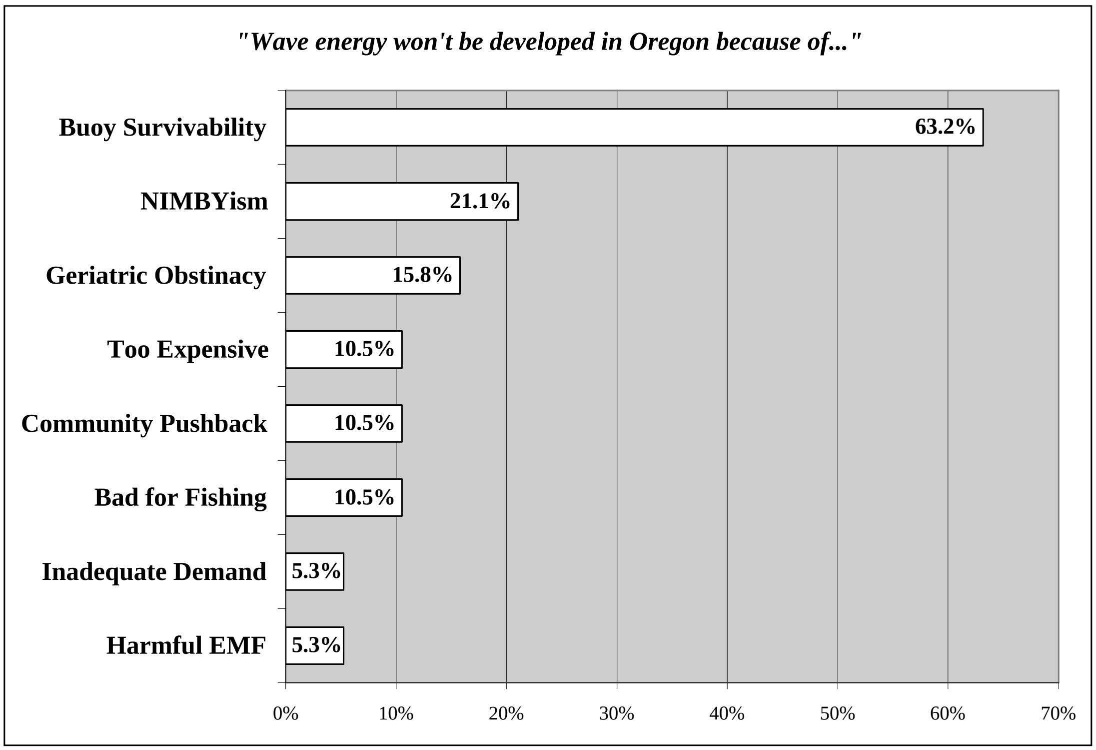
Perhaps the most commonly cited positive impact of wave energy development was the prospective employment opportunities it would offer residents of coastal communities. Given the chance to develop a promising new industry, many on the coast expressed a willingness to promote wave energy as a source of *job creation*. There is good reason to believe that wave energy would create of an array of skilled jobs in close proximity to project sites along the coast. An implicit assumption by those who argued that wave energy would create jobs was that the most likely candidates for these jobs are precisely the ones that will need them the most: fishermen. The potential for wave energy to create a new industry also inspired some to envision a growth in regional technical training programs as well. Wave energy was often seen as "the next big thing" for many workers and a way forward to economic growth on the coast. Aspirations for both *job creation* and *educational opportunity* characterized the positive aspects of vocational dimensions of the impacts of wave energy. Others argued that jobs created from wave energy development would far from offset those lost as a result of it. Aspects of perceived vocational opportunity remained characterized by a great deal of speculation and disagreement among residents of coastal communities. When wave energy was perceived as a source of job creation it represented an opportunity for long term economic sustainability. But, when perceived as leading to short-term job loss, especially in the fishing industry, it was cast as a significant threat to community well-being.

Psychological Impacts

As anxiety over rising fuel prices escalated in the summer of 2008, *energy independence* became a more critical component to community well-being on the Oregon coast. The idea that outside forces could exert undue control over local residents was seen a serious disadvantage to protecting the cultural integrity of coastal communities. Skepticism toward multi-national corporations helped frame foreign sources of energy in terms of economic *greed* and social *oppression*. Wave energy represented a kind of resistance to the petroleum industry in as much as it could serve to establish a more *locally controlled* and politically transparent energy generation system.

In contrast, others expressed a more targeted skepticism over wave energy technology viewing it as a poorly designed exercise in futility that would only result in greater *social strife* and *economic insecurity*. To the extent that wave energy could displace existing ocean users, some participants expressed a deep concern over *the sense of fear* that such a possibility might instill in people as they seek to prepare for a worst case scenario. A preference for *alternative forms of alternative energy* also emerged, and even fossil fuels often came to be viewed as less invasive and less destructive to community well-being than wave energy. This particular mode of logic reflects a perception regarding what some saw as a deluge of *environmental propaganda* aimed at building public opposition against both potential and existing ocean users. Ultimately, many participants felt that wave energy could nonetheless provide coastal communities with an independent and reliable source of electrical energy, both filling a growing public need and providing for *economic stability* and *resource self-sufficiency*.

Perceived Barriers to Wave Energy Development in Oregon



Conclusions

When wave energy was perceived as an opportunity to achieve long term energy security from distant and unpredictable market forces, a strategy emphasizing localized energy production to fill local energy demand encouraged the cultivation of partnerships between public entities and private developers. Alternately, wave energy was sometimes perceived as a threat to the social fabric of coastal communities and as a source of divisive confusion over the drivers behind and potential effects of wave energy development. In those instances, a strategy emerged focusing on bolstering community networks by endorsing historic and existing ocean uses, in particular recreational and commercial fishing enterprises.

While direct observation of environmental and economic changes during active and post-development stages had generally dominated the field, they asserted that critical social changes begin taking place as soon as developers and local leaders make their project proposals known to the public. Wave energy development is currently in the pre-development phase. Proposals for preliminary projects continue to be discussed and debated in numerous public forums including administrative meetings, industry conferences, and newspaper editorials.

Recommendations / Considerations

Opportunity-threat Analysis

Perceptions regarding wave energy could not be accurately predicted based on demographic group. Nor was there was any evidence to support significant differences in aggregate attitudes between counties. Differences that arose among participants fell along either side of an *opportunity-threat perception* divide. All participants expressed concern for the well-being of their communities. Some were oriented toward *local systems* which could potentially be affected by wave energy in the *near term*. Others were predominantly oriented toward *larger-scale systems* which could potentially be influenced by wave energy in the *long term*. An increasingly critical role for proponents should be reflecting those perceptions in their public outreach efforts.

Attitudinal Extremism

Wave energy development is characterized by both its novelty and its nascence. In the absence of a global precedent it was impossible to validate residents' perceptions of either the potential risks or benefits of proposed local wave energy projects. Attitudes tended toward the extreme as perceptions of potential threats and opportunities were likely shaped as much by residents' imaginations as much as by carefully examined empirical evidence. Misconceptions were fueled by mutual distrust, and sources of valid information were limited to those with whom people felt most affiliated. Until ommunities experience the full spectrum of wave energy development on the ground, it remains to be seen who will be proven correct as to how community well-being will actually be impacted.

New Media

Public meetings are an important way for proponents and policy makers to maintain a high profile within impacted communities and to receive unfiltered feedback from concerned citizens. However, fewer residents actually utilized public meetings for gaining new information and learning about wave energy. Proponents should mitigate attitudinal extremism by focusing outreach efforts on *local newspapers and the internet*. This could help dispel unrealistic expectations of potential benefits and exaggerated predictions of negative impacts with greater efficiency than periodic large public gatherings. One strategy could include reconfiguring existing websites in order to cater to concerned community members while still providing policy makers and industry agents separate content access points. By also providing links to *third-party publications*, proponents can provide relatively *objective content* to provide empirical evidence in support continued wave energy research efforts.

Participatory Research

Additionally, proponents could gain community support for wave energy development by building partnerships with coastal community groups to collaborate in the research process. Community based research encourages local residents to join in the outreach and data gathering processes associated with social science research. By allowing community members to participate, policy makers and developers can provide a means for concerned citizens to help establish a relevant body of knowledge with high levels of community validity. Instead of remaining simply *re*active to scientists and developers, residents should be invited to become *pro*active members of the research community. Expanding the presence of Oregon State University and Oregon Sea Grant would also reinforce the local ownership of wave energy innovation and lend credibility to a collaborative research process.

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