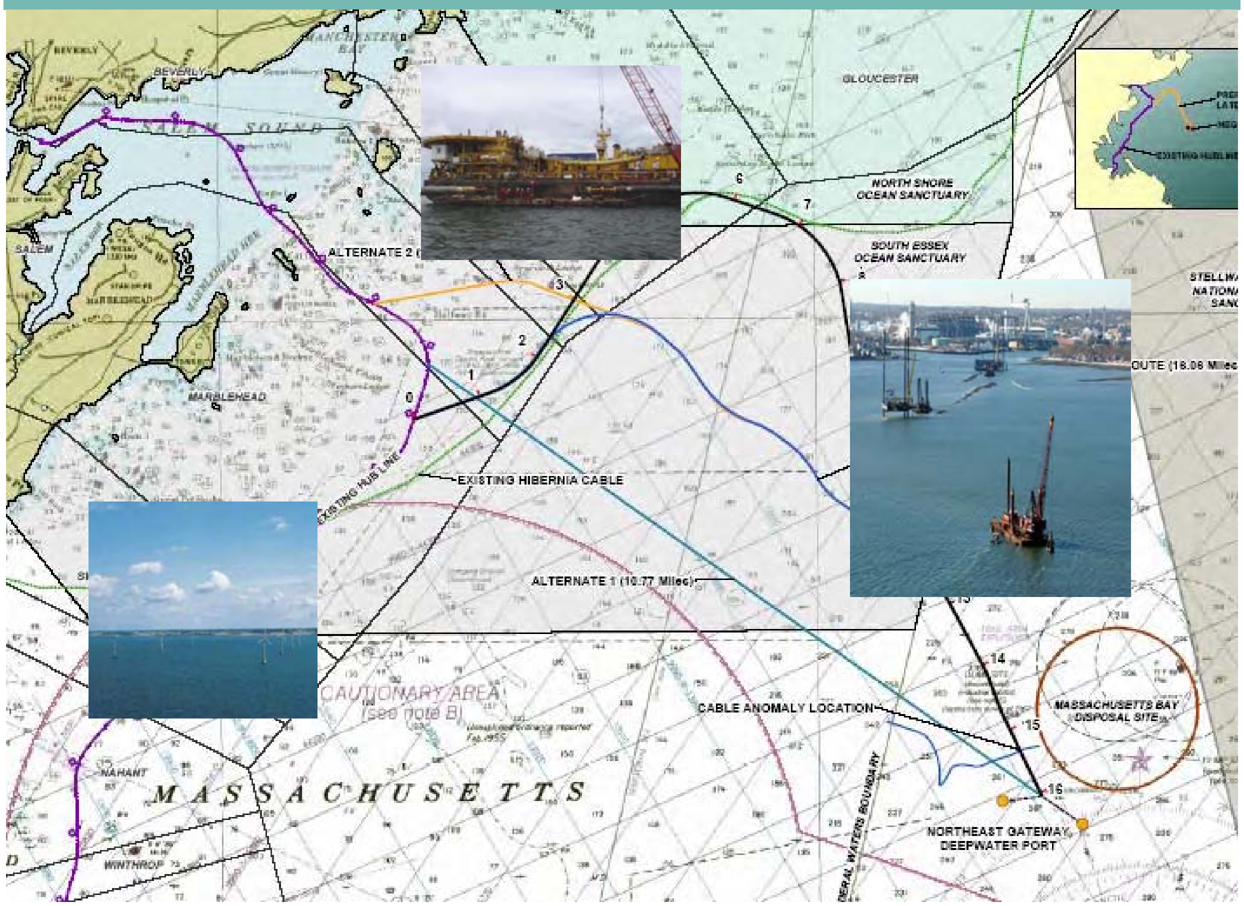
Existing and Potential Ocean-Based Energy Facilities and Associated Infrastructure in Massachusetts

RFR #: ENV 06 CZM 15



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EXECUTIVE SUMMARY

This report identifies and describes reasonably foreseeable ocean-based energy facility technologies and their broad potential development areas within Massachusetts state waters and federal waters up to 200 miles from the Massachusetts coastline (the project). The intent of the report is to identify candidate areas for the respective facilities that appear reasonably capable of development, by virtue of being: 1) feasible for technologies commercially available now, or expected to be so within the next decade; and 2) not likely to be cost prohibitive, in terms of macro-level locational factors affecting the balance of development costs/benefits. This project does not include or precede an actual screening process to identify specific sites for any offshore energy facilities; rather, the information presented in this document is for reconnaissance-level purposes only, to identify those segments of the ocean that appear most likely to be of future interest to the energy industry for development in the foreseeable future.

The project began with research into offshore energy technologies to determine what technologies are reasonably foreseeable and then sought to understand the key technology-specific parameters ("screening criteria") affecting the identification of broad candidate areas with development potential, with respect to both the physical environment and with respect to general macro-economic considerations. TRC Environmental Corporation (TRC) then mapped the broad potential development areas for each reasonably foreseeable technology. The chief technologies that were identified as reasonably foreseeable included: offshore wind turbines, Tidal In-Stream Energy Conversion (TISEC) devices, wave energy, and the siting of offshore liquefied natural gas (LNG) import terminals. Technologies screened out as not reasonably foreseeable included solar (photovoltaic and thermal electric), ocean thermal, floating wind turbines, structurally supported wind turbines at depths greater than 45 meters (m), and wind energy conversion to hydrogen.

The results of the project include large scale maps depicting the broad potential development areas derived from the screening criteria for each of the referenced technologies. The maps show general locations where development of each reasonably foreseeable technology is possible. To develop a map that provides the most information possible as to prospective offshore development locations, these maps should later be combined with other human ocean use data, and also information about environmental resources and sensitive areas (which is beyond the scope of this project). The resulting maps would in turn provide a good source of information that the Commonwealth may consider in broader planning efforts. The maps created by TRC in this project provide one component of this more comprehensive evaluation process.

In general, the research shows that the Commonwealth has marginal resources in terms of wave energy and tidal power when compared to some other locations across the country. With respect to wind, the research shows that Massachusetts has excellent offshore wind resources and additional offshore wind projects can be expected to be proposed for development. The current most economical development for wind projects is in waters 5-20 m deep. Within this water depth, siting decisions will hinge on the general tradeoff of maximizing wind speed versus minimizing the distance to an on land interconnection and also consideration of environmental and human use factors.

The mapping work also shows that there are many other locations where offshore LNG facilities could be developed based on their water depth requirements together with proximity to the existing pipeline distributions system. However, the types of LNG technologies, number of LNG facilities and their locations are heavily dependent on market forces, which are extremely difficult to assess, and beyond the scope of this effort.

1.0 INTRODUCTION

TRC Environmental Corporation (TRC) is pleased to provide this report entitled, *Existing and Potential Ocean-Based Energy Facilities and Associated Infrastructure in Massachusetts* to the Massachusetts Executive Office of Environmental Affairs (EOEA) through the Office of Coastal Zone Management (CZM). This report identifies and describes reasonably foreseeable ocean-based energy facility technologies and the broad candidate areas with development potential within Massachusetts state waters and federal waters up to 200 miles from the Massachusetts coastline (the project), in accordance with the scope requirements of Task Nos. 3 and 4 of CZM's Scope of Work (Request for Responses # ENV 06 CZM 15).

1.1 Project Background and Purpose

In March 2003, Massachusetts Governor Mitt Romney launched the Ocean Management Initiative in an effort to develop a comprehensive approach to manage ocean resources. The Ocean Management Initiative is intended to: 1) establish a proactive process for ocean management; 2) provide a seamless ecosystem approach by working with the federal government to improve management of ocean resources in federal waters; and 3) review existing statutes and regulations to determine which elements need to be strengthened or revised.

To advise the Massachusetts Ocean Management Initiative, EOEA Secretary Ellen Roy Herzfelder named a Task Force, which examined the issues, identified data and information gaps, reviewed existing ocean governance mechanisms, and issued recommendations for administrative, regulatory, and statutory changes in the March 2004 publication, *Waves of Change: The Massachusetts Ocean Management Task Force Report and Recommendations.*

This report works toward the implementation of the Task Force's Management Tools Recommendation #6: Use Characterization, which states:

> To support fully informed and inclusive decision-making, ocean management planning should be supported by the development and maintenance of inventories of the activities and resources of the state's marine waters. GIS-based data should be organized on maps and databases to depict activities and resources on the seafloor, in the water column, and/or at the ocean surface, as well as activities in the airspace over these areas, and when activities (human uses and natural) occur in time.

1.2 Report Organization

This report includes the following sections:

- Section 1.0, Introduction.
- Section 2.0, Inventory methodology for reasonably foreseeable advances in energy siting.
- Section 3.0, Screening out of technologies not reasonably foreseeable.
- Section 4.0, Profiles of reasonably foreseeable energy facilities including discussion of location, physical technological constraints, and mapping results for each technology.
- Section 5.0, Analysis of information gaps found during data collection to identify areas and issues with limited to no information.
- Section 6.0, Conclusions and recommendations for consideration of project results in ocean planning efforts.
- Section 7.0, List of references and contacts.

Appendix A of this report contains the final report completed under Task No. 1 of CZM's Scope of Work, *Inventory of Existing and Proposed Offshore Energy Facilities and Associated Infrastructure in Massachusetts* dated June 2006. The inventory report contains a description of the methodology used to identify existing energy facilities which includes public and private sector developed data sets and profiles that describe purposes, locations, and physical descriptions of existing and proposed energy facilities and associated infrastructure. See Appendix D, Figure D-1 of this report for an oversized map of Existing and Proposed Offshore Energy Facilities.

Appendix B contains the screening criteria tables for each of the existing, proposed, and reasonably foreseeable ocean-based energy facility technologies identified by TRC.

Appendix C of this report contains a copy of the Questionnaire and Information Needs Forms completed for each of the sources of information researched, reviewed and/or contacted as well as copies of email correspondence.

Appendix D contains the five oversized maps (Figure D-1 through D-5) referenced in this report.

2.0 METHODOLOGY

This section documents the methodology used to develop the inventory of reasonably foreseeable ocean-based technologies and their broad potential development areas. Prior to conducting the research for this report, this methodology was submitted to CZM for their comment, review and approval, to help ensure that TRC's efforts would meet the CZM's project goals as required under Task No. 2 of CZM's Scope of Work. The intent of this report is to identify candidate areas for the respective facilities that appear reasonably capable of development, by virtue of being: 1) feasible for technologies commercially available now, or expected to be so within the next decade; and 2) not likely to be cost prohibitive, in terms of macro-level locational factors affecting the balance of development costs/benefits.

This section addresses the following with regard to project methodology: 1) ocean-based technologies considered; 2) sources of information; 3) research methods; 4) Questionnaire and Information Needs Form; 5) telephone call procedures and protocol; and 6) trade and academic journals.

2.1 Ocean-Based Technologies Considered

The ocean-based energy facility technologies considered included: wind turbines; free flow hydropower turbines such as wave turbines; tidal (hydrokinetic); ocean thermal; ocean current; on-sea solar electric; solar thermal electric; and ocean-based liquefied natural gas (LNG) port and or ocean-based LNG storage and vaporization facilities. For the purposes of this effort, TRC defined "energy facilities" as electric generation facilities, fossil fuel-related importation facilities, and their associated interconnection pipelines and transmission lines. Additionally, because the focus of this project is ocean-based energy facilities, associated infrastructure was limited to ocean-based energy facilities. For example, if an energy facility was land-based, but had associated infrastructure (i.e., an electric transmission line) located within Massachusetts state waters or federal waters up to 200 miles out, the associated infrastructure was not considered in the inventory of existing, proposed, or reasonably foreseeable energy facilities and associated infrastructure. However, associated infrastructure that is a part of, or necessary to, an ocean-based energy facility was considered in the inventory of energy facilities and associated infrastructure. Section 3.0 discusses procedures for screening out ocean-based technologies that are not reasonably foreseeable.

2.2 Sources of Information

In order to successfully develop an inventory of reasonably foreseeable ocean-based technological advances of energy facilities, TRC believed that it was paramount to first identify all existing, proposed, and reasonably foreseeable ocean-based energy facility technologies within and outside of the United States, and then to assess them to identify technological constraints and economic feasibility. TRC used several informational sources. Based on the type of source and the sources position in the market (federal or state agency, research and development [R&D], equipment vendor, etc.), TRC anticipated that some sources would prove more useful than others. The sources were divided into three categories as listed below. As expected, the amount and quality of information provided by each group was variable in nature. Copies of correspondence are provided in Appendix C and discussed in greater detail in Section 2.4.

Category 1. (Federal and State Agencies)

- Federal Energy Regulatory Commission (FERC)
- United States (U.S.) Army Corps of Engineers (USACE)
- Minerals Management Service (MMS)
- Massachusetts Energy Facilities Siting Board (EFSB)
- Massachusetts Department of Environmental Protection (MA DEP)
- Electric Power Research Institute (EPRI)
- Edison Electric Institute (EEI)
- Gas Technology Institute (GTI)
- American Wind Energy Association (AWEA)
- U.S. Department of Energy (DOE), National Renewable Energy Laboratory (NREL)
- U.S. DOE, Energy Efficiency and Renewable Energy (EERE), Wind and Hydropower Technologies Program
- Oak Ridge National Laboratory

Category 2. (Associations and Other National and International Organizations)

- Central Research Institute of Electric Power Industry (CRIEPI)
- United Kingdom Department of Trade and Industry (DTI)
- Energy Information Administration
- European Union (EU)
- Consumer Energy Council of America (CECA)
- Renewable Energy Access
- Canadian Wind Energy Association (CanWEA)
- European Wind Energy Association (EWEA)
- World Wind Energy Association (WWEA)

Category 3. (Equipment Vendors)

- General Electric (GE) Power and GE Global Research
- The Wind Turbine Company
- Northern Power Systems
- Enertech
- Clipper Wind Power, Inc.
- Marine Current Turbines Ltd
- Wavegen
- Energetech

The organizations listed above did not require membership in order to access information relevant to the proposed project with one exception, EPRI. However, EPRI ultimately proved willing and very helpful in providing their available ocean energy information to TRC as it related to their wave energy and tidal energy research.

2.3 Research Methods

The research methods TRC used for this project were as follows:

- Conducted web-based research for all of the information sources listed above. During the web-based research, focused on the questions and information needs outlined in the Questionnaire and Information Needs Form and discussed in Section 2.4 below (see Appendix C).

- If the web search did not provide sufficient information or it was suspected that an information source would be able to provide additional useful information if telephone contact was made, then TRC obtained a contact telephone number and called the information source directly. TRC followed the Telephone Protocols and Procedures discussed later in Section 2.5. Telephone logs of the correspondence are included as part of the Questionnaire and Information Needs Form provided in Appendix C.

- If during research activities, an information source had a web-based question form or email address of where questions could be sent and additional information was required, TRC completed and submitted the question form or sent an email with the outstanding questions and information needs to the contact address listed.

Note that TRC did not mail questionnaires to prospective sources due to the poor responses typically received to mail inquiries, especially considering the short duration of this project.

2.4 Questionnaire and Information Needs Form

TRC developed a Questionnaire and Information Needs Form in order to ensure information was gathered consistently from phone contacts and web-based searches by all researchers. One form was filled out for each contact (to the extent there was applicable information, and if there was not, the contact name and address was provided with information explaining how it was not applicable to the project). To the extent a single contact provided information about more than one technology, an individual form was completed for each technology. Appendix C contains copies of the Questionnaire and Information Needs Forms accumulated during TRC's investigation. In summary, attempts were made to contact 32 separate organizations. Appendix C shows a total of 14 successful contacts (8 representing federal or state agencies from Category 1; 2 from associations and organizations in Category 2; and 4 representing equipment vendors and research and development from Category 3). Online research provided supplementary data to the contacts, or provided the only data when contacts were not successfully made. In all, TRC researched information from more than 80 sources (see References in Section 7.0).

2.5 Telephone Call Procedures and Protocol

TRC also devised a protocol for telephone calls placed during the research effort to further ensure consistency in execution of the methodology.

Prior to Telephone Call:

- TRC reviewed information on an agency, company, organization before placing a call. TRC made sure that it understood the agency, company, or organization's position in the market and where the agency, company, or organization could be the most helpful in terms of providing information. This enabled TRC to focus on the questions.

Making the Telephone Call:

- A copy of the Questionnaire and Information Needs Form was in front of the caller when making the call.

- The caller introduced him/herself (Name and TRC) and stated the purpose of the call. For example, "I am working on a project with the Massachusetts CZM to identify/inventory proposed and reasonably foreseeable energy facilities and associated infrastructure that could be located within Massachusetts state waters and federal waters beyond state jurisdiction, up to 200 miles offshore. The purpose of the proposal was to gather descriptive and spatial information to further the Commonwealth's understanding of offshore energy facilities' siting parameters (i.e., technological capabilities/limitations and other feasibility issues) to help inform decision-making in these areas." TRC also informed the contact that the information collected during the course of the project would be made public.

- If the caller was redirected to someone else within the organization, the caller reintroduced him/herself and the project.

- After introducing the project, the caller described/explained why TRC was contacting this specific agency, company, or organization and/or the person the caller had reached (i.e., the agency, company, or organization manufactures offshore wind/wave/geothermal/etc. technology or the agency, company, or organization was a trade association with cutting edge knowledge of their industry/a technology).

- In order to get the contact involved, TRC provided examples of the information we were looking for and information that would be useful to the project (refer to the Questionnaire and Information Needs Form).

  - If the contact stated that they could not be of any assistance, TRC asked them if they knew anyone that could be of assistance or if there were any websites, papers, or studies they recommended.

  - If the contact was hesitant to provide the caller with any information, TRC provided them with the CZM Data Lead letter and a CZM contact name to verify the legitimacy of the project. Additionally, TRC asked why they were hesitant to provide information (trade secret, etc.).

- TRC thanked each person contacted for their assistance and time.

Other Notes:

- TRC called each contact twice, leaving a message if the caller was unable to reach the contact. When leaving a message, the TRC caller left his/her name, that he/she was affiliated with TRC, his/her phone number, and the reason for the call including that it was under contract with CZM.

- TRC tried calling a contact a third time; however, if TRC did not get an answer, TRC did not leave a third message.

- TRC completed the Questionnaire and Information Form for all telephone calls made as part of the project, including those with failed responses.

2.6 Trade and Academic Journals

In addition to web-based research and follow-up phone calls, TRC researched and reviewed trade and academic journals for information pertinent to the project. Many of these articles are available on the web as well. In addition, TRC assessed two electronic databases via EBSCOhost® Research Databases. The first is called MasterFILE Premier. The database is a multidisciplinary database that provides full text for nearly 1,950 general reference publications with full text information dating as far back as 1975. This database covers virtually every subject area of general interest. MasterFILE Premier also includes nearly 500 full text reference books, 84,011 biographies, 83,472 primary source documents, and an Image Collection of 192,999 photographs, maps and flags. The second database TRC used is the Academic Search Elite and it offers full text for more than 2,000 serials, including more than 1,500 peer-reviewed titles. This multi-disciplinary database covers virtually every area of academic study. More than 100 journals have Portable Document Format (PDF) images back to 1985. This database is also updated on a daily basis via EBSCOhost®. The data bases are available via the North of Boston Library exchange.

3.0 SCREENING OUT OF TECHNOLOGIES NOT REASONABLY FORESEEABLE

TRC screened out technologies that were not reasonably foreseeable for the purposes of this project and report. The scope of work defined reasonably foreseeable as those technologies that have already been identified by a credible source, even if at only a concept level with no actual design. In addition, the technology must be based on something with a likelihood of actually occurring in the next ten years. Technologies premised on some yet to be invented material or mechanical/chemical process or requiring futuristic construction methods or equipment are not considered to be valid reasonably foreseeable technologies for the purposes of this investigation.

TRC also screened out unsuitable technologies based on macro-economic information to the extent data was available. Specifically, technologies were screened out if they resulted in a significantly higher cost of electricity produced so as to make them clearly non-competitive with even the most costly electric production technologies being used, and even with the most optimistic efficiency improvements in the technology within the next ten years. The following technologies have been screened out of this study.

3.1 Solar (Photovoltaic and Thermal Electric)

Photovoltaic systems used to generate electricity include: 1) concentrator technology, which uses an arrangement of photovoltaic cells that includes a lens to concentrate sunlight on a small area of cells; and 2) flat plate technology, which uses an arrangement of photovoltaic cells mounted on a rigid flat surface with the cells exposed freely to in coming sunlight.

Based on the systems currently in operation, flat plate systems range in size from 50 kilowatt (kW) – 200 kW and concentrator sizes range between 2 kW and 200 kW. At these lower power generation levels, photovoltaic applications are most feasible and economical for off-grid and consumer applications. (Cape Wind 2005).

Despite their prevalence in consumer applications, photovoltaics have the highest cost of energy among renewable energy sources (greater than $0.20/kilowatt-hour (kWh) in 2002). The high cost of energy may be attributed to the costs of producing the materials in photovoltaic cells and modules, which is very energy intensive. In addition, photovoltaic technology is not very efficient. Currently, crystalline technologies, which are among the most efficient photovoltaic systems, are only approximately 13 percent efficient. Photovoltaic technology developments being pursued are expected to increase the efficiency of crystalline photovoltaic cells up to 18 percent by 2010 (Cape Wind 2005).

As indicated above, the high capital costs associated with photovoltaics, coupled with low efficiencies, make this technology economically unfeasible on a large scale. While the cost of energy of other renewable energy sources averages approximately $0.15/kWh, photovoltaics remain significantly higher. Although advances in the development of new materials are expected to reduce the cost of energy generated by photovoltaic technology to $0.21-0.50/kWh, these developments have yet to be achieved or demonstrated in practice. These costs do not consider the complexities and added cost of photovoltaic installation in an offshore location. Accordingly, this technology has been screened out.

3.2 Ocean Thermal

Ocean Thermal Energy Conversion (OTEC) is a technology that converts solar radiation to electric power. Since the ocean is composed of layers of water that have different temperatures, a natural thermal gradient is created. OTEC systems use this gradient to drive a power-producing cycle, which can produce a significant amount of energy as long as the temperature differential is about 36 degrees Fahrenheit (°F) (20 degrees Celsius [°C]) between the warmer surface water and colder deep water. More than 70 percent of the Earth's surface is covered by oceans making them the largest solar energy collector and energy storage system. The potential for OTEC as a renewable resource is great; however the economics of energy production have delayed the financing of a permanent, continuously operating OTEC plant (NREL 2006).

Based on TRC's research, it does not appear that commercially operated OTEC technologies are reasonably foreseeable in the next ten years. Additionally, siting criteria for such facilities is not compatible with the existing conditions found along the coast of Massachusetts. The natural thermal gradient necessary for OTEC operation is generally found in the tropical zone between the latitudes of 20 degrees North (N) and 20 degrees South (S). As discussed the temperature of the warm surface seawater must be approximately 36°F (20°C) warmer than the cold deep water which should be no more than 1,000 meters (m) below the surface. Many territories and developing nations are located in this tropical zone, however only small portions of developed countries like the United States and Australia have the potential for OTEC development (NREL 2006). Massachusetts is located at approximately 42 degrees N latitude and therefore is well out of the necessary siting range. It has been hypothesized that OTEC is a very promising alternative energy resource, particularly for tropical island nations that rely heavily on imported fuels. Preliminary research suggests that OTEC plants can offer secondary benefits to its users such as desalinated water and nutrient rich deep seawater to be used in mariculture activities.

Commercial OTEC facilities can be built on land or near the shore, on platforms attached to the Continental Shelf, or on moorings/free-floating facilities in deep ocean water. Preferred locations for near shore facilities minimize the length of the cold-water intake structure and include narrow shelves such as volcanic islands, steep (15-20 degree) offshore slopes, and smooth seafloors. Optimal depths are 10 to 30 m deep offshore. On the other hand, OTEC facilities can be mounted on the continental shelf at depths up to 100 m. These facilities are often constructed on shore, towed to the site, and fixed to the sea bottom. Floating facilities present a number of challenges including difficulty with stabilization and power delivery. Cables for floating OTEC facilities would be difficult to maintain and repair at depths greater than 1,000 m, and current mooring technology is limited to depths of about 2,000 m. Free-floating alternatives proposed include drifting or self-propelled plantships, but are not likely to be commercially viable in the near future.

As ocean thermal technology is not applicable to the latitude of Massachusetts waters, it has been screened out from this study.

3.3 Floating Wind Turbines

Consideration is being given to floating wind turbine technology where conventional foundation types are not suitable, such as in deep waters offshore. A floating structure must provide enough buoyancy to support the weight of the turbine. It must also be able to restrain pitch, roll, and heave motions within acceptable limits in order to operate efficiently and safely. A variety of platform, mooring, and anchoring technologies have been proposed for floating offshore wind turbine systems.

TRC contacted Mr. Walter Musial of the NREL, a national laboratory of the U.S. DOE in the EE&RE. Mr. Musial recently presented a collaborative report entitled "Coupled Dynamic Modeling of Floating Wind Turbine Systems" at an Offshore Technology Conference held May 1-4, 2006 in Houston Texas. According to conversations with Mr. Musial (Musial 2006), floating wind turbine technology is still in its infancy. The advancement of this science is heavily dependent upon federal funding and research agencies to date have been reluctant to pursue its development. It was Mr. Musial's opinion that floating wind turbine technology would not be commercially viable in the United States within the next 15-20 years without significant federal funding. The present domestic focus is shallow water offshore wind development first, followed by deepwater alternatives such as floating wind turbine systems. According to Mr. Musial, the group closest to testing a full-scale prototype at sea is in Norway. Current design models are based on computer modeling and laboratory demonstrations, but no real world testing has been conducted. According to the NREL (Musial et al. 2006), the U.S. requires substantial experience in shallower water as well as substantive research and development initiatives to realize this technology over the next 15 years. Without significant funding Mr. Musial speculates an additional 10 years could be added to that estimate. Accordingly, floating wind turbines are not reasonably foreseeable within the scope of this study and therefore have been screened out.

Formidable engineering, environmental, economic and policy challenges will need to be addressed before wind farms can be sustainably deployed in these deeper waters of the Outer Continental Shelf. To assess these challenges, the Massachusetts Technology Collaborative (MTC), partnered with the U.S. DOE and GE Wind to create the Offshore Wind Collaborative Organizing Group, and convened offshore wind energy stakeholders representing a broad spectrum of interests and expertise to establish a research agenda. The deliberations of these stakeholders has led to the preparation of A Framework for Offshore Wind Energy Development in the United States, which details the aforementioned challenges and outlines a coordinated approach for tackling them. The Framework sets the stage and creates the context for moving offshore wind energy forward in the United States. That next step will be to structure a collaborative organization that can effectively tackle the issues outlined in the Framework and, in so doing, enable acceptance and deployment of offshore wind energy systems in U.S. waters (MTC 2006).

3.4 Structurally Supported Wind Turbines at Depths Greater than 45 Meters

At present there are no wind turbines in water depths over 30 m (Wright 2006; Alkington 2006), and the deepest water depth for a proposed project is 45 m, which is for the Beatrice Offshore Demonstrator Wind Farm in the United Kingdom (see Section 4.3.1). Monopiles can only be installed up to a depth of approximately 25 m. At depths deeper than this, a tripod or truss foundation must be used to withstand the additional forces associated with a deep water site. This technology has been used on oil platforms to a depth of 450 m. While this technology clearly exists, it is very unlikely that projects at a depth of greater than 45 m will be economically viable during the next ten years due to the significantly higher construction costs (Musial 2006). Accordingly, wind siting criteria is not included for depths of greater than 45 m.

3.5 Wind Energy Conversion to Hydrogen

The NREL and Xcel Energy recently have recently signed a cooperative agreement for an innovative "wind to hydrogen" research, development and demonstration project. Researchers will analyze and compare hydrogen production from wind power and the electric grid. The hydrogen will be produced through electrolysis – the process of splitting water into hydrogen and oxygen using electricity (Renewable Energy Access 2006).

The production of hydrogen at offshore energy facilities would be a way to avoid cost and limitations of requiring interconnection lines to offshore facilities. The technology remains in its research phase and is not reasonably foreseeable within the timeline of this study.

4.0 PROFILES OF REASONABLY FORESEEABLE ENERGY FACILITIES

TRC conducted research on all existing, proposed, and reasonably foreseeable ocean-based energy facility technologies within and outside of the U.S. The research performed by TRC was based on the sources listed in the three categories outlined in Section 3.0, Methodologies of the inventory report prepared under CZM Task No. 1, which is provided as Appendix A to this report.

Reasonably foreseeable energy facilities identified included:

- Tidal In-Stream Energy Conversion (TISEC) Devices,
- Offshore Wind Turbines **–** mounted on seabed with monopole or other structure,
- Wave Turbines, and
- Offshore LNG Import Facilities.

4.1 Tidal In-Stream Energy Conversion (TISEC) Devices

4.1.1 General Description

Tidal In-Stream Energy Conversion (TISEC) devices are a similar technology to wind turbines except that they are installed in the water column and are moved by underwater tidal currents. Though the speed of tidal currents is very slow compared to that of wind, the density of water is more than 1,000 times that of air, and thus even slow tidal current speeds can generate considerable energy. TISEC devices also avoid the issues of aesthetics, as they are underwater, which has proved to be an important issue for siting offshore project in Massachusetts. Another advantage of TISEC technology is that current speeds are predictable, whereas wind speeds for wind turbine projects are not. This can result in a more consistently reliable electric generation source.

In addition to the turbine itself, which must be able to either move so that it faces into the direction of changing currents or allow for multidirectional flow, TISEC devices require an anchoring system, and an electrical interconnection line to a land-based transmission system.

4.1.2 Current Status of Technology

At present there are no TISECs in commercial operation, though many have been tested, and Verdant plans to operate a small scale (approximately 2 megawatts [MW]) commercial test facility beginning in the fall of 2006 in the East River in New York. In addition, there are several project's that have applied for preliminary permits from the FERC to secure priority right to sites for testing and possible further development in the United States.

Table 4-1. Development Status of TISEC Devices

	GCK	Lunar	MCT	Open Hydro	Seapower	SMD Hydro	UEK	Verdant
Device Name	GHT	RTT 2000	SeaGen	OCT	Exim TTPP	TidEL	Underwater Electric Kite	RITE
Type	V-axis Helical Turbine	H-axis Ducted Turbine	H-axis Twin Turbine	H-axis Twin Open Center	V-axis Savonius Turbine	H-axis Twin Turbine	H-axis Augmented Turbine	H-axis Unducted Turbine
Development Status	1 m dia X 2.5 m high test in Merrimack River in September 2004.	1 to 1.5 m dia ($1/20^{th}$) scale test in water tank	11 m dia 300 kW tested at sea (not 1) since May 2003 15 kW tested in 1994 – 5	3 m ($1/5^{th}$) scale testing at sea	Full scale test in September 2003	$1/10^{th}$ scale tested	7 prototypes up to 10 m in dia	Tested Pakistan 1989, Maryland and New York in 2002-2003
Next Development Step	Develop shaft mounted gen unit optimized for GHT	Deploy 1 MW unit in 2006 at EMEC – plan 2 MW com'l unit	Deploy SeaGen unit in 2006	Deploy 1.5 MW unit in 2006	Fullscale pilot plant to be commission ed in 2005	Fullscale prototype to be deployed at EMEC in 2006	10 MW – 25 unit project in Delaware – in permitting	Pilot 6-Unit Integrated System in the East River, New York
Power Train Type	Direct drive permanent magnet gen connect to GHT shaft	Hydraulic based on modified COTS pump	PlanetaryCO TS Gearbox	Direct rim drive generator	Gearbox	Gearbox	Planetary drive – proprietary	Speed Increaser COTS
Foundation/	Suspension or attached to sea floor	Gravity Base	Monopile embedded in sea bed	Gravity base or monopole	Anchors & Chains 4-fold	Anchors and chains	Via cable (note 3)	Monopile
Rotor Size	1 m dia x 2.5 m length	19.5 m (3.9 m hub dia)	2 rotors 18 m dia	15 m	1 m dia X 3 m high – 2 pieces	8 m blades on 2.5 m dia hubs	Twin 10 feet	5 m
Rate Power (kW)	7	2,000	1,548	1,520	44	1,000	400	34

Table 4-1. Development Status of TISEC Devices								
	GCK	**Lunar**	**MCT**	**Open Hydro**	**Seapower**	**SMD Hydro**	**UEK**	**Verdant**
Rate Speed	2.58	3.1 m/s	3.0 m/s with MMSS of 3.5	2.57 m/s	3.0 m/s	2.3 m/s	3 m/s	2.1 m/s
Area (m^2) in $P=0.5pAV^3$ equation	2.5	490.8 (cross section of 25tm dia duct	5092	313.8	6	537	14.59	19.6
Commercial Price	Yes, turbine only.	Not Commercial yet	Not Commercial yet	Not Commercial yet	Yes, but excluding site specific costs, grid	Not Commercial yet	Yes	Yes

Source: (Hagerman 2006)

Note: dia = diameter
m/s = meters per second

Manufactures of TISEC devices include GCK, Lunar, MCT, Open Hydro, Seapower, SMD Hydro, UEK, and Verdant. Table 4-1 is a summary of the manufacture's, turbine types available, their specifications, and their current development status. As at least one manufacturer will be in commercial operation by next year (Verdant), TRC considers this technology as "reasonably foreseeable" in terms of the scope of this report (i.e., it is technologically feasible to install within the next ten years).

As noted above there are several proposals by developers to install TISEC devices in the United States. The only one to complete permitting for its test phase is the Verdant Project. Other development projects are in only the initial permitting stage, which requires the securing of a FERC preliminary permit to allow for testing followed by possible development. The projects other than Verdant still all require local, state and federal permitting before installation and testing can be conducted. The FERC preliminary permit application schedules show that developers are pursing a multi-phased approach starting with the testing of units and then proceeding to full commercial build out in one or more stages over a period of several years.

The currently proposed TISEC projects in the United States are summarized in Table 4-2.

4.1.3 Potential Candidate Siting Areas Criteria

A good in-stream tidal site is one that has a large amount of water moving at a high speed, a seabed geology that allows for proper installation of anchors or piles (i.e., preferably not bedrock), is located close to transmission lines, and does not disrupt the use or environmental resources of the area.

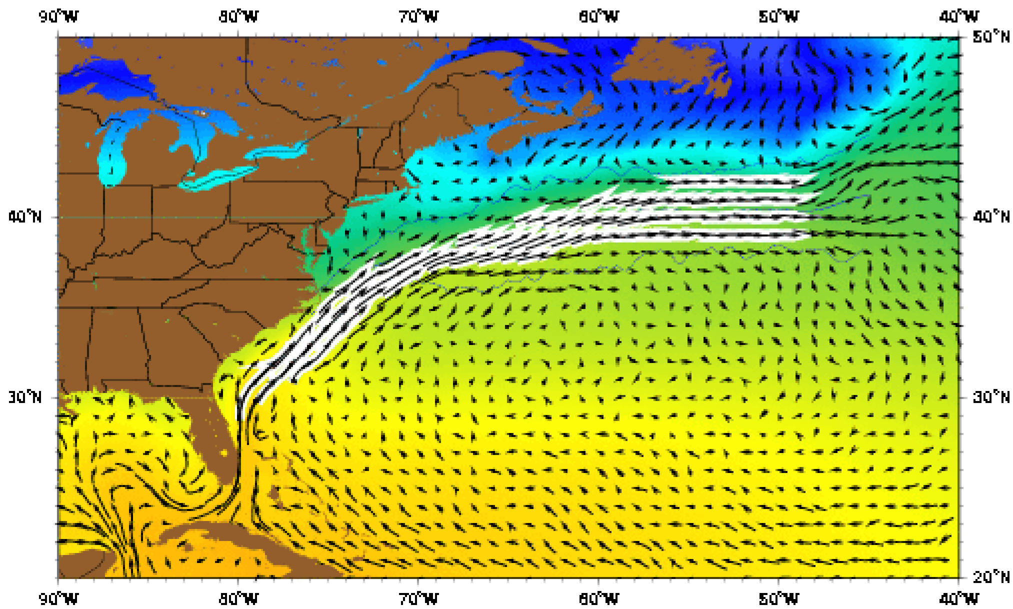
The currently proposed projects listed in Table 4-2 confirm developers are following these siting criteria for installation of TISEC devices. A review of these applications shows that the projects are located at or near known areas with a strong current regime with current speeds ranging from 2 to 4.7 knots. In addition, with the exception of Florida Hydro (to be discussed) they are all sited relatively close to onshore transmission lines (either immediately adjacent to or within ¼ mile to ½ mile). Depths at the proposed sites are in the range of 20 feet to 100 feet deep (with the exception of Florida Hydro). All these locations are at narrow portions of a tidal waterway, where tidal flux is channeled through a limited cross sectional area and thus tidal speed is maximized.

Table 4-2. Status and Siting Characteristics of Pending TISEC Preliminary Permit Applications with the FERC						
Developer (a)	**Location (a)**	**Size No. of Units and MW (a)**	**Design/ Manufacturer (a)**	**Permitting Status (a)**	**Max Current Speed at Closest NOAA Monitoring Location (flood/ebb) in knots (b) (c)**	**Water Depth (feet) (a)**
Verdant	East River, New York (East side of Roosevelt Island)	6 units in initial testing phase (17.9 kW/unit based on a current velocity of 3.5 knots. Total capacity at full buildout is 10 MW (using 500 turbines).	Verdant	Received USACE authorization for testing of 6 demonstration units in May 2006	(3.8/4.7) (west of Roosevelt Island)	25 to 40
Ocean Power	Applications have been filed for preliminary permits in the vicinity of Roosevelt Island, NY, Vineyard Sound, MA, Penobscot River, ME, Kennebec River, ME, Piscataqua River, NH, and ME, Deception Pass, WA, and Columbia River, OR and WA	Projects vary in size depending on location from 50 units to 150 units. Generation of 0.5 to 2 MW per unit.	Undetermined	Requested FERC Preliminary Permit in the time frame from 3/24/06 to 4/27/06	Max flood/ebb current at the different sites ranges from 2.0/2.5 at the site with the lowest maximum flow (Bucksport, ME) to 5.2/6.6 at the site with the highest maximum flow (Deception Pass, OR)	Water depth varied from 20 to 100' deep at the sites.
Tidewalker Associates	Little Machias Bay, Cutler, Maine	13.5 MWs total.	Undetermined	Requested 4/29/06	(3.2/3.1) Western Passage off Kendall Light	20 to 50
Florida Hydro	5 miles off Palm Beach, Florida in Gulf Stream	No. of units to be determined. Generation of 2 to 3 MW per unit.	Florida Hydro	Requested FERC Preliminary Permit on 7/8/04	(3 to 4) approximately	300 to 1,600
ORPC Alaska, LLC	Upper Cook Inlet, Alaska	0.3 MW per unit with 70 to 100 units	OCGen	Requested May 2006	(3.5/3.1)	95 to 193

(a) (FERC 2006)
(b) Tidal Current Speed Data from National Oceanic and Atmospheric Administration (NOAA) Tidal Current Tables; Atlantic Coast of North America and from NOAA Tidal Current Tables: Pacific Coast of North America
(c) Information is based on closest tidal gage. Tidal speed can vary widely depending on location of project versus NOAA tide measurement device location.

With respect to the Florida Hydro Project, the developer is attempting to harness the power of the Gulf Stream current rather than lunar based tides. In Florida, the Gulf Stream can be as close as approximately 5 miles from the shoreline. Therefore, this project has a much longer transmission line requirement. The Gulf Stream passes well south of Massachusetts waters, so this type of project is not possible in Massachusetts (refer to Figure 4-1).

Figure 4-1. Location of Gulf Stream



Source: (CIMAS 2006)
Note: Location of Gulf Stream shown in White.

4.1.4 EPRI Studies

EPRI recently completed a North American Tidal In-Stream Energy Conversion Technology Feasibility Study, in which they chose their test sites based on the much the same criteria described above. A key siting criteria for EPRI was the "power density" of in-stream locations, which is defined as 0.5 multiplied by the cross sectional area of water available at a site, multiplied by the density of water, multiplied by the cube of the water velocity. Thus EPRI searched for sites with high tidal velocities and large cross sectional areas to allow for maximum derived power. Proximity to transmission lines was also an important siting factor for EPRI.

EPRI's choice of the most promising location to site TISEC devices in Massachusetts was Muskeget Channel, located between Nantucket and Martha's Vineyard. This location was chosen based on the criteria above because it had the strongest power density available in Massachusetts other than the Cape Cod Canal, which was off limits due to conflicts with navigational use. EPRI's conclusions were that the Muskeget

Channel site was "somewhat small (17,500 m^2), low in power density (0.95 kW/m^2) and was not easily interconnected to the grid," and that they could "find no other good tidal sites in Massachusetts." EPRI concluded that even the Muskeget Channel, which was the best site in Massachusetts, "could not produce a rate of return for a non-utility generator." EPRI did show that other sites in other areas of the country and Canada did have a very positive rate of return on investment. As such, EPRI concluded it would be unlikely that TISEC technology would be installed in Massachusetts waters (Bedard 2006).

4.1.5 Cape and Islands Tidal Energy Hydropower Project

MATidal's recently proposed Cape and Islands Tidal Energy Hydropower Project in Vineyard Sound provides a somewhat conflicting view for the future of tidal energy in Massachusetts compared to that of the EPRI study. Given that a project is proposed here, it would appear that there are positive siting aspects to this location, or that at least there remains uncertainty as to the economic viability of particular sites given the new and changing nature of the technology. One advantage to this site is that is located adjacent to an existing electric cable crossing that connects Martha's Vineyard to Falmouth, and thus, the site has the possibility of interconnecting with an onland transmission system at a closer distance than EPRI's selected Muskeget feasibility site. This could be an important economic factor as the cost of transmission line installation for the Muskeget feasibility study site was almost ⅓ of the overall project development cost (Bedard 2006).

4.1.6 Mapping Results

TRC mapped all sites in Massachusetts with a maximum 3 knot current speed or better using the NOAA Tide Current Tables for the Atlantic Coast of North America (see Appendix D – Figure D-2. Inventory of Reasonably Foreseeable Energy Siting: Tidal In-Stream Energy Conversion Devices). We note that NOAA provides data on only "maximum" current speeds at particular sites, so maximum current speed was used as the siting criteria. The velocity of 3 knots was chosen to capture the very best locations in Massachusetts. This tidal velocity is well below the maximum current speed for which most turbines are designed to operate (roughly 4 to 6 knots – based on the rated speed of the turbine (see Table 4-3) and is below the approximate four knot speed suggested as a very rough proxy for minimum viable current speed for this technology (Bedard 2006). We note also that it is below the overall 3.5 knot combined average maximum speed of all the proposed sites in the United States. TRC chose the current speed of 3 knots or more, in order to be inclusive of the best sites in Massachusetts. Table 4-3 provides a summary of the NOAA sites with current speed of greater than 3 knots.

Table 4-3. Locations in Massachusetts with NOAA Tidal Current above 3 Knots						
NOAA Tidal Gage No.	**Specific Location**	**Maximum Flood**	**Maximum Ebb**	**NOAA Reference Site**	**Longitude Degrees/ Minutes**	**Latitude Degrees/ Minutes**
981	Blyman Canal Entrance, Gloucester Harbor	**3.0**	**3.3**		42° 36.6’	70° 40.4’
1811	Muskeget Channel	**3.8**	**3.3**	Pollock Rip Channel	41° 20.9’	70° 25.2’
1906	0.8 Mile North of West Chop	**3.1**	**3**	Pollock Rip Channel	41° 29.6’	70° 35.7’
Vineyard Sound-Buzzard’s Bay						
1991	Wood’s Hole – 0.1 mile South of Devils Foot Island	**3.5**	**3.6**	Cape Cod Canal	41° 31.2’	70° 41.4’
Cape Cod Canal						
2156	Cape Cod Canal Railroad Bridge	**4**	**4.5**	Cape Cod Canal	41° 44.5’	70° 36.8’
2161	Bourne Highway Bridge	**3.3**	**4**	Cape Cod Canal	41° 45’	70° 35’
2166	Bournedale	**3.4**	**3.6**	Cape Cod Canal	41° 46’	70° 34’
Source: (NOAA 1998)						

Mapping results show that the sites for TISEC devices are best suited to locations close to the shore where the strongest currents are formed by shoreline configurations which tend to funnel large volumes of water through narrow openings. These include areas on the south of Cape Cod near Martha’s Vineyard and Nantucket and other diverse locations such as Wood’s Hole, Cape Cod Canal, and Gloucester, where the Annasquam River empties out through Blyman Canal. Areas further out from shore have low current speed and are not practicable for development of this technology.

We note that tidal speeds change drastically depending on shoreline configurations, specific location, and water depth, and thus, it is not possible to mathematically interpolate other tidal velocities located between or near know NOAA data points. Therefore, the mapping for this section consists of only individual points on a map with reference to their maximum tidal ebb and tidal flow velocities. TRC has also included the location of the selected EPRI feasibility study site on the map. Other potential tidal sites would need to be assessed on an individual, site specific basis, with tidal monitoring and or tidal modeling if possible.

4.2 Offshore Wind Turbines

4.2.1 General Description

Offshore wind projects are similar to onshore wind projects, though construction, maintenance and operation are typically more complicated and more costly.

Offshore wind farms encounter many siting constraints and engineering obstacles including foundations that must be firmly lodged in the seabed and capable of withstanding ocean currents and wave stress. Often many miles of cabling are required to transfer their power back to shore. Both construction and maintenance work for offshore wind facilities must be carried out in reasonable weather conditions, and this work generally requires specialized boats and equipment. Specific considerations for offshore facility design include: low mass nacelle arrangements; large rotor technology and advanced composite engineering; and offshore foundations design, erection and maintenance. The large cost associated with offshore projects, together with the many technological factors, suggest that it will be very challenging to develop economically viable turbines above the 5 MW rating based on current technology. However, new concepts may emerge to allow for the development of generating units larger than 5 MW capacity for offshore projects, which is the latest challenge for the wind industry and will open up more economically feasible locations.

4.2.2 Current Status of Technology

At present there is more than 804 MW of commercial offshore wind power in Europe, with many projects proposed in the U.S. (Musial 2006).

Table 4-4 provides a listing of existing offshore wind farms in Europe.

Table 4-4. Offshore Wind Installations

Location	Capacity (MW)	Turbines	Year of Installation	Distance from Shore	Depth
Vindeby, Denmark	5	11 Bonus 450 kW	1991	-	-
Lely, The Netherlands	2	4 NedWind 500 kW	1994	750 m	5-10 m
Tunø Knob, Denmark	5	10 Vestas V39 500 kW	1995	-	-
Dronton, The Netherlands	17	28 Nordtank 600 kW	1997	-	-
Bockstigen-Valor, Sweden	3	5 Wind World 500 kW	1998	-	-
Blyth, UK	4	2 Vestas 2 MW	2000	800 m	6-11 m

Table 4-4. Offshore Wind Installations

Location	Capacity (MW)	Turbines	Year of Installation	Distance from Shore	Depth
Middelgruden, Denmark	40	20 Bonus 2 MW	2000	3 km	3-6 m
Utgruden, Sweden	10	7 GE Wind 1.425 MW	2000	8 km	7-10 m
Yttre Strengund, Sweden	10	5 NEG Micon 2 MW	2001	5 km	6-10 m
Samsø, Denmark	23	10 Bonus 2.3 MW	2003	3.5 km	20 m
North Hoyle, UK	60	30 Vestas 2.0 MW	2003	6 km	10-20 m (partly tidal)
Horns Rev, Denmark	160	80 Vestas V80 2 MW	2003	14-20 km	6-12 m
Nysted, Denmark	158.4	72 Bonus 2.2 MW	2003	10 km	5-9.5 m
Arklow Bank, Ireland	25 (520 upon completion)	7 GEWE 3.6 MW (200 upon completion)	2003 (completion 2007)	10 km	2-5 m
Barrow-in-Furness, UK	90	30 Vestas 3 MW	2006	7 km	21-23 m
Scroby Sands, UK	60	30 Vestas 2 MW	2004	2.3 km	4-8 m
Ems-Emden, Germany	4.5	1 Enercon 4.5 MW	2004	40 m	3 m
Frederikshavn	10.6	4 Vestas, Bonus, Nordex	2003	-	-
Breitling, Germany	2.3	1 Nordex 2.5 MW	2006	500 m	2 m
Kentish Flats, UK	90	30 Vestas 3 MW	2005	8.5 km	5 m

Sources: (EWEA 2003; OWE 2006)
km = kilometer

Presently there are no offshore wind facilities located off the coast of the United States. Table 4-5 lists offshore wind parks proposed in North American waters.

Table 4-5. Proposed Offshore Wind Projects in North America

Project Name and Location	Capacity (MW)	Turbines	Year of Proposed Installation	Closest Distance to Shore	Depth
Cape Wind – Nantucket Sound, Massachusetts USA (1)	420 MW	170	To be Determined	5.2 miles	<50 feet
LIPA, FP&L Long Island, New York (2)	140 MW	39 GE Wind 3.6 MW	2006	6.5 miles	NA
Wind Energy Systems Technologies (W.E.S.T., LLC) Louisiana/Texas (3)	150 MW	+/- 50	Research to be completed by 2007	(7 miles off Galveston Island)	NA
Nai Kun Wind Farm – Hecate Strait, British Columbia, Canada (4)	700 MW	200 turbines	2010	NA	Shallow
Off Padre Island and south of Baffin Bay, Texas (5)	500 MW	100	NA	3 miles	NA
Patriot Renewables, LLC, Buzzards Bay, Massachusetts (6)	300 MW	90 to 120	2011	3 to 4 miles	NA

Sources:
(1) (Cape Wind 2004)
(2) (Neighborhood Network 2006)
(3) (Renewable Energy Access 2005)
(4) (OWE 2006)
(5) (Washington Post 2006)
(6) (Providence Journal 2006)
NA = Not Available

Generating Capacity Range of Offshore Wind Facilities

The megawatt generating capacity of existing offshore wind farms in Europe ranges from 2 MW to 160 MW (see Table 4-4) and the capacity of proposed wind farms in North America ranges from 140 to 700 MW (see Table 4-5). The trend in offshore construction is toward the use of larger turbines which are generally able to provide larger output relative to their construction and operating costs compared to smaller turbines (Musial

2006). However, this does not preclude the use of smaller turbines and smaller scale projects from being constructed offshore as has been shown in Europe with the construction of a 2 MW offshore project in Lely, in the Netherlands, and a 2.3 MW offshore project in Breitling, Germany. This report has not attempted to screen out smaller wind facilities, as depending on development goals and project specifics, there is no clear set megawatt capacity below which it is not practicable to install an offshore turbine. We note that small generation capacity turbines would need to be constructed close to shore as they would not be able to offset expenses associated with long interconnection lines and the higher costs of constructing far from land.

4.2.3 Potential Candidate Siting Areas Criteria

The offshore siting factors for wind turbines in Massachusetts waters are water depth, wind resources, geology of substrate, and distance to the shoreline. These are described in greater detail below.

Water Depth

Offshore wind farms can be sited in various depths, but are currently best suited for shallow waters. According to the Massachusetts Renewable Energy Research Laboratory, the current maximum depth of offshore turbines in operation is 30 m (Wright 2006; Alkington 2006). However, Depths of 45 m are in planning stages presently, such as the Beatrice Offshore Demonstrator Wind Farm proposed in the waters of the United Kingdom (Talisman Energy 2006).

The minimum water depth that is technically foreseeable and macro-economically foreseeable for installation of wind turbines is approximately -2.5 m (Manwell 2006). Sites with depths that are more shallow than this would generally require special construction equipment and have unknown macro-economics. The minimum depth for installation is variable and can range up to approximately -5 m, depending on a host of project specific factors such as size of project, site specific environmental conditions, type of substrate, and construction equipment (i.e., specific kind of jack-up barge and or other construction equipment used) (Manwell 2006; Olmsted 2006). TRC has used a minimum depth of -5 m for mapping purposes rather than -2.5 m due to the limitation of MassGIS data. MassGIS data is provided in discrete depth increments, beginning at the edge of the shoreline, which is considered elevation zero, and then with the next depth contour being at -5 m, with no further breakdown of depth within the 0 to -5 m interval.

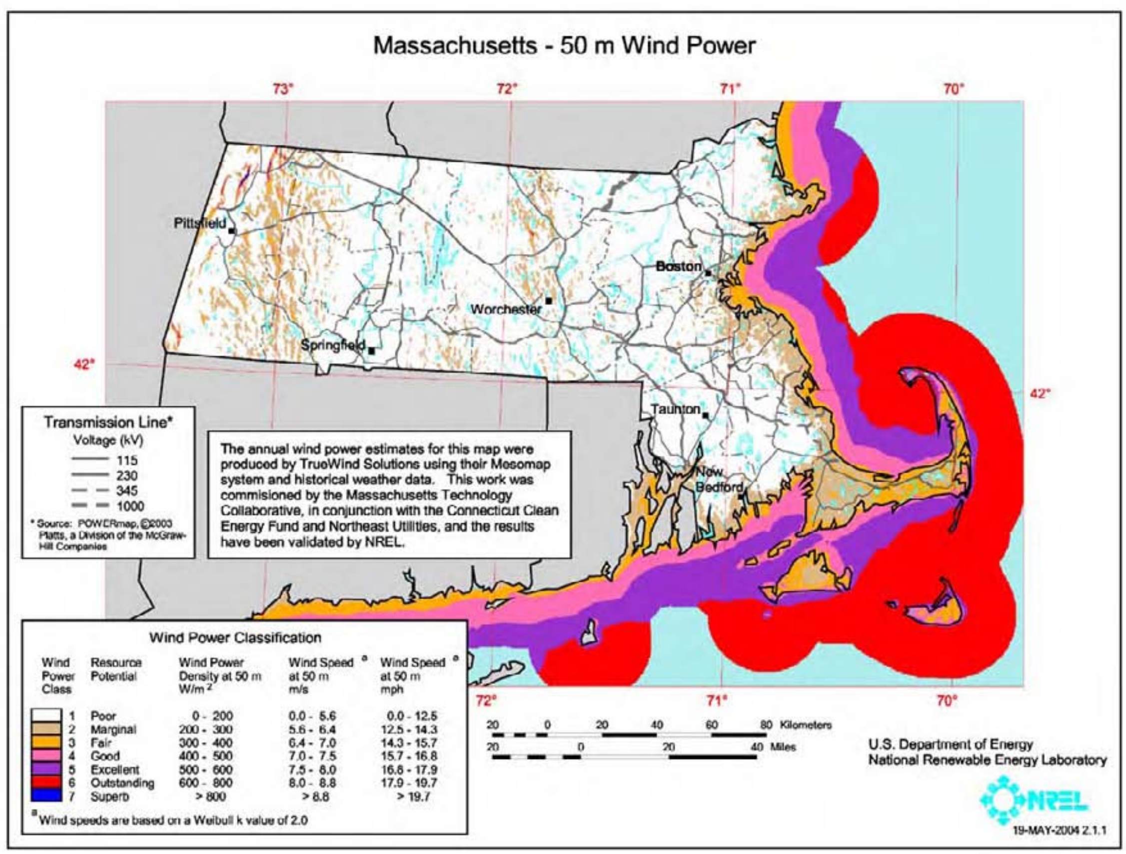
As shown in Table 4-4 above, in Europe facilities presently in operation range in depths from -2 m to -23 m deep. In comparison, Cape Wind proposes to develop their project in water depths of less than 15 m in Nantucket Sound.

The NREL has a goal of developing systems to be sited in depths up to 183 m. However, based on the current technology and practices utilized around the globe, it is likely that offshore wind development will remain for shallow water depths of up to at most 45 m for the near future, with approximately 5 m to 20 m being the most economically viable water depth (Alkinton 2006; Cape Wind 2005; Musial 2006).

Wind Speed

The Department of Energy (DOE) Wind Program and the National Renewable Energy Laboratory (NREL) produced a wind resource map for the state of Massachusetts as shown in Figure 4-2. Figure 4-2 estimates wind speeds at 50 m above the water surface which is more useful for estimating the resource availability that could be used for utility-scale wind development.

Figure 4-2. Massachusetts Wind Resource Map



Source: (USDOE EERE 2006)

According to the DOE Energy Efficiency and Renewable Energy (EERE), wind power Class 4 or higher can be useful for generating wind power with large turbines at 50 m, and given advances in technology, a number of locations in the Class 3 areas may be suitable for utility-scale wind development in the future. This map indicates that Massachusetts has excellent-to-outstanding wind resources located on the northern part of Cape Cod, the southern part of Cape Cod, and along the shore of Martha's Vineyard and Nantucket.

Bedrock

Where bedrock is located at the surface, installation of monopiles can require drilling, which increases the price and makes such locations less attractive (Alkinton 2006). Structures can be installed using footings to the extent bedrock is not immediately present at the surface. Areas of bedrock are located principally along the north and south shores of Boston and an area immediately east of Boston. The presence of bedrock also can make it cost prohibitive to bury interconnecting electric cables that run between each monopole in a wind farm.

Distance from Shoreline

Distance of wind sites from the shoreline can be a particularly influential factor in the overall cost of wind turbine installation, and can constitute a large percentage of overall project cost for smaller wind farm developments. A typical offshore wind farm has a network of cables connecting the individual turbines and a buried or covered transmission cable which brings the electricity generated at sea to the power grid onshore. Installing the transmission system and the cost associated with maintenance and repair tends to be significantly greater the further a project is from the shore. As an example, the 115 kV interconnection cable for the Cape Wind Project will cost $3.7 million per mile, and siting alternatives requiring a longer interconnect distance than that proposed were ruled out based on cost (EFSB 2005).

As shown on Table 4-4, the existing offshore wind farms in Europe range greatly in their distance from the coastline. The single turbine associated with the Ems-Emden facility is located only 40 m off the coast of Germany while the 80-turbine Horns Rev wind farm is located between 14 and 20 km offshore of Denmark. Obviously large projects with higher output can justify the cost associated with siting a further distance from the shoreline.

It is not possible to determine the distance beyond which transmission lines would be economically infeasible. Such distances can vary considerably based on the size of the project, transmission voltage selected, type of transmission voltage (alternating current [AC] versus direct current [DC]) and the volatile cost of electricity that factors into overall project revenues. Other factors influencing potential transmission line length in the ocean include geological conditions in the area, the environmental sensitivity of the location, and the onshore transmission line length required to an onshore interconnect. AC is the preferred method of transmission of electricity in underwater cables up to roughly 15 miles in length because of its lower cost compared to DC. Once beyond approximately 15 miles, DC current is required for technical reasons. DC cables are capable of serving locations out to and beyond the 200-mile limit offshore, but require costly converters to change current back to AC for on-land transmission (Estey 2006).

Wave height is also a consideration in siting of a wind farm, though somewhat less important than those criteria previously described. Areas with higher wave energy can require more substantial foundations or structural reinforcement than low energy areas, and thus can be more costly.

4.2.4 Mapping Results

The key offshore screening criteria have been plotted on a map provided in Appendix D – Figure D-3. Inventory of Reasonably Foreseeable Energy Siting: Offshore Wind Turbines. These criteria include water depth (5 to 20 m) for locations that are technically foreseeable and macro-economically foreseeable. Depths from 0 to 5 m and 20 to 45 m are defined as being technically foreseeable, but with unknown economics. Other criteria include location of bedrock, and wind speed. Higher wind speed zones will deliver higher power yields, but almost all of the Massachusetts offshore area is capable of yielding viable wind speeds for a wind farm. Actual wind speed requirements vary depending on the specific attributes of a project (i.e., MW capacity of a project, height of turbines, overall project cost, and financing). The lowest wind speeds are in the inner harbors, estuaries, and small bays of the Massachusetts shoreline. The highest wind speeds are furthest seaward from shore. Figures D-3 shows locations out to 40 miles off the coast of Wellfleet, which are well beyond the locations that have shallow enough depths (up to 45 m) and remain reasonably foreseeable in terms of their construction. At depths greater than 45 m, the high economic cost of construction precludes any reasonably foreseeable Projects during the study period of the project.

4.3 Wave Turbine Technology

4.3.1 General Description

According to the EERE, wave turbine technology can be defined as the following (USDOE EERE 2006):

> Wave energy conversion devices create a system of reacting forces, in which two or more bodies move relative to each other, while at least one body interacts with the waves. The body moved by the waves is called the *displacer*, while the body that reacts to the displacer is called the *reactor*. There are many ways that such a system may be configured, including: oscillating water columns (OWC), point-absorbers, attenuators, and overtopping devices.

Several types of wave energy conversion devices exist. The most well known conversion devices are described below (USDOE EERE 2006).

Terminator – A terminator is any structure that extends perpendicular to the predominant wave direction. One example of a terminator is a breakwater – essentially, a wall. However, a breakwater merely reflects or diverts the energy of oncoming waves without capturing any of that energy. Some form of displacement-reaction must be employed to capture the power that would otherwise be reflected or absorbed by the terminator. An

OWC is one example of a device designed to convert the energy captured by a terminator into electricity.

Oscillating Water Column – An OWC consists of a partially submerged structure (the collector) which is open to the sea below the water surface so that it contains a column of water with air trapped above it. As waves enter and exit the collector, the water column moves up and down and acts like a piston, pushing the air back and forth. The air is channeled towards a turbine and forces it to turn, generating electricity (e.g., Energetech's *Oscillating Water Column*).

Point-absorber – Whereas a terminator is designed to absorb energy coming predominantly from one direction, a point absorber is a floating structure that absorbs energy from all directions by virtue of its movements at or near the surface of the water. The amount of power available for capture may be maximized by designing the device to resonate by moving with larger amplitudes than the waves themselves (e.g., AquaEnergy's *AquaBuOY*).

Attenuator – Like a terminator, an attenuator is a long floating structure. However, unlike a terminator, an attenuator is oriented parallel to the predominant direction of travel of the waves. It rides the waves like a ship, extracting energy by virtue of restraints at the device's bow and along its length (e.g., Ocean Power Delivery's *Pelamis*).

Overtopping Devices – An overtopping device is essentially a floating reservoir, a partially-submerged structure consisting of walls over which waves topple, filling the reservoir and creating a head of water which turns hydro turbines at the bottom of the reservoir as the water is released back into the ocean (e.g., *Wave Dragon*).

In addition to the number of conversion devices, the location or placement of wave energy conversion devices are varied and include shoreline, near to shore and offshore locations. Further, the way in which a device is fixed to a site can also vary. Ways in which to fix a device to a site include bottom-mounted devices that are fixed to a seabed by a static member and floating devices that are anchor moored to the seabed.

4.3.2 Current Status of Technology

At present there are several manufactures that have wave energy devices in the testing phase or close to commercial development phase. Accordingly, we have deemed this technology reasonably foreseeable from a technical standpoint. Table 4-6 summarizes the current manufactures of wave turbines and their specifications and siting criteria.

Table 4-6. Wave Energy Conversion Device Manufacturers that Responded to Request for Information							
Company (1)	**Device Length (m) (1)**	**Device Width (m) (1)**	**Device Weight (tons) (1)**	**Avg Power (kW) (1)**	**Principal of Operation (1)**	**Power Train (1)**	**Siting Depth (m) (based on Proposed or Existing Projects)**
Ocean Power Delivery	120	4.6	380	153	Floating Attenuator	Hydraulic	> 50 (2) (Portugal)
Energetch	25	35	450	259	Bottom mounted Terminator – OWC	Air Turbine	20 to 30 (Based on RI project) (3)
Wave Dragon	150	260	22,000	1,369	Floating overtopping Ramp	Low Head Hydro	20 to 30 (Based on Milford Haven, UK project) (4)
Wave Swing	9.5	9.5	NA	351	Bottom mounted Point Absorber	Linear Generator	80-90 (5) (Portugal)
WaveBob	15	15	440	131	Floating Point Absorber	Hydraulic	NA
Aqua Energy	6	6	22	17	Floating Point Absorber	Water Pump	50 to 75 (Based on Makah Bay project) (6)
OreCON	32	32	1,250	532	Floating OWC	Air/Hydraulic	NA
Independent Natural Resources Inc	5.4	5.4	112	16	Bottom mounted Point Absorber	Water Pump	NA

Source:
(1) (Bedard et al. 2005)
(2) (Scott 2006)
(3) (Enertech 2006)
(4) (Wave Dragon 2006)
(5) (AWS Ocean Energy 2006)
(6) (AquaEnergy Group Ltd. 2006)

4.3.3 Potential Candidate Siting Areas Criteria

Wave Height

One key siting criterion devices is wave height. Wave height factors in to the determination of the wave power density (kW/m) available at any particular location, the amount of wave energy that can ultimately be produced, and the potential profitability of a site. NOAA tracks wave height in terms of "significant wave height," which is equal to the average height of the highest one-third of waves recorded in a 12-hour period. In Massachusetts waters and out to 200 miles, NOAA monitors significant wave height at only four buoys. This is because wave height in general does not vary significantly in offshore waters. The Table 4-7 summarizes significant wave height.

Table 4-7. Significant Wave Height		
NOAA Buoy ID	**Range of Significant Wave Height (m)**	**Time Period**
44003	0.2 to 4.1	3/1979 to 2/1984
44013	0 to 1.9	6/1986 to 12/2001
44018	0.3 to 3.8	8/1982 to 12/2001
BUZM3	0.3 to 2.1	10/1990 to 12/2001
Source: NOAA Buoy Information		

The table above shows that there is little difference in significant wave height between the two outer buoys located more than 50 miles apart (NOAA Buoy ID 44003 and 44018) as shown on Figure D-4. Inventory of Reasonably Foreseeable Energy Siting: Wave Energy in Appendix D. The two locations near the shore, are sheltered from wind (and thus wave energy) when the wind is blowing from certain directions as a result of Cape Cod (NOAA Buoy ID BUZM3 and 44013). These two nearshore locations have approximately half the significant wave height as the offshore locations.

Water Depth

Water depth requirements vary considerable depending on the type of wave technology (see Table 4-6). In general, the wave energy generation technologies can be employed beginning at depths of 20 m and up to 90 m. Ocean Power Delivery states that its system can be employed at any locations where depth is greater than 50 m (Scott 2006).

Bedrock

Most of the wave energy devices require an anchoring system. Developers are likely to avoid bedrock locations as they can be problematic to anchoring, unless the location is in a particularly good site in terms of access to transmission lines or other criteria.

Distance to Shoreline

Distance of wave turbines sites to the shoreline can be a particularly influential factor in the overall cost of wind turbine installation, and can take on large percentage of overall project cost for smaller wave turbine developments. A typical wave energy project has a network of cables connecting the individual turbines and a buried or covered transmission cable which brings the electricity generated at sea to the power grid onshore. Installing the transmission system and the cost associated with maintenance and repair tends to be significantly greater the further a project is from the shore.

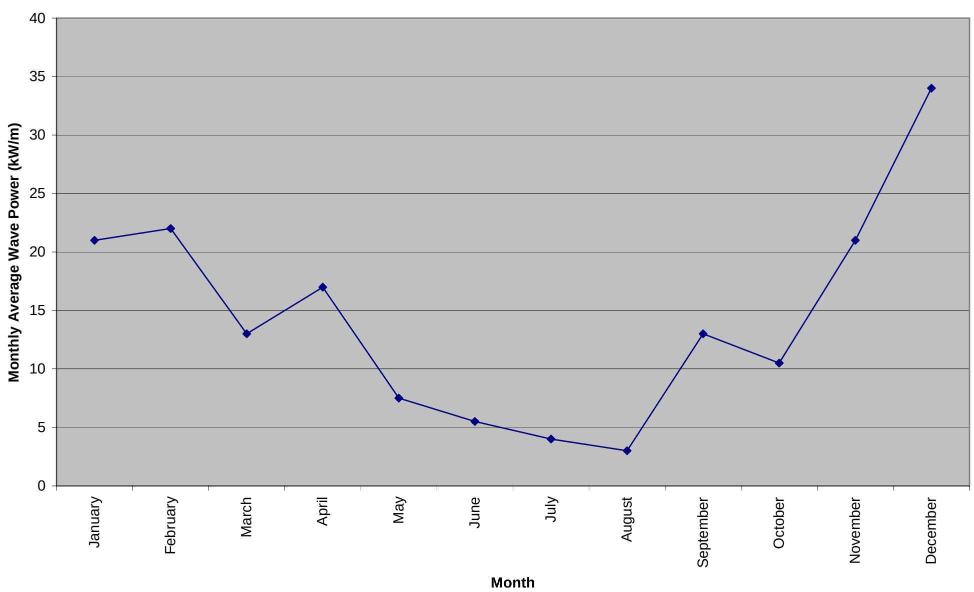
4.3.4 Mapping Results

As provided in Appendix D – Figure D-4. Inventory of Reasonably Foreseeable Energy Siting: Wave Energy, the mapping results show the various locations that different types of wave turbines can be installed based on their water depth. Wave height data is very limited, but it can be assumed that offshore locations will have a significant wave height ranging from 0.2 m to about 4.1 m, and will be reduced closer to shore by the sheltering effects of land. Developers will choose sites based on where by they can achieve the highest possible wave height given the technology depth requirements, and yet still be located close enough to the shoreline to minimize transmission line costs, construction costs, and maintenance costs. EPRI conducted a feasibility study on wave energy and chose the area off Truro as having the highest wave energy, though noted this was still half the wave energy of sites on the west coast of the United States (Bedard 2005). The map area shows out to approximately 80 miles off the coast of Wellfleet, beyond which it would be highly unlikely that any incremental wave height increase with distance from the shore would outweigh the added cost of transmission line requirements and other costs.

The information shows that the further ones goes away from the sheltering effects land has on wind and wave energy, the greater the overall significant wave height. As there are only four NOAA wave height monitoring stations, TRC did not attempt to interpolate the wave heights between the four points, as it would not yield accurate information.

The average power density at the two NOAA buoys to the southeast of Cape Cod (NOAA ID 44003 and 44018) is approximately 14 kW/m. As this is only half the average power density on the west coast of the United States, the offshore areas of Massachusetts are less likely for development of this technology. TRC's conversation with a wave energy manufacturer confirmed that the Massachusetts coastline is only a marginal location for this activity (Scott 2006). Moreover, wave energy in the summer months is only half that of the winter months (see Figure 4-3). At present, TRC is not aware of any plans to build a wave turbine off the coast of Massachusetts, and conclude from a macro-economic standpoint that it is unlikely to occur in the next ten years.

Figure 4-3. Monthly Average Wave Power Flux (kW/m)



Source: (Previsic et al. 2004) Information supporting the graph came from NOAA Buoy ID 44018.

4.4 Offshore LNG

4.4.1 General Description

LNG provides one percent of the United States' natural gas supply, a figure that could triple by 2020, according to the Energy Information Administration (EIA). The ability to convert natural gas to LNG, which can be shipped on specially built ocean tankers, provides access to the world's largest underutilized natural gas resources.

Access to LNG is critical as natural gas now accounts for about one quarter of all energy used in the United States. Residential use accounts for 22 percent, with more than 60 million homes employing natural gas for heating, cooling and cooking. Industry consumes 40 percent and the business sector 15 percent. Some 14 percent is used to generate electricity. Natural gas also serves as the raw material to make paint, plastics, fertilizer, steel, fabrics, glass, and numerous other products (EIA 2006).

4.4.2 Current Status of Technology

In general, there are five basic configurations of LNG terminals being considered today for siting at U.S. offshore locations. They are: 1) Gravity Based Structure (GBS) supported firmly from the sea bottom; 2) Floating Storage and Regasification (usually a specially fitted LNG tanker with regasification equipment); 3) Submerged Turret Loading™ (STL™) Buoy System; 4) conventional fixed platform based facility supported firmly on a jacket from the sea bottom; and 5) HiLoad LNG Regas. These are described in further detail below (Northeast Gateway 2005; Pepper et al. 2004).

Gravity-Based Structures (GBS)

Similar to land-based LNG storage and regasification terminals, the GBS terminals are designed for the storage of LNG on fixed platforms in relatively shallow water.

The components of a GBS terminal design are as follows: a reinforced concrete structure embedded in the ocean bottom, LNG storage tanks, high-pressure pumps, vaporizer equipment, a transfer meter, and a subsea pipeline. The high-pressure pumps, LNG vaporizers, and transfer metering station are located on the platform of the concrete structure that remains above water at all times.

In the operations phase, LNG ships typically would offload LNG to the GBS terminal via two berths with loading arms on each side. The LNG ship pumping capacity, which can typically transfer a cargo of 145,000 m^3 in 12 to 14 hours, controls cargo offloading. The complete tanker unloading cycle is approximately 24 hours, including berthing, hook-up, offloading, disconnect, and unberthing.

Floating Storage and Regasification Units (FSRU)

Floating storage and regasification units are specialized LNG vessels that store and regasify LNG onboard. For the Broadwater Energy Project, the proposed FSRU is 1,250 feet long (381 m) and 200 feet (61 m) wide (Broadwater Energy 2006). Conventional LNG vessels would transport LNG to the FSRU, and a ship-to-ship transfer of LNG would occur between the conventional vessels and the FSRU, where it would be stored, regasified, and then transported to onshore markets through new pipeline to the shore or connection to an existing offshore pipeline system. The FSRU design for Broadwater Energy provides the capability of receiving and storing approximately 350,000 m^3 of LNG. Because the terminal is a floating vessel, it can be redeployed at a different geographic location (assuming available pipeline connections to shore).

Submerged Turret Loading™ (STL™) Buoy System

This technology involves an offshore gas delivery system, typically consisting of a mooring buoy system, pipeline end manifold (PLEM), flexible riser, and an undersea pipeline to shore. The LNG is transported on a conventional LNG carrier that has been modified to include onboard regasification equipment and a docking compartment for attaching the buoy. After the LNG is regasified, it is transferred off the vessel through a submerged turret buoy and flexible riser leading to a seabed PLEM and natural gas pipeline. The system design can utilize a variety of anchors, but suction-piled mooring anchors are the preferred option to hold the buoy in place, whether it is connected or unconnected to a transport and regasification vessel. When not in use, the buoy would drop and remain at a depth of approximately 80 to 100 feet (24 to 30 m) below the surface of the water, and above the seabed until retrieved by the vessel. Current Energy Bridge™ vessel design provides for the transport of approximately 138,000 m^3 of LNG and delivery of natural gas to downstream infrastructure at a rate of 0.5 billion cubic feet per day (Bcfd) or more (Northeast Gateway 2006).

Platform-Based Unit

The platform-based unit design would consist of construction or re-using an offshore platform adapted to include LNG unloading arms and equipment. This concept would require locating the high-pressure LNG pumps and vaporizer on the offshore jacket structure. This option would not include significant offshore LNG storage and would rely on directly vaporizing LNG and exporting it directly into the pipeline. The LNG carrier would be moored adjacent to a platform with fixed unloading arms, a short pipe trestle and breasting/mooring dolphins.

HiLoad LNG Regas

HiLoad LNG Regas is a specially designed floating unit that can connect to a LNG carrier, unload , and re-gasify the LNG. This technology utilizes a single point mooring buoy, the HiLoad with integrated LNG re-gasification system, remote power controls, metering, a gas treatment facility, and a connection to pipeline infrastructure. Using the

SPM, the LNG carrier can weather vane 360 degrees. The HiLoad LNG Regas requires approximately the same water depth as the floating storage and re-gasification units.

The following table shows existing, proposed, and known potential offshore LNG facilities in the United States:

Table 4-8. Existing, Approved, Proposed and Potential Offshore LNG Facilities in the United States*

Project Name	Location	Capacity (Bcfd)	Proponent
Existing			
Gulf Gateway Energy Bridge	Gulf of Mexico	0.5	Excelerate Energy
Approved			
Gulf Landing	Offshore Louisiana	1.0	Shell
Proposed			
Broadwater Energy	Long Island Sound	1.0	TransCanada/Shell
Cabrillo Port	Offshore California	1.5	BHP Billiton
NA	Offshore So. California	0.5	Crystal Energy
NA	Offshore Louisiana	1.0	Main Pass McMoRan Exp.
Compass Port	Gulf of Mexico	1.0	ConocoPhillips
Beacon Port Clean Energy Terminal	Gulf of Mexico	1.5	ConocoPhillips
Neptune LNG	Offshore Boston, Massachusetts	0.4	Tractebel
Northeast Gateway	Offshore Boston, Massachusetts	0.8	Excelerate Energy
Bienville Offshore Energy Terminal	Gulf of Mexico	1.4	TORP
Potential			
NA	Offshore California	0.75	Chevron Texaco
OceanWay	Offshore California	0.75	Woodside Natural Gas
Safe Harbor Energy	Offshore New York	2.0	ASIC, LLC
NA	Offshore Florida	NA	Calypso SUEZ
Pacific Gateway	Offshore California	0.6	Excelerate Energy
Esperanza Energy	Offshore California	NA	Tidelands

Source: (FERC 2006a; FERC 2006b)
*As of May 9, 2006
NA = Not available

4.4.3 Potential Candidate Siting Areas Criteria

Water Depth

Water depth is a factor which normally determines the type of configuration that is likely to be utilized for offshore LNG terminals. Generally, there is a draft requirement of around 40 to 44 feet for the LNG carrier. Therefore, 50-foot water depth is a minimum requirement for any of the LNG technologies described in above in Section 4.11.

The concrete GBS based terminal configuration described above is ideal for 15 to 23 m of water depth. As the water depth increases above 30 m, economic evaluations must be carried out based on the type and size of the structure, local soil and seismic conditions, and met-ocean data. GBS based LNG terminals have been considered for a water depth as much as 36 m, but current designs have generally shown unfavorable economics at greater water depths. In additions, a suitable location for graving dock must be considered for GBS construction (Pepper et al. 2004).

The floating storage and re-gasification unit utilizes a permanently moored ship, which serves as an unloading area, an LNG storage area, and a vaporization plant. This is currently being proposed for the Broadwater LNG Project in Long Island Sound. The technology either requires depths between 15 to 30 m (as in the case of their Long Island Project) or requires depths deeper than between 70 m and up to 1,000 m. The technology is not feasible between 30 and 70 m (Cameron 2006).

Fixed structure platform based LNG terminals can be considered for water depth of 15 m to above 100 m.

Proximity to Onshore/Offshore Pipeline Distribution System

Natural gas can be transported very long distances via sub-sea gas lines. For instance, the existing underwater Algonquin HubLine is approximately 29 miles long and the previously proposed underwater Blue Atlantic Gas Pipeline Project from Nova Scotia to New York would have been 750-miles long (see Section 4.5). Accordingly, there is no gas transportation based technological limitation with respect to how far an LNG facility could be sited from the shoreline. Rather, such decisions will be based on the macro-economics of each developer's project objectives with respect LNG importation.

Based on existing proposals, an obvious location to site an offshore LNG facility is within close proximity to the Hubline Project. The three LNG projects proposed, which include the Neptune LNG Port, Northeast Gateway Deep Water Port, and the Brewster Island LNG Storage Facility, have interconnection lines that are approximately 8.6 miles long, 16.1 miles long and 1.2 miles long, respectively. However there is no clear and discrete economic cut off distance from a gas line, beyond which, an LNG facility would not be economically viable. The Economic interconnection distance to an onshore or offshore gas line will depend on a complex array of factors, which may include: the character of the underwater substrate (i.e., presence of large rocks and or bedrock versus smaller unconsolidated sediments); the price of natural gas, the type of offshore LNG facility proposed, the desired gas marketplace (i.e., Metropolitan Boston, South Shore of Boston, Cape Cod, etc.); the financial funding capacity of the proponent; the proximity to onshore gas lines and cost of onshore access routes to those gas lines; the transportation cost charged by owners of gas lines; the capacity of offshore and onshore gas lines; and the redundancy of those gas lines (i.e., number of gas transport line options available to address contingencies). As it is not possible to address these factors, no siting criteria based on gas transmission line interconnection length are possible at this point.

4.4.4 Mapping Results

The results of the mapping show there are various locations along most of the Massachusetts shoreline that are suitable in terms of water depth for siting various types of LNG facilities (see Appendix D – Figure D-5. Inventory of Reasonably Foreseeable Energy Siting: Offshore LNG). Developers will seek to find an area that is closest to their desired gas market delivery point with respect to their chosen technology's required water depth. For instance, in the case of the Northeast Gateway Energy Bridge Deepwater Port, the developer sought a location close to their desired market place (metropolitan Boston area with distribution via the HubLine) while still maintaining the optimal water depth of approximately 220 to 320 feet. That project also sought to avoid bedrock for the installation of the interconnecting gas line, and minimization of impacts with respect to ocean uses and environmental impacts.

The map shows locations out to 60 miles off the coast of Wellfleet, beyond which it would be unlikely that a project would be sited due to the higher cost of construction, operations, and the natural gas interconnection line.

4.5 Offshore Gas Lines

Discussion of the possibility of further offshore gas lines is also part of this project scope. At present TRC is unaware of offshore lines being proposed or planned (other than those interconnection lines to the LNG facilities discussed in the report on existing and proposed energy facilities and provided here as Appendix A.

Possibilities for further development of offshore gas lines are difficult to predict due to the complexity of the natural gas distribution market and uncertainties in demand. Furthermore, developers of such projects keep such plans confidential due to the competitive nature of the industry and thus information on long range plans for offshore gas lines is difficult if not impossible to obtain. We note that it is at least possible that a similar project to the Blue Atlantic Gas Pipeline Project could be proposed again. The Blue Atlantic Gas Pipeline Project was proposed by El Paso Energy several years ago, and would have involved a 1,000 million cubic feet per day (MMcf/d), 750-mile, 36-inch pipeline that would run from Nova Scotia to New York (EIA 2004). The project has since been cancelled. At this time, TRC is not aware of plans for other future offshore gas pipelines off the coast of Massachusetts, and we can not provide further information about future offshore gas pipeline work.

5.0 GAP ANALYSIS

One minor data gap in this study is the lack of wave energy data recorded by NOAA monitoring buoys. As noted previously, there are only four monitoring buoys, and thus information on wave height at various locations in offshore waters is not available. While this affected the ability to map wave heights, further information is not necessary for CZM's planning purposes. EPRI's feasibility study showed that the area off Truro, was likely to have the highest wave energy in Massachusetts, yet even this site had a wave energy less than half that of areas on the west coast of California. Therefore, further development is unlikely to occur here and the data is not needed. If a project were to occur, the developer could make rough approximations of wave energy based on the buoy data, and if necessary conduct modeling to better understand wave energy at a site specific location.

With respect to NOAA tidal velocity monitoring stations, there are a considerable number of such monitoring locations, but current velocity can vary dramatically depending on site specific locations. Accordingly, though we have provided information at the most promising tidal monitoring sites, there remains some uncertainty about tidal currents nearby these areas because tidal speed can change substantially within a very short distance based on underwater bathymetry and shoreline configuration. However, given the low tidal speed relative to other areas in the country, the development of additional TISEC devices is not likely to occur.

Although not technically a data gap, it is important to note that with all the mapping information, the scale at which it is presented varies between technologies and between criteria. TRC did not undertake an effort to develop any new criteria data, but rather relied on available existing information. It is possible that large scale data collection efforts taken by others to develop the information TRC obtained for mapping purposes, were inadequate to identify small scale features. For instance, some areas of constricted flow within the Boston Harbor Islands are well known to generate high current velocities, such as Hull gut, but at the scale necessary for a tidal current power project, this small area is not worthy of consideration, plus there would be numerous conflicts with other uses of this area.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In general, the research shows that state has marginal resources in terms of wave energy and tidal power relative to other locations across the country. For instance, Massachusetts has approximately half the wave energy per meter as the west coast of the United States (see Figure D-4 in Appendix D) and there are many other TISEC siting locations in the United States and or Canada that have tidal energy levels well exceeding resources in Massachusetts. Accordingly, development may be less likely in this area during the next decade compared to other locations, though we note that a TISEC project has indeed now been proposed in Massachusetts as shown on Figure D-2. in Appendix D.

With respect to wind, the research shows that Massachusetts has excellent offshore wind resources and additional offshore wind projects can be expected (see Figure D-3 in Appendix D). The current most economical development is in waters that are -5 to -20 m deep. Within this water depth, siting decisions will hinge on the general tradeoff of maximizing wind speed versus minimizing the distance to an on land interconnection and also consideration of environmental and human use factors.

The mapping work (see Figure D-5 in Appendix D) also shows that there are many other locations where LNG facilities could be sited based on their water depth requirements together with proximity to the existing pipeline distribution system, though the types of LNG facility, number of LNG facilities and their locations are heavily dependent on market forces, which are extremely difficult to assess. Clearly the current level of LNG facility proposals in Massachusetts indicates a strong market need, but one that may be filled by already planned projects.

There is additional financial incentive for some of these technologies to be sited and developed in Massachusetts due to the Renewable Energy Portfolio Standard (RPS). In April 2002, the Division of Energy Resources (DOER) set forth regulations (225 CMR 14.00) which require all retail electricity providers in the state of Massachusetts to utilize a specified percentage of new renewable energy sources for their power supply (DOER 2006). The schedule was set to start at 1 percent in 2003 and increase to 4 percent by 2009.

State RPS requirements allow owners of clean energy facilities constructed after 1998 to sell their RECs under a variety of pricing and contract terms to provide additional monetary benefits beyond what a company would receive as a non-renewable energy generator. This provides an added incentive for developers to site renewable energy facilities in Massachusetts. Owners and developers of clean energy facilities can take advantage of the Massachusetts Technology Collaborative's (MTC) Green Power Partnership, which purchases RECs from and provides risk-hedging contracts to developers of RPS-qualified projects and to companies that purchase RECs from eligible facilities. The program encourages generators and brokers to enter into long-term contracts for RECs, either directly with MTC or with other market participants, in order to create a guaranteed revenue stream and improve prospects for project financing. (MTC 2006)

6.2 Recommendations

Based on the research results, the analyses performed and the resulting mapping products, TRC has the following recommendations for incorporating the results of this project into ocean planning efforts.

6.2.1 Integrate Mapping Effort with Human Use Data and Environmental Data

The mapping products developed under this project need to be integrated with the human use mapping project currently underway by CZM, in such a way that the information is useful. One way to do this would be to overlay the two maps on each other so that human use limitations (i.e., shipping channel locations, special whale watching areas, fishing sites, etc.) can be plotted with the reasonably foreseeable sites for offshore energy facilities identified in this study. This could help planners in identifying optimal sites for energy facilities from both a human use and technological standpoint. We recommend that TRC and the developers of the human use data be included in the coordination of this effort.

As well, in responding to the Request for Proposals, CZM and TRC acknowledged that the criteria used for the mapping would be limited in terms of taking into account environmental resources and sensitive areas, relative to those areas that are technically feasible for a given technology. However, this limitation is a shortfall in the overall process of assessing environmental suitability for identifying potential candidate siting areas of offshore energy facilities. Accordingly, we recommend a similar mapping project that: 1) maps the location of environmental resources; 2) discusses in general the environmental impacts that can be expected as a result of the technologies; and 3) maps locations best suited for siting based on environmental issues (assuming this has not already been done or is in process). Integration of this environmental information with the human use data and siting areas found under this project should be via a map that incorporates the full range of human use, technological and environmental siting constraints.

6.2.2 Dissemination of Information

The report and maps should be made available to individuals within the EOEA, including CZM, other state agencies, and individuals who are interested in taking part in the development of policies that address offshore development of renewable energy. Local, state and federal environmental permitting agencies that do not necessarily have a planning or policy development focus may also find this information useful in order to understand and prepare for the review of future offshore energy projects. A summary presentation of this material to applicable agencies and or the public would be one effective way to introduce this information to interested parties. A presentation would allow the Commonwealth the opportunity to explain the results of the study, discuss the state's goals with respect to its planning efforts for offshore development, and allow input from stakeholders into the planning efforts.

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Appendix A

Inventory of Existing and Proposed Offshore Energy Facilities and Associated Infrastructure in Massachusetts

Appendix B

Potential Candidate Siting Areas Criteria Tables

Potential Candidate Siting Areas Criteria Tables: Wind Turbine Siting				
Relative Ranking of Criteria by Importance (1)	**Siting Criteria (2)**	**Sub-Criteria**	**Notes**	**Data Source**
1	Wind	Wind Speed Categories at 70 Meters: 15.7 to 16.8 mph 16.8 to 17.9 mph 17.9 to 19.0 mph 19.0 to 20.3 mph	Higher wind speed zones will deliver higher power yields, but almost all of Massachusetts offshore area is capable of yielding viable wind speeds for a wind farm. Actual wind speed requirements vary depending on the specific attributes of a project (i.e. MW capacity of a project, height of turbines, overall project cost, and financing). To assist in planning and siting uses in the future, TRC has shown the location of different wind zones (See Appendix D - Figure D-3. Inventory of Reasonably Foreseeable Energy Siting: Offshore Wind Turbines)	Available wind maps were obtained from AWS True Wind (http://www.awstruewind.com).
1	Depth	5 to 20 meters (optimal)	This is the water depth range that is technically foreseeable and macro-economically foreseeable, and is the most geographically limiting siting criteria in this study.	(Alkinton, 2006, Musial, 2006; Manwell 2006; Olmsted 2006)
1	Depth	0 to 5 meters and 20 to 45 meters	These areas are technically foreseeable with unknown macro-economics.	(Alkinton, 2006; Musial, 2006; Manwell 2006; Olmsted 2006).
2	Bedrock	Presence of Bedrock at or near the surface	Requires costly drilling and or foundations	See metadata: U.S. Geological Survey 200506 CONMAPSG: Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin
2	Distance to on-shore electrical interconnection	-	Though distance to onshore electrical interconnection is an important siting factor, it is not possible to assume a macro-economic cut off distance beyond which transmission lines would not be economically feasible. Such distances can vary considerably based on the size of the Project, transmission voltage selected, type of transmission voltage (alternating current (AC) versus direct current (DC)) and the volatile cost of electricity that factors into overall Project revenues. Other factors influencing the maximum transmission line length in the ocean include geological conditions in the area, the environmental sensitivity of the location, and the onshore transmission line length required to an onshore interconnect.	Shoreline Location from CZM Human Use Data. See metadata

Notes:

(1) Relative importance of ranking criteria within a technology can vary widely depending on the size of the Project, the developer's goals, cost of electricity. All criteria have the potential to be critical. We have ranked them based on our professional judgment. Some rankings are equal and were given the same number.

(2) See Figure D-3 in Appendix D for an Inventory of Reasonably Foreseeable Energy Siting: Offshore Wind Turbines in Massachusetts.

Potential Candidate Siting Areas Criteria Tables: TISECs Siting

Relative Ranking of Criteria by Importance (1)	Siting Criteria (2)	Sub-Criteria	Notes	Data Source
1	Current Speed	Minimum of 3 knots	TRC mapped all sites in Massachusetts with a maximum 3 knot current speed or better using the NOAA Tide Current Tables for the Atlantic Coast of North America. The velocity of 3 knots was chosen to capture the very best locations in Massachusetts. This tidal velocity is well below the maximum current speed for which most turbines are designed to operate (roughly 4 to 6 knots – based on the rated speed of the turbine and is below the approximate four knot speed suggested as a very rough proxy for minimum viable current speed for this technology (Bedard, 2006). We note also that it is below the overall average maximum speed of all the proposed sites in the United States combined of 3.5 knots. TRC chose the current speed of 3 knots or more, in order to be inclusive of the best sites in Massachusetts.	Bedard, 2006 NOAA Tide Tables for North America. 2006 FERC Preliminary Permit Applications of Verdant, NYTidal, MATidal, METidal, NHTidal, Tidwalker Associates, WATidal, ORTidal, Florida Hydro
2	Bedrock	Presence of Bedrock at or near the surface	Can be problematic in terms of anchoring and add to project cost.	See metadata: U.S. Geological Survey 200506 CONMAPSG: Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin
2	Distance to on-shore electrical interconnection	-	Though distance to onshore electrical interconnection is an important siting factor, it is not possible to assume a macro-economic cut off distance beyond which transmission lines would not be economically feasible. Such distances can vary considerably based on the size of the Project, transmission voltage selected, type of transmission voltage (alternating current (AC) versus direct current (DC)) and the volatile cost of electricity that factors into overall Project revenues. Other factors influencing the maximum transmission line length in the ocean include geological conditions in the area, the environmental sensitivity of the location, and length of the onshore transmission line interconnection required.	Shoreline Location from CZM Human Use Data. See metadata

Notes:

(1) Relative importance of ranking criteria within a technology can vary widely depending on the size of the Project, the developer's goals, cost of electricity. All criteria have the potential to be critical. We have ranked them based on our professional judgment. Some rankings are equal and were given the same number.

(2) See Figure D-2 in Appendix D for an Inventory of Reasonably Foreseeable Energy Siting: Tidal In-Stream Energy Conversion Devices in Massachusetts.

Potential Candidate Siting Areas Criteria Tables: Wave Energy Siting				
Relative Ranking of Criteria by Importance (1)	**Siting Criteria (2)**	**Sub-Criteria**	**Notes**	**Data Source**
1	Wave Height	Significant Wave Height	NOAA tracks wave height in terms of "significant wave height", which is equal to the average height of the highest one third of waves recorded in a 12 hour period. Minimum wave energy/height for viable operation was not available from manufactures except from Ocean Power Delivery which stated 15kW per meter statistic was their approximation of economic viability. Below that, locations are clearly marginal. The site off of Truro, (one of the best in Massachusetts for wave power) had an ocean power rating of only 13.8 kW/m and is therefore considered marginal.	See Metadata: Offshore NOAA buoys
1	Depth	Required Depths for Each Manufacturer: Ocean Power Delivery > 50 Meters (1) Energetch 20 to 30 Meters (2) Wave Dragon 20 to 30 Meters (3) Wave Swing 80 to 90 Meters (4) Aqua Energy 50 to 75 Meters (5)		(1) Scott, 2006 (2) http://www.energetech.com, ` (3) http://www.wavedragon.co.uk (4) http://www.waveswing.com/ (5) http://aquaenergygroup.com/projects/index.php
2	Bedrock	Presence of Bedrock at or near the surface	Can be problematic in terms of anchoring and add to project cost.	See metadata: U.S. Geological Survey 200506 CONMAPSG: Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin
2	Distance to on-shore electrical interconnection	-	Though distance to onshore electrical interconnection is an important siting factor, it is not possible to assume a macro-economic cut off distance beyond which transmission lines would not be economically feasible. Such distances can vary considerably based on the size of the Project, transmission voltage selected, type of transmission voltage (alternating current (AC) versus direct current (DC)) and the volatile cost of electricity that factors into overall Project revenues. Other factors influencing the maximum transmission line length in the ocean include geological conditions in the area, the environmental sensitivity of the location, and the onshore transmission line length required to an onshore interconnect.	Shoreline Location from CZM Human Use Data. See metadata

Potential Candidate Siting Areas Criteria Tables: Wave Energy Siting				
Relative Ranking of Criteria by Importance (1)	**Siting Criteria (2)**	**Sub-Criteria**	**Notes**	**Data Source**
Notes: (1) Relative importance of ranking criteria within a technology can vary widely depending on the size of the Project, the developer's goals, cost of electricity. All criteria have the potential to be critical. We have ranked them based on our professional judgments for general informational purposes. Some rankings are equal and were given the same number. (2) See Figure D-4 in Appendix D for an Inventory of Reasonably Foreseeable Energy Siting: Wave Energy in Massachusetts.				

Potential Candidate Siting Areas Criteria Tables: LNG Siting				
Relative Ranking of Criteria by Importance (1)	**Siting Criteria (2)**	**Sub-Criteria**	**Notes**	**Data Source**
1	Depth	Depth Criteria Depending on LNG Technology Type GBS Based Terminal Configuration 15 – 30 meters (1) Fixed Structure Platform 15 to 100 meters (1) Floating Storage and Re-gasification Unit 15 to 30 meters (2) Floating Storage and Regasifiction Unit Deeper Technology (less favorable) 70 to 1000 meters (2) Submerged Turret Loading Buoy System 70 to 100 meters (1)(3) Submerged Turret Loading Buoy System (less favorable) 100+ meters (3)		1 Pepper, et al, 2004 2 Cameron, 2006 3 New England Gateway Environmental Report
2	Bedrock	Presence of Bedrock at or near the surface	Can be problematic in terms of anchoring and add to project cost.	See metadata: U.S. Geological Survey 200506 CONMAPSG: Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin
2	Distance to on-shore electrical interconnection	-	Though distance to onshore gas interconnection is an important siting factor, it is not possible to assume a macro-economic cut off distance beyond which transmission lines would not be economically feasible.	Shoreline Location from CZM Human Use Data. See metadata

Notes:

(1) Relative importance of ranking criteria within a technology can vary widely depending on the size of the Project, the developer's goals, cost of electricity. All criteria have the potential to be critical. We have ranked them based on our professional judgment. Some rankings are equal and were given the same number.

(2) See Figure D-5 in Appendix D for an Inventory of Reasonably Foreseeable Energy Siting: Offshore LNG in Massachusetts.

Appendix C

Questionnaire and Information Needs Forms

Note on Format of Question and Needs Forms

In some of the following Questionnaire and Information Needs Forms, entry fields were left intentionally blank as specific questions were either not applicable or an answer could not be readily obtained through the contact or available online resources.

The Questionnaire and Information Needs Forms are arranged in alphabetical order by the source contacted.

Appendix D

Oversized Maps

Provided as Separate Attachment

Appendix C

Questionnaire and Information Needs Forms

Note on Format of Question and Needs Forms

In some of the following Questionnaire and Information Needs Forms, entry fields were left intentionally blank as specific questions were either not applicable or an answer could not be readily obtained through the contact or available online resources.

The Questionnaire and Information Needs Forms are arranged in alphabetical order by the source contacted.

American Wind Energy Association
(AWEA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	American Wind Energy Association	Name:	Jeff Brandt
Name / Title:	Lori Jodziewicz, Communications and Policy Specialist	Date and Time of 1st Call:	May 2, 2006
Mailing Address or Web Address:	http://www.awea.org/	Date and Time of 2nd Call:	
Phone Number:		Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Trade Association

2. Type of Technology
   Wind

3. Name of Equipment/Technology Manufacturer(s)
   NA

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? Ms. Jodziewicz had just had a conference call with a large number of wind energy companies to respond to the MMS new Regulations for offshore siting of energy facilities. She summarized the feelings of the wind industry as follows: They did not foresee further offshore wind energy development in the United States because of the lack of locations. Regarding water depth, she feels that the industry is willing to look at depths up to 50 feet. Depths up to 100' may be possible, though very unlikely. She said floating turbines were not even discussed as they are a long way off in terms of feasibility (well more than 10 years). She said to contact the NREL – Walt Musial for further information. She said AWEA's comments on the new regulations are available at OCSConnect.gov and to use the comment reference number RIN 1010-AD30.

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

2. What are optimal siting conditions?

   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

4. Technological Limitations-- water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

   ____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

   ____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

   ____

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Broadwater LNG

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Broadwater LNG	Name:	Jeff Brandt
Name / Title:	Froydis Cameron	Date and Time of 1st Call:	May 22, 2006
Mailing Address or Web Address:		Date and Time of 2nd Call:	
Phone Number:	1-800-798-6379	Other:	

I spoke with Ms. Forydis Cameron, development director for the Broadwater LNG project in Long Island. Their technology utilizes a permanently moored ship, which serves as both an unloading area, an LNG storage area, and a vaporization plant. With respect to water depth, the technology either requires depths between 15 to 30 meters (as in the case of their Long Island Project) or requires depths between 70 meters and 1000 meters. The technology is not feasible between 30 and 70 meters.

Canadian Wind Energy Association (CanWEA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Canadian Wind Energy Association (CanWEA)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.canwea.ca/ Canadian Wind Energy Association Suite 320, 220 Laurier Avenue West Ottawa, Ontario Canada K1P 5Z9 Toll Free: 1-800-922-6932 Phone: 613-234-8716 Fax: 613-234-5642 E-mail: info@canwea.ca	Date and Time of 2nd Call:	
Phone Number:		Other:	Sent email to info@canwea.com on 5/1/06 requesting offshore wind information.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

The Canadian Wind Energy Association (CanWEA) is a non-profit trade association that promotes the appropriate development and application of all aspects of wind energy in Canada, including the creation of a suitable policy environment.

Established in 1984, CanWEA represents the wind energy community – organizations and individuals who are directly involved in the development and application of wind energy technology, products and services.

Our members are Canada's wind energy leaders. They are wind energy owners, operators, manufacturers, project developers, consultants, and service providers, and other organizations and individuals interested in supporting Canada's wind energy industry.

CanWEA's goal is to achieve 10,000 MW of installed wind energy capacity in Canada by 2010.

2. Type of Technology
   Wind power – not specifically offshore though

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?
   http://www.canwea.ca/en/CanadianWindFarms.html

   Link gives installed projects in Canada, but includes onshore wind.

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

The CanWEA website did not provide siting specific studies or information and addressed more national policy and land-based projects.

Cape Wind Associates

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Cape Wind	Name:	Jeff Brandt
Name / Title:	Craig Olmsted, Vice President	Date and Time of 1st Call:	June 21, 2006
Mailing Address or Web Address:		Date and Time of 2nd Call:	
Phone Number:	617-904-3100 x 119	Other:	

Mr. Olmsted said that Cape Wind researched the minimum water depth based on numerous conversations with marine contracts and said they found it was not practicable to install at a water depth much above around approximately -5m. He said cost and feasibility at shallow water depth can vary widely based on a host of factors such as number of turbines, site specific location and economics of the Project, and type of jack-up-barge. He checked his project information and said -4m was the absolute minimum, but if you were just installing one turbine or very few, it may be feasible to do this at a more shallow depth.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

___

___

___

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

___

___

2. What are optimal siting conditions?

___

___

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

___

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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___

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Central Research Institute of Electric Power Industry
(CRIEPI)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Central Research Institute of Electric Power Industry (CRIEPI)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://criepi.denken.or.jp/en/index.html	Date and Time of 2nd Call:	
Phone Number:		Other:	Sent information request email on 4/28/06 using the online form http://criepi.denken.or.jp/en/etc/mailform.html.

The CRIEPI website is not helpful with very little relevant information available to this project, inadequate translation in some pages, and no clear links to better resources. Can't find ocean-based energy specifics anywhere.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) R&D for ensuring stable electricity supply, established in 1951 as a comprehensive research organization for the electric utility industry. Objectives include: Cost reduction and ensuring reliability, creation of integrated energy services, and harmonizing energy and environmental priorities. Headquartered in Tokyo, Japan.

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

____

____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

____

____

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

____

2. Has the technology been installed (if yes, where)?

____

3. Is the technology in operation (if yes, where)?

____

4. Total MWs installed/in operation?

____

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

____

6. Critical flaws or unresolved technical or operational issues?

____

____

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

____

____

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

____

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

____

____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Clipper Wind Power, Inc.

- Liberty Turbine

- Jumbo Wind Turbine

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Clipper Wind Power, Inc.	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.clipperwind.com/ .	Date and Time of 2nd Call:	NA
Phone Number:	805-690-3275 (Corporate Phone Number)	Other:	info@clipperwind.com
Fax Number:	805-899-1115		**Liberty Turbine**

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) wind energy technology company and actively develops wind power generating projects in the Americas and Europe

2. Type of Technology
   Wind energy

3. Name of Equipment/Technology Manufacturer(s)
   2.5 MW Liberty turbine

4. General Description (How Technology Works) The patented technology of the Liberty turbine developed by Clipper substantially increases the efficiency of wind-generated electricity, providing a formidable increase in the potential geographic areas for turbine deployment. The Liberty turbine has certification (Germanischer Lloyd) to international standards.

5. Physical Description – size/aerial extent, MW capacity of a single unit Each turbine can generate 2.5 MW. Horizontal axis, 3 blades, upwind. Typically 65 meter towers with a blade diameter of 70 meters. The diameter of the base of the tower is approximately 12 feet. 80 meter hub height. The Liberty is a variable speed turbine (9.7 to 15.5 rpm). The Liberty has varying designs for Class I, IIa, IIb and IIIa wind classes.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Wind, transmission to grid, generators (4 – Clipper Megaflux® Permanent Magnet), and power converter (IGBT, 4 modules).

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

   ____

2. Has the technology been installed (if yes, where)?

   ____

3. Is the technology in operation (if yes, where)?

   ____

4. Total MWs installed/in operation? Clipper has in excess of 3000 MW of wind development resource in addition to its 3000 MW strategic Midwest site, and is actively adding additional sites (Web 04/11/06). Flying Cloud Project 43.5 MW in northwestern Iowa, in Service in December, 2003. Intrepid, 160.5 MW, went on line in December 2004. Note, these are all land based.

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

   ____

6. Critical flaws or unresolved technical or operational issues?

   ____

   ____

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

   ____

   ____

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? Liberty turbine = $2.5 Million each

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ____

     ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Maintenance Post Commissioning – Once at 500 hours, every 6 months periodic, optional periodic at 12 months.

10/16/05 article, "The turbine is very suited to offshore deployment"

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Clipper Wind Power, Inc.	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.clipperwind.com/	Date and Time of 2nd Call:	NA
Phone Number:	805-690-3275 (Corporate Phone Number)	Other:	info@clipperwind.com
Fax Number:	805-899-1115		**Jumbo Wind Turbine**

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) wind energy technology company and actively develops wind power generating projects in the Americas and Europe

2. Type of Technology
   Wind energy

3. Name of Equipment/Technology Manufacturer(s)
   Jumbo Wind Turbine

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit 7.5 MW (3x times the electricity as the Liberty)

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Wind, transmission.

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation? In article dated 10/16/05, the jumbo wind turbine is proposed and still in the development phase (3x as much electricity as the Liberty)

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? Liberty turbine = $2.5 Million each

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Consumer Energy Council of America
(CECA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Consumer Energy Council of America (CECA)	Name:	Erika Lunn
Name / Title:	Electric Power Program Contact Person: Peggy Welsh Email: pwelsh@cecarf.org Phone: 202-659-0404	Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.cecarf.org/ Consumer Energy Council of America 2000 L St. NW, Suite 802 Washington DC, 20036	Date and Time of 2nd Call:	
Phone Number:	202-659-0404 Email outreach@cecarf.org	Other:	Emailed 4pm 4/28/06

Peggy responded 5/1/06 via email with the following information…

Erika ---
The Consumer Energy Council of America has not undertaken any research in the area of ocean-based energy. Therefore, there is nothing on our website about the subject. I suggest that you contact the Electric Power Research Institute located in Palo Alto, CA as I believe they are doing some research on it. Also, check the U.S. Department of Energy's website to see if DOE has done any R&D on the subject. As you may know, there are several national laboratories that support DOE and one of them might have looked into it. You might try the National Renewable Energy Laboratory in Denver.

Those are my best suggestions. Good luck with your project
Peggy Welsh

Peggy Welsh
Senior Vice President
Consumer Energy Council of America
2000 L Street, NW, Suite 802
Washington, DC 20036
(202) 659-0404
(202) 659-0407(fax)
pwelsh@cecarf.org

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) **The Consumer Energy Council of America (CECA)** is the senior public interest organization in the U.S. focusing on the energy, telecommunications, and other network industries providing essential services to consumers. A non-profit §501(c)(3) organization based in Washington, DC, CECA is dedicated to promoting public policy positions that advance the best interest of residential and small business consumers of essential energy services. Our overarching goal is to provide leadership in shaping public policy guiding essential consumer services. Sub-goals of this are:

   - To educate consumers on the complexities of essential services
   - To become a trusted and valuable resource for policymakers
   - To advocate the policies on behalf of consumers and small businesses
   - To serve as a liaison between different business and industry groups to facilitate positive social or environmental development
   - To produce balanced and informative papers and reports on cutting edge issues
   - To work towards an environmentally responsible energy infrastructure

   The electricity industry faces great challenges to keep the system vibrant, reliable, secure, and more responsive to consumer needs. The CECA Electric Power Program was launched to work towards developing policies that increase system efficiency and provide more options and services to consumers.

2. Type of Technology

   ____

3. Name of Equipment/Technology Manufacturer(s)

   ____

4. General Description (How Technology Works)

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   ____
   ____

5. Physical Description – size/aerial extent, MW capacity of a single unit

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   ____
   ____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

   ____
   ____
   ____

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

The other contacts proposed by Peggy are on the Category I list that J. Brandt is researching.

Additional Information

Edison Electric Institute
(EEI)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Edison Electric Institute	Name:	Jeff Brandt
Name / Title:	Mr. Aria Fishman, Information Specialist	Date and Time of 1st Call:	May 2, 2006
Mailing Address or Web Address:	http://www.eei.org/	Date and Time of 2nd Call:	
Phone Number:		Other:	

Mr. Fishman said EEI mainly would get involved in transmission related issues with respect to renewable offshore energy. He said right now, they are not involved in renewables except for comments that they sent to MMS with respect to transmission requirements.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Energetech

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Energetech	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.energetech.com.au/index.htm	Date and Time of 2nd Call:	NA
Phone Number:	1 (860) 526-9574	Other:	eneamerica@energetech.com.au
		General Inquiries email:	info@energetech.com.au

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Energetech Australia PTY Ltd. Is a renewable energy company.

2. Type of Technology
   Wave conversion technology

3. Name of Equipment/Technology Manufacturer(s)
   Patented Dennis-Auld Turbine

4. General Description (How Technology Works) Energetech has developed a unique technology using an "oscillating water column" (OWC) as a key component. For two decades, the OWC has been the world's foremost wave energy technology, demonstrating proven results in numerous projects. Energetech's technology enhances OWC's commercial viability. In brief, the up-and-down movement of waves forces air to rush into a hollow chamber where it is compressed, turning a turbine and powering the generator. The structure, with its four legs resting on small pads on the ocean floor, is stabilized by cables moored to the seabed.

   To address flows from different directions and at different velocities, the Energetech turbine has adopted a different method, "slower rotational speed with higher torque' improves efficiency and reliability and reduces the need for maintenance. The turbine uses a sensor system with a pressure transducer which measures the pressure exerted on the ocean floor by each wave as it approaches the capture chamber, or as it enters the chamber. The transducer sends a voltage signal proportional to the pressure which identifies the height, duration and shape of each wave. The system will be calibrated to small-scale "noise" from activating it."

5. Physical Description – size/aerial extent, MW capacity of a single unit Port ***Kembla Wave Energy project*** – weighing 485 tons with dimension of 40m by 35m by 18m. ***Greenwave Project in RI*** – structure will measure appoximately 100 feet x 120 feet x 40 feet high above the water surface. ***General*** – uses about 40 meters of coastline.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) water, transmission, generator (coupled with the Energetech turbine "designed so that the electrical control will vary the speed and torque characteristic of the generator load real-time to maximise the power transfer." Generator located in weatherproof building external to air duct.

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? Yes. Port Kembla, October 26, 2005.

2. Has the technology been installed (if yes, where)? Unknown – check on status of San Francisco Bay Project. The Greenwave Project in RI is expected to be in operation in early 2007.

3. Is the technology in operation (if yes, where)? Yes.

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   San Francisco Bay Project – using Energetech technology in its current form, a 150 MW wave power project situated off the coast of San Francisco would produce 300 million kWh of electricity per annum at 9 cents per kWh, and return an IRR of 30% to an investor. (Based on January 2005 Energetech Media Update)
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

"keys to a successful project include a favorable wave climate, proximity to the area's electrical power system, and suitable bathymetric conditions (contour of the ocean floor)."

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

Can be deployed as a single device or strung together in a series (similar to wind farm concept). In suitable locations, can also be combined with wind or solar units.

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Overview of the Energetech Wave System

The Energetech Wave Energy System is a shoreline device suitable where there is fairly deep water up the coast, such as on harbour breakwaters and rocky headland and cliffs. The device uses about 40m of coastline.

Shoreline devices are known to have several advantages compared with other wave energy systems:

- they experience less extreme wave loadings, allowing a less expensive structure
- they can be built as part of a coastal structure, such a harbour breakwater
- they are more easily accessed, resulting in lower maintenance costs
- they have lower costs for the transmission of electricity

The Energetech system employs the concept of the oscillating water column (OWC), a design that has been the subject of considerable research over the past two decades, and is the most developed type of wave energy device. The Energetech system has two novel aspects:

1. a turbine suited to the oscillating airflows in OWCs
2. a parabolic shaped reflector to concentrate the wave resource on the OWC

Can also be used as an integrated component in the construction of coastal structures, such as harbour breakwaters.

The Denniss-Auld turbine, can be sold as a separate component and incorporated into wave energy devices developed by other companies.

Energy Information Administration
(EIA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Energy Information Administration (EIA)	Name:	Erika Lunn
Name / Title:	Fred Mayes 202-287-1750	Date and Time of 1st Call:	4/28/06
Mailing Address or Web Address:	http://www.eia.doe.gov/	Date and Time of 2nd Call:	
Phone Number:	Energy Information Administration is located at 1000 Independence Ave., SW, Washington, DC 20585 »call 202-586-8959 »email wmaster@eia.doe.gov	Other:	Emailed Fred Mayes same day.

Called Chris Bucker of the Renewables dept. at 202-287-1751. Her department does nothing with offshore energy technologies and pointed me to Fred Mayes 202-287-1750 who may know better about the EIA in general. He was not in on 4/28/06 so an email was set to fred.mayes@eia.doe.gov . Most offshore information available on the site is related to oil and gas drilling. The EIA does not provide siting related information needed for this study.

General Information:

Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) ___The **Energy Information Administration** (EIA), as part of the U.S. Department of Energy, collects and disseminates data on energy reserves, production, consumption, distribution, prices, technology, and related international, economic, and financial matters. Coverage of EIA's programs includes data on coal, petroleum, natural gas, electric, and nuclear energy.

1. The Energy Information Administration (EIA), created by Congress in 1977, is a statistical agency of the U.S. Department of Energy. We provide policy-independent data, forecasts, and analyses to promote sound policy making, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment.

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Enertech

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Enertech	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://enertechwind.com/	Date and Time of 2nd Call:	NA
Phone Number:	1-800-701-2888	Other:	info@enertechwind.com

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Wind Turbine Developer, Wind Turbine Refurbisher, Renewable Energy R&D

2. Type of Technology
   Wind turbines

3. Name of Equipment/Technology Manufacturer(s)
   Enertech has its own equipment/technology

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit. E44 Series - 44 Foot Rotor Diameter, 40 kW Generator. Enertech has redesigned several aspects of this turbine including gearbox, control system, main brake and tip brakes (reintroducing this wind turbine)

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? Yes, E44 series on land, approximately 750 Enertech turbines installed between 1982 and 1986 (U.S. and other countries)

2. Has the technology been installed (if yes, where)? Yes, E44 series on land (U.S. and other countries)

3. Is the technology in operation (if yes, where)? Yes, E44 series on land (U.S. and other countries)

4. Total MWs installed/in operation? Based on approximately 750 * 40kW = 30,000 kW on land (However, information from web says most of them still operating today)

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

____

____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information
Enertech is currently developing new and improved wind turbines for homes, farms and small business customers (Web search 04/17/06)
Reconditioned wind turbines from time to time, several name brands (40 kW – 225 kW)

Electric Power Research Institute
(EPRI)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted	TRC Representative
Organization/Group/ Company: EPRI	Name: Jeff Brandt
Name / Title: Roger Bedard, EPRI Ocean Energy Leader	Date and Time of 1st Call:
Mailing Address or Web Address: http://my.epri.com/portal/server.pt?	Date and Time of 2nd Call:
Phone Number:	Other:

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) EPRI [Information on tidal and wave energy is free via a separate web site called www.epri.com/oceanenergy. Other reports require membership, which costs $25,000 per year. Roger said a good rule of thumb to use for minimum viable current velocity is 2.2 m/second (below the rate basis, but well above the cut in velocity of about 0.5 m/s.. He said that EPRI uses power density to better assess sites when looking at them on a site specific basis. With respect to waves he said Massachusetts has half the power density of California, which makes it less attractive for development – average is 15kw/meter of wave energy. With respect to ocean wind he said to talk with Dr. Greg Watson, at the MTC, and Jim Manual at UMASS Renewable Lab at 413-545-4359, and Walt Musel at NERL at 413-545-4359.

2. Type of Technology Current Turbines

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works) EPRI has published a report titled "EPRI – Survey and Characterization – Tidal In Stream Energy Conversion (TISEC) Devices" November 9, 2005- the document provides an overview of current turbines and information on their design water flow rates and "cut in rates."

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

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Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? Technologies are mostly in the testing stage, but appear close enough to be considered viable for this Project.

2. Has the technology been installed (if yes, where)?

____

3. Is the technology in operation (if yes, where)?

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4. Total MWs installed/in operation?

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5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

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6. Critical flaws or unresolved technical or operational issues?

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7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

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Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

____

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

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3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   ___

   ___
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).
   The turbine rated speeds for optimal efficiency range from 2.1 to 3 m/second. GHT turbines are not recommended below 1.5 m/s with a cut in speed of 0.5 m/s. RTT has a cut in speed of 1 m/s, MCT a cut in speed of .7 m/s, Open Hydro a cut in speed of 0.7 m/s, and Exim a cut in speed of 0.7 m/s, SMDH, a cut in speed of 0.7 and UEK a cut in speed of 1.5 m/s (3 knots). Cut in speeds are minimal speeds for operation, but rated speed is the criteria to assess economic viability.

2. What are optimal siting conditions?

___

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

___

___

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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European Union (EU)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	European Union (EU)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://europa.eu.int/index_en.htm	Date and Time of 2nd Call:	
Phone Number:		Other:	Emailed Energy Research and Maritime Transport Policy and Maritime Safety groups on 5/1/06.

Energy page in English - http://europa.eu.int/pol/ener/index_en.htm
Read Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy" which generally encourages renewables like offshore wind, wave, and tidal development. Web site does not provide siting related data needed in this research.

General Information:

Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
"We take energy for granted. Fuel shortages and power cuts are rare, but timely, reminders that we rely on energy for transport, for heating our homes in winter, cooling them in summer and running our factories, farms and offices. But many energy resources are finite. In addition, energy use is often a source of pollution. Sustainable development means using less fossil fuel more intelligently and developing alternatives.

Some 80% of the energy the EU consumes is from fossil fuels – oil, natural gas and coal. A significant and increasing proportion of this comes from outside the EU. Dependence on imported oil and gas, which is currently 50%, could rise to 70% by 2030. This will increase the EU's vulnerability to supply cuts or higher prices resulting from international crises. The EU also needs to burn less fossil fuel in order to reverse global warming.

The way forward is a combination of energy savings through more efficient energy use, alternative sources (particularly renewables within the EU), more efficient use of gas-fired co-generation plants, which also produce steam and heat, more use of biomass from organic matter in energy production and biofuels in transport, and more international cooperation.

None of this will be enough. Ultimately, the EU must become a low-carbon economy using less fossil fuel in industry, transport and the home, and making use of renewable energy sources to generate electricity, heat or cool buildings, and fuel transport, *particularly cars. This presupposes an ambitious switch to wind (particularly offshore wind), biomass, hydro and solar power and bio-fuels from organic matter. The following step could be to become a hydrogen-based economy."*

1. ______________________________

2. Type of Technology

   ____

3. Name of Equipment/Technology Manufacturer(s)

   ____

4. General Description (How Technology Works)

   ____
   ____
   ____
   ____

5. Physical Description – size/aerial extent, MW capacity of a single unit

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   ____
   ____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

   ____
   ____
   ____

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

   ____

2. Has the technology been installed (if yes, where)?

   ____

3. Is the technology in operation (if yes, where)?

   ____

4. Total MWs installed/in operation?

   ____

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

   ____

6. Critical flaws or unresolved technical or operational issues?

   ____
   ____
   ____

7. If the technology is not existing, is it reasonably "Forseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

   ____
   ____
   ____

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

   ____

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____
   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ____
     ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

____

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2. What are optimal siting conditions?

____

____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

____

____

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

____

____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

____

____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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European Wind Energy Association
(EWEA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	European Wind Energy Association (EWEA)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.ewea.org/ **European Wind Energy Association** Rue d'Arlon 63-65 B-1040 Brussels Belgium Tel: +32 2 546 1940 Fax: +32 2 546 1944 E-mail: ewea(at)ewea.org	Date and Time of 2nd Call:	
Phone Number:		Other:	Emailed ewea@ewea.org on 5/1/06.

The EWEA website has good general information on the pros and cons of siting wind projects offshore, however, site specific requirements/constraints for the technology are not provided in detail.

- Wind Force 12: the definitive industry analysis of the potential of wind power. Small general section on offshore potential.
- Wind Energy - The Facts: a detailed overview of the whole wind energy sector. Volume 1 – Technology has general offshore siting considerations.
- Also reviewed a position paper on Offshore wind farms, which again was general in nature.

General Information:

Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) EWEA is the voice of the wind industry - promoting the best interest of the sector in Europe and worldwide.

EWEA members include manufacturers covering 98% of the global wind power market, as well as component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants. The combined strength of more than 250 members from over 40 countries makes EWEA the world's largest renewable energy association.

Located in Brussels, the EWEA Secretariat co-ordinates international policy, communications, research and analysis. EWEA manages European programmes, hosts events and supports the needs of its members.

EWEA is a founding member of the European Renewable Energy Council (EREC) which groups the 8 key renewable industry and research associations under one roof, and is a founding member of the Global Wind Energy Council (GWEC).

1. ________________________________

2. Type of Technology
   Wind

3. Name of Equipment/Technology Manufacturer(s)

   ____

4. General Description (How Technology Works)

   ____

5. Physical Description – size/aerial extent, MW capacity of a single unit

   ____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

   ____

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

___

2. Has the technology been installed (if yes, where)? 522.4 MW of offshore wind have been installed in European waters (from Wind Energy – The Facts). The largest WTs now desgined primarily for offshore use reveal design changes, mainly higher tip sppeds (noise isn't as much of an issue as land based projects) and built in handling equipment in the nacelle.

3. Is the technology in operation (if yes, where)?

___

4. Total MWs installed/in operation?

___

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

___

6. Critical flaws or unresolved technical or operational issues?

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7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

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Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

___

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

___

___

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

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- Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,) Offshore wind farms require strong foundations which must be firmly lodged in the sea bed. Many kilometers of cabling is required to bring their power back to shore, construction and maintenance work must be carried out in reasonable weather conditions using specialist boasts and equipment. Special features to withstand the more severe weather out at sea are being manufactured. In order to avoid coastal conservation zones, many facilities are proposed up to 60 km from shore and in water depths of up to 35 meters. Specific considerations for offshore facility design include: low mass nacelle arrangements; large rotor technology and advanced composite engineering; and design for offshore foundations, erection and maintenance. Due to the large cost associated with offshore projects, many technological factors indicate that it will be very challenging to develop economically viable turbines above the 5 MW rating based on current technology. New concepts may emerge to provide generating units larger than 5 MW capacity for offshore projects which is the latest challenge for the wind industry and will open up more economically feasible locations.

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

Table 1.5: Summary of Foundation Concepts

Foundation Type/Concept	Application	Advantages	Disadvantages
Mono-piles	Most conditions, preferably shallow water and not deep soft material. Up to 4 m diameter. Diameters of 5-6 m are the next step.	Simple, light, versatile. Of lengths up to 35 m.	Expensive installation due to large size. May require pre-drilling a socket. Difficult to remove.
Multiple-piles (tripod)	Most conditions, preferably not deep soft material. Suits water depth above 30 m.	Very rigid and versatile.	Very expensive construction and installation. Difficult to remove.
Concrete gravity base	Virtually all soil conditions.	Float-out installation.	Expensive due to large weight.
Steel gravity base	Virtually all soil conditions. Deeper water than concrete.	Lighter than concrete. Easier transportation and installation. Lower expense since the same crane can be used as for erection of turbine.	Costly in areas with significant erosion. Requires a cathodic protection system. Costly compared with concrete in shallow waters.
Mono-suction caisson	Sands, soft clays.	Inexpensive installation. Easy removal.	Installation proven in limited range of materials.
Multiple suction caisson (tripod)	Sands, soft clays. Deeper water.	Inexpensive installation. Easy removal.	Installation proven in limited range of materials. More expensive construction.
Floating	Deep waters – 100 m.	Inexpensive foundation construction. Less sensitive to water depth than other types. Non-rigid, so lower wave loads.	High mooring and platform costs. Excludes fishing and navigation from most areas of farm.

Source: EWEA. 2003. Wind Energy – The Facts: Volume 1 – Technology. P 30.

These projections ignored various factors that are now evident with the advent of commercial offshore wind:

- Perhaps most significantly, higher mean wind speedsare often available at the offshore sites that would compete with land-based sites to serve a given population area.
- There is excellent offshore resource near centres of consumption (south east England and Long Island New York, for example) where little land-based development is feasible.
- Although infrastructure costs are necessarily much higher, there is some mitigation of turbine machinery costs. With relaxation of acoustic noise constraints, higher tip speeds are feasible, so reducing drive train torque and cost. Also, there is generally reduced wind turbulence offshore compared to land-based sites.

> It is expected that the wind industry will continue to develop with an ever sharper focus on the specific needs of offshore technology. Some of this development is seen in the turbines themselves, in the tendencies towards increased tip speed and specific maintenance aids. Although the use of helicopters for installation and maintenance operations may be prohibitively expensive, and helicopters are very limited in lift capacity, some manufacturers provide helipads on the nacelle of their offshore turbines to increase access opportunities for maintenance engineers. Some offshore turbines have in-built cranes whilst others have provision for winches to be brought to the turbine in order to exchange components.

Source: EWEA. 2003. Wind Energy – The Facts: Volume 1 –Technology. P 32.

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

   ____

   ____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

   There are two published offshore wind maps for Europe. Wind speeds are provided for a range of heights, the 100 m height values are the most appropriate for current offshore turbines.

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

Offshore and onshore R&D should be integrated to a degree. Although the parameters involved in onshore and offshore R&D differ, the issues are essentially the same. For example, loading must be analysed for both offshore and onshore turbines and, although different data sets exist in each case, the software necessary to analyse them can be of similar type. Such integration would also help avoid potential conflicts of interest between industries in the coastal countries of northern Europe and southern Europe, the former typically having a larger offshore resource. In addition, it would reduce duplication in R&D efforts. Furthermore, it should be borne in mind that although the offshore sector is growing fast, by 2020 it is estimated that three-quarters of installed capacity will still be onshore.

R&D Objectives

- Monitoring of environmental impacts of near and far offshore projects.
- Potential conflicts of interest: defence, fisheries, shipping, oil and gas exploration and pipelines, and sand mining, etc.
- Legal research into offshore ownership in coastal waters, Exclusive Economic Zones, etc.
- Higher tip speed designs, as noise issues are less significant offshore.
- Minimisation of O&M-related downtime. The distance offshore and the water depth at the site have significant impacts on O&M.
- Special designs of systems and components for erection, access and maintenance of offshore turbines.
- Design studies of systems rated above 5 MW for offshore, possibly including multi-rotor systems.
- Offshore meteorology – short and long-term forecasting; hardware for measurements.
- Development of alternative, and deep water, foundation structures.
- Combined wind and wave loading.

Source: EWEA. 2003. Wind Energy – The Facts: Volume 1 – Technology. P 90-91.

Federal Energy Regulatory Commission
(FERC)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	FERC	Name:	Jeff Brandt
Name / Title:	Preliminary Permit search/ Inquiry with Robert Bell, FERC permit Reviewer	Date:	April 10, 2006
Mailing Address or Web Address:	WWW.FERC.Gov	Date and Time of 2[nd] Call:	
Phone Number:		Other:	

Mr. Bell did not have further information than what we found under the preliminary permit search – see below:

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   FERC

2. Type of Technology
   Current Turbine

3. Name of Equipment/Technology Manufacturer(s)
   TSED

4. General Description (How Technology Works) _____ _____

   Physical Description – size/aerial extent, MW capacity of a single unit ___The physical description of one type of underwater current turbine is provided in several existing FERC applications for preliminary permits. These Include projects at:

   Deception Pass, Washington State - 12663-000

   Portsmouth Tidal, Portsmouth, NH - 12664-000

   Astoria Tidal, NYC - 12665-000

   Kennebec Tidal, Bath ME - 12666-000

   Penobscot tidal, Maine - 12668-000

   The nature of each TISEC device is currently being researched by the Electric Power Research Institute in a study titled "EPRI North American Tidal In Stream

Energy Conversion Feasibility Demonstration Project." Because this technology is not yet commercially available, the physical description of the devices may only be described in general terms. It is envisioned that each TISEC device would consist of: (1) rotating propeller blades, approximately twenty (20) to fifty (50) feet each in diameter; (2) an integrated generator, producing 500 kilowatts to two (2) megawatts of electricity; (3) anchoring systems supporting the TISEC device at varying depths underwater; (4) a mooring umbilical line to an anchor on the river bottom; and (5) an interconnection transmission line to shore. Monitoring systems for parameters including but not necessarily limited to pressure, temperature, vibration, RPM, and power output may be located on the TISEC devices and on shore. Transmission from the TISEC device cluster to shore will also be by submerged cable, which may be buried beneath the river bed in its inshore portion. Onshore underground transmission cables will carry the electricity to where it will be fed into the land-based electrical use infrastructure

One TISEC device with a diameter of 20-50 feet is expected to produce approximately 500 kilowatts to two (2) megawatts of electricity. Therefore, each TISEC device is capable of providing power to about 750 homes. The units will be installed in groups or clusters to the extent allowed by the configuration of the waterway. The configuration will be designed to avoid wake-interaction effects between the devices and to allow for access by maintenance vessels. An 80 percent capacity factor is targeted, averaging approximately 8,760 megawatt-hours per unit per year. It is expected that the overall capacity of the project will be determined by research which identifies the best number of TISEC devices and transmission lines to provide power while avoiding significant use conflicts and avoiding impacts on significant environmental resources

Permitting schedules for the referenced projects show permitting completion and full build out operation in approximately 3 years.

In addition there is another project in NYC proposed by Verdant. F(P-12611) on the east side of Roosevelt Island on the Hudson River. It is a "free-flow, by directional turbine to convert kinetic hydro energy to electric power. It is an annual-flow propeller turbine Each turbine is 16 feet in diameter, with more than 100 feet will separate each row. (a field with a width of 5700 feet and a length of 284 feet will support more than 500 free-flow turbines. Each will deliver 17.9 kV based on a current velocity of 3.5 knots.

5. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?
   Yes, the technology is reasonably foreseeable. Proponents are already requesting permits ahead of its commercial operation.

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? Yes - Sale of the energy from the Verdent project is expected to be competitive with gas (assuming no transmission line charge due to location) and is expected to sell at $0.07 per kWh and $0.09 kWh.

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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General Electric (GE) Energy

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	GE Energy	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.gepower.com/businesses/ge_wind_energy/en/index.htm	Date and Time of 2nd Call:	NA
Phone Number:	No phone number available – contact form used on website	Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) Wind turbine design, manufacturing, and assembly. Offer installation, operation and maintenance services. Can engineer, procure, construct, and operate or can partner with a customer through joint development providing a full range of development services or partial customer service.

2. Type of Technology
Wind Turbine

3. Name of Equipment/Technology Manufacturer(s)
3.6 MW Offshore Series Wind Turbine Manufactured by GE

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit 3.6 MW capacity per turbine, hub height is site dependent, 3 rotor blades (See technical data for more information). Arklow Bank Project – Each turbine utilizes a footprint 16 feet in diameter and the wind turbines are spaced approximately 1,970 feet apart.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Submarine cable

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

   25 MW Arklow Bank Wind Park – 7 GE 3.6s Offshore turbines located in the Irish Sea. Placed into operation in June 2004. Previous, world's first "megawatt class" offshore wind farm in Utgrunden (south east coast of Swedent). Note Phase II of Arklow Bank Project is currently being developed (Airtricity and ACCIONA Energia of Spain) – 520 MW.

2. Has the technology been installed (if yes, where)? Yes, see above

3. Is the technology in operation (if yes, where)? Yes, see above

4. Total MWs installed/in operation? 25 MW, Arklow Bank Wind Park

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

   ____

6. Critical flaws or unresolved technical or operational issues?

   ____

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"? Not Applicable, technology is existing. However, new 5-7 MW wind turbine that is under partnership between GE and DOE, may be foreseeable within 10 years.

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

   ____

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)
Monopile foundation. Arklow Bank Project was installed in 9 weeks from the beginning of the first foundation. Arklow Bank is a sand bank.

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information
March 9, 2006, a news article* states, GE and DOE entered into a $27 million partnership to design a next generation offshore wind turbine. The power rating of the new turbine will be optimized for minimal cost of energy but is expected to be between 5 and 7 megawatts. – Partnership will last 3-4 years. commercialization is some years away.

GE has several onshore wind turbines (1.5 MW Series Wind Turbine, 2.X MW Series Wind Turbine and 3.6 MW Series Wind Turbine). The onshore wind turbines were not reviewed/investigated as part of this project as they are not relative to offshore energy.

*GE, U.S Department of Energy to Partner on Next-Generation Offshore Wind Turbine Design Project http://home.businesswire.com/portal/site/ge/index.jsp?ndmViewId=news_view&newsId=20060309005510&newsLang=en&ndmConfigId=1001109&vnsId=681

Marine Current Turbine Ltd

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Marine Current Turbines Ltd (MCT)	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.marineturbines.com/home.htm	Date and Time of 2nd Call:	NA
Phone Number:	+44(0)117-979-1888	Other:	Email sent
Fax Number:	+44(0)117-906-6140		

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) Development

2. Type of Technology Tidal Current

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works) The technology under development by MCT consists of twin axial flow rotors of 15m to 20m in diameter, each driving a generator via a gearbox much like a hydro-electric turbine or a wind turbine. The twin power units of each system are mounted on wing-like extensions either side of a tubular steel monopile some 3m in diameter which is set into a hole drilled into the seabed. The patented design of our turbine is able to be installed and maintained entirely without the use of costly underwater operations. A unique, patented feature of MCT's technology is that the turbines and accompanying power units can be raised bodily up the support pile clear above sea-level to permit access for maintenance from small service vessels. This is an important feature because underwater intervention using divers or ROVs (Remotely Operated Vehicles) is virtually impossible in locations with such strong currents as are needed for effective power generation.

5. Physical Description – size/aerial extent, MW capacity of a single unit The submerged turbines, which will generally be rated at from 750 to 1500kW per unit (depending on the local flow pattern and peak velocity), will be grouped in arrays or "farms" under the sea, at places with high currents, in much the same way that wind turbines in a wind farm are set out in rows to catch the wind. The main difference is that marine current turbines of a given power rating are smaller, (because water is 800 times denser than air) and they can be packed closer

together (because tidal streams are normally bi-directional whereas wind tends to be multi-directional).

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Water, gearbox, generator, transmission (Key patanted feature of the technology is that the rotor, and drive train (gearbox and generator) can be raised completely above the surface.

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? Yes. Phase I, the Seaflow has been tested. The seaflow is a 300 kW single 11 m diameter rotor system off Lynmouth, Devon, UK. Successfully installed in May 2003 and uses a dump lod in lieu of grid connection and only generally operates with the tide in one direction. Phase 2, the Seagen is expected to be operational in 2006. Phase 3 a Seagen array and overseas demonstration projects are expected in 2006 and later.

2. Has the technology been installed (if yes, where)? Yes. See question 1 above.

3. Is the technology in operation (if yes, where)? Yes, the Seaflow is in operation and has been since 2003. The Seaflow was installed on May 26, 2003. However, no commercial products are available yet. The commercial Seagen is expected to be in operation in 2006.

4. Total MWs installed/in operation? 300 kW

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed). 2 ½ years

6. Critical flaws or unresolved technical or operational issues? The Phase I Seaflow only generally operates with the tide in one direction. The Phase 2, Seagen will be grid connected and operate with the flow in both directions.

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"? The technology is operating. It is reasonable to see a commercial array within the next 10 years.

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? 20 year design life

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).
   Mean spring peak velocity exceeding about 2.25 to 2.5 m/s (4.5 to 5 knots) with a depth of water of 20 to 30 meters.

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)
   The technology for placing monopiles at sea is well developed by Seacore LTd. The rotors mounted on steel piles set into a socket is drilled into the seabed.

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?
   "The main difference is that marine current turbines of a given power rating are smaller, (because water is 800 times denser than air) and they can be packed closer together (because tidal streams are normally bi-directional whereas wind tends to be multi-directional)."

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Another key advantage of MCT's technology as a future large scale generating technique is that it is modular, so small batches of machines can be installed with only a short period between investment in the technology and the time when revenue starts to flow. This is in contrast to large hydro electric schemes, tidal barrages, nuclear power stations or other projects involving major civil engineering, where the lead time between investment and gaining a return can be many years.

Massachusetts Technology Collaborative

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Mass Technology Collaborative	Name:	Jeff Brandt
Name / Title:	Greg Watson	Date and Time of 1st Call:	May 2, 2006 [left message about siting of offshore wind facilities]
Mailing Address or Web Address:		Date and Time of 2nd Call:	May 9, 2006, May 20, 2006
Phone Number:	508-775-9230	Other:	

Greg said he would try to find out about the offshore hull municipal light project. He said he new of no other offshore Projects. I called two more times to follow up regarding the Hull Project and was unable to make contact.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations – water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Minerals Management Service
(MMS)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Minerals Management Service	Name:	Jeff Brandt
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.mms.gov/offshore/RenewableEnergy/RenewableEnergyMain.htm	Date and Time of 2nd Call:	
Phone Number:		Other:	

Information on this site is not applicable to the Project. We also searched for oceanographic data here to support mapping efforts, but could not find any useful information.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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National Renewable Energy Laboratory (NREL)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	National Renewable Energy Laboratory (NREL)	Name:	Erika Lunn
Name / Title:	Walter Musial	Date and Time of 1st Call:	May 3, 2006 – left message
Mailing Address or Web Address:	National Wind Technology Center National Renewable Energy Laboratory 1617 Cole Blvd Golden, CO 80401 (303) 384-6956 cell (303) 349-9819 walter_musial@nrel.gov www.nrel.gov	Date and Time of 2nd Call:	May 4, 2006 he returned the call
Phone Number:	303-684-6956	Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Government research lab

2. Type of Technology
   Offshore Wind – specifically deepwater and floating wind turbine systems

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works) Anchor, platform, or mooring based structures for deep water instead of conventional pile driving (monopole), suction or gravity based shallow water techonologies. Consideration is being given to floating wind turbine technology where conventional foundation types are not suitable, such as in deep waters offshore. A floating structure must provide enough buoyancy to support the weight of the turbine. It must also be able to restrain pitch, roll, and heave motions within acceptable limits in order to operate efficiently and safely. A variety of platform, mooring, and anchoring technologies have been proposed for floating offshore wind turbine systems.

5. Physical Description – size/aerial extent, MW capacity of a single unit

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6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

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Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? No – however a group in Norway says they will be testing a full-scale prototype______________________________

2. Has the technology been installed (if yes, where)?
_____No______________________________

3. Is the technology in operation (if yes, where)?
_____No______________________________

4. Total MWs installed/in operation?
_______0______________________________

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

____

6. Critical flaws or unresolved technical or operational issues? Mr. Musial noted that deepwater systems are too risky to take on for most so there is little entrepreneurial funding of government funding at this time. He also noted that the Gulf of Mexico could be a troublesome siting area for conventional shallow water technologies and the soft bottom soil for future U.S. projects.

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?
TRC contacted Mr. Walter Musial of the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy in the Office of Energy Efficiency & Renewable Energy. Mr. Musial recently presented a collaborative report entitled "Coupled Dynamic Modeling of Floating Wind Turbine Systems" at an Offshore Technology Conference held May 1-4, 2006 in Houston Texas. According to conversations with Mr. Musial (Musial 2006), floating wind turbine technology is still in its infancy. The advancement of this science is heavily dependent upon federal funding and research agencies to date

have been reluctant to pursue its development. It was Mr. Musial's opinion that floating wind turbine technology would not be commercially viable in the United States within the next 15-20 years without significant federal funding. The present focus is shallow water offshore wind development in the U.S. first, followed by deepwater alternatives such as floating wind turbine systems. According to Mr. Musial, the group closest to testing a full-scale prototype at sea is in Norway. Current design models for are based on computer modeling and laboratory demonstrations, but no real world testing has been conducted. The deepest offshore wind turbine structure known to NREL is in Denmark and is 18 meters deep with a bell shaped concrete gravity base. Monopole structures are not preferable greater than 25 meters deep as the structures become too flexible and lose its stiffness. According to the NREL (Musial et al. 2006), the U.S. requires substantial experience in shallower water as well as substantive research and development initiatives to realize this technology over the next 15 years. Mr. Musial said you could safely add 10 years to that estimate without appropriate funding.

<u>Economic Feasibility:</u>

1. Is Cost of Technology competitive with other technologies? floating structures will be more expensive at greater depths, but no other technology is proposed for deepwater (100 meters or more
2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ____

     ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

<u>Key Siting Requirements:</u>

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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   ____

2. What are optimal siting conditions?

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   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations – water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Northern Power Systems

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Northern Power Systems	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.northernpower.com/company.html	Date and Time of 2nd Call:	NA
Phone Number:	(802) 496-2955	Other:	NorthWind® 100 Wind Turbine
Fax Number:	(802) 496-2953	Email contact:	info@northernpower.com; nw100@northernpower.com

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) Designs, builds, installs and services on-site and integrated power systems to customers
2. Type of Technology Wind Turbine

3. Name of Equipment/Technology Manufacturer(s) NorthWind 100 Wind Turbine by Northern (NW 100)

4. General Description (How Technology Works) "The variable speed, stall controlled turbine rotor assembly consists ofthree fiberglass reinforced plastic (FRP) blades bolted to a rigid hub, which mounts directly to the generator shaft.This simple, robust design eliminates the need for rotating blade tips. blade pitch systems. and speed increasing gearboxes. Using a state-of-the-art airfoil design increases the blade's aerodynamic efficiency and renders them insensitive to surface roughness caused by dirt build-up and insects.The advanced FRP-resin infusion molding process ensures a high-quality blade while the cold chamber tested root connection guarantees it will meet extreme temperature requirements. The direct drive generator is a salient pole synchronous machine designed specifically for high reliability applications. Electrical output of the generator is converted to high quality AC power that can be synchronized to conventional or weak isolated grids.The advanced power conversion system also eliminates the inrush currents and poor power factor of conventional wind turbines. The variable speed direct drive generator/converter system is tuned to operate the rotor at the peak performance coefficient, and also allows stall point rotor control to contend with wide variation in air density found in the target applications. The safety system consists of a spring applied, pressure released disk brake mounted on the generator shaft for emergency conditions, and an electrodynamic brake system that provides both normal shutdown and emergency braking backup functions."

5. Physical Description – size/aerial extent, MW capacity of a single unit Hub Height: 25/32 m (82/105 ft), 100 kW, Rotational Axis = Horizontal, Orientation = Upwind, 3 blades, Variable Speed Stall

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Wind

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? "The NW100 is currently installed in the villages of Kotzebue and Toksook Bay, Alaska.The Kotzebue turbine has been running successfully for over two years.The Alaska Village Electric Cooperative (AVEC) installed three turbines located in Toksook in the fall of 2005. In addition to the turbines located in Toksook Bay,AVEC has purchased seven turbines to be installed in three other Alaskan villages." Note, not installed offshore. R&D for MW and 2 MW turbines.

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Ocean Power Delivery LTD

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Ocean Power Delivery LTD	hName:	Jeff Brandt
Name / Title:	Andrew Scott	Date and Time of 1st Call:	May 16, 2006
Mailing Address or Web Address:	104 Commercial Street, Edinburgh EH6 6NF	Date and Time of 2nd Call:	
Phone Number:	011440131554844	Other:	

Andrew Scott, Project Development Engineer said that the 15kW per meter statistic listed on their web site is a good rule of thumb to use as a rough approximation of economic viability. Below that, locatations are marginal. I asked him about the EPRI study off Truro, MA and the wave energy there which was calculated at 13.8 kW/m. He said that would be a marginal site. He emphasized that as the technology is in its infancy, developers will cherry pick locations around the world for the highest wave energy to begin with. He said the proposed wave farm off of Portugal (three devices) had a wave energy double that of Massachusetts (or approximately 30 kW/m). He thought MA was a good ten years away from development of a wave turbine, though he said it of course could happen, if a developer had a lot of money and was less interested in max return on investment. He said the key factor for siting them is a minimum water depth of 50 meters.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) Regulatory
2. Type of Technology
3. Name of Equipment/Technology Manufacturer(s)
4. General Description (How Technology Works)
5. Physical Description -- size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?
2. Has the technology been installed (if yes, where)?
3. Is the technology in operation (if yes, where)?
4. Total MWs installed/in operation?
5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)
6. Critical flaws or unresolved technical or operational issues?
7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?
2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   ____

   ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

   ____

2. What are optimal siting conditions?

   ____

   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

   ____

4. Technological Limitations-- water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

   ____

   ____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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   ____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

   ____

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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RenewableEnergyAccess.com

- **AWS Ocean Energy LTD**
- **Current to Current Bermuda Ltd.**
- **Ocean Power Technologies**
- **Ocean Wind Technology LLC**
- **Ocean Power Delivery LTD**

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Renewable Energy Access	Name:	Erika Lunn
Name / Title:	Jim Callihan	Date and Time of 1st Call:	4/28/06 11am
Mailing Address or Web Address:	http://www.renewableenergyaccess.com/rea/home	Date and Time of 2nd Call:	
Phone Number:	603-924-4405	Other:	

Called Jim Callihan 4/28/06 at 11 a.m. Jim couldn't assist us with our task directly, nor could anyone in his office. He pointed me to his contacts for ocean technology and news instead.

Jim directed me to Sean O'Neill and Carolyn Elephant at Ocean Renewable Energy Coalition http://oceanrenewable.com . Called Carolyn at 202-297-6100/301-869-3790 in DC on 4/28/06. She returned my call 5/1/06 in the morning.

- She has read and seen papers highlighted at conferences on state of the art windpower technologies and information such as siting requirements, but could not direct me to any by name.
- She mentioned that Minerals Management Service (MMS) (from J. Brandt's Cat. 1 list) is working on a programmatic EIS for mapping of potential energy facilities on the continental shelf. She said they got the authority to lease that land in an energy policy act from last year and the siting of facilities there would be on a case by case basis.
- She also said a January 2005 paper by EPRI (also from Cat. 1 list) on wave technology and available resources included discussions on the coastal waters of MA and leading technologies
- Apparently EPRI is coming out with a similar paper in a couple weeks on tidal energy/resources - keep an eye out for it
- The contact she gave for EPRI was Roger Bedard (rbedard@epri.com) for more information.
- Finally, Caroline mentioned Bruce Bailey of AWF Scientific/TrueWind participated in a number of assessments for offshore windpower development sites and might be a contact we should try.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
__Internet news group for renewable technologies________________________

2. Type of Technology
All renewables, not specifically offshore________________________________

3. Name of Equipment/Technology Manufacturer(s)
News articles listed the following technologies which have been addressed in separate questionnaires:

    - Pelamis (wave)
    - Archimedes Wave Swing (wave)
    - Bermuda Current to Current (current)
    - Oceanwind Tech (wind power)
    - Ocean Power Technologies (wave)

4. General Description (How Technology Works)

    The technologies are described in separate questionnaires.

5. Physical Description – size/aerial extent, MW capacity of a single unit
__NA____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)
___ NA ________________________________

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?
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2. Has the technology been installed (if yes, where)?
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3. Is the technology in operation (if yes, where)?
____

4. Total MWs installed/in operation?
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5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?
As described above, Renewable Energy Access directed TRC to Ocean Renewable Energy Coalition for further information.

Additional Information

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	AWS Ocean Energy LTD	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	www.awsocean.com and http://www.waveswing.com/	Date and Time of 2nd Call:	
Phone Number:	AWS Ocean Energy Ltd Redshank House Alness Point Business Park Alness Ross-shire IV17 0UP Scotland Tel: +44 (0) 1349 88 44 22 Fax: +44 (0) 1349 88 44 66 e-mail: info@awsocean.com	Other:	

General Information:

RenewableEnergyAccess.com – AWS generator gets new funding to install full-scale demonstrator to be fabricated in 2007 and commissioned in 2008.

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Developer - Our mission is to deliver substantial benefits to mankind an the environment by making wave power work.

2. Type of Technology
   Wave power

3. Name of Equipment/Technology Manufacturer(s)
   Archimedes Wave Swing (AWS)

4. General Description (How Technology Works) The AWS wave energy converter consists of a large air-filled cylinder which is submerged beneath the waves. As a wave crest approaches, the water pressure on the top of the cylinder increases and the upper part or 'floater' compresses the air within the cylinder to balance the

pressures. The reverse happens as the wave trough passes and the cylinder expands. The relative movement between the floater and the fixed lower part or 'basement' is converted directly to electricity by means of an innovative linear generator. First-generation machines will be rated at over 1MW and have a load factor in excess of 35%.

The device is intrinsically simple with only one main moving part - the floater. Ancillary systems are limited to ballast water pumps, an integral damper to absorb excessive power and modules for air supply control and lubrication. All will use existing sub-sea technology and be capable of maintenance during rough weather using ROVs.

5. Physical Description – size/aerial extent, MW capacity of a single unit

   With outputs >1.2MW and 4GWh pa mean that the AWS is a real option for power utilities looking to secure multi-MW developments.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

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AWS PILOTPLANT	COMMERCIAL SYSTEM	
Purpose	To test all equipment at full scale	To produce electricity at market price via learning curve
location	Lexious (offshore North Portugal)	Not decided yet (Portugal, UK, Spain)
Anchor	Pontoon for flexible submerge and emurge	Tension leg with gravity anchour
Energy collector	vertical motion offloater	vertical motion of floater
dia	9.5 m	12 m
stroke	7 m (nominal) 9m (maximum)	11m (nominal) 12m (maximum)
Power take off	Linear permanent magnet generator	Linear premanent magnet generator
voltage	3.3 kV at 2.2 m/s (10s cycle)	3.3 kV at 3.5 m/s
max. power	2 MW at 2.2 m/s(10 s cycle)	9.5 MW at 3.5 m/s
rated power	1 MW (average over 1 cycle)	4.75MW at 3.5 m/s (average over 1 cycle)
Converter	Thyristor (cycloconverter)	IGBT (to be specified)
Gridconnection	15 kV 4.8 MVA	depending on location.
TUNING	from 9 to 20 second	9 to 12 second
operating wave heights	Hs 0.75 m - Hs 4 m	Hs 0.75 m - Hs 5 m
Survival conditions	to be measured	Hs 20 m (in secure mode)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? The complete system has been tested at full-scale via a pilot plant that is installed off the coast of Portugal. Engineering fo the pre-commercial demonstrator is now ongoing.

2. Has the technology been installed (if yes, where)?

   ___

3. Is the technology in operation (if yes, where)?

____

4. Total MWs installed/in operation?

____

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

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6. Critical flaws or unresolved technical or operational issues?

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If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Our next objective is to construct and deploy a pre-commercial demonstrator unit. This will be tested and operated for 12 months before being sold on to a utility customer who will run the plant for the remainder of it's 15 year life.

We are considering a number of suitable sites in western Europe and it is likely that the decision where to deploy will be heavily influenced by the availability of public financial support. The programme is as follows:

- Conceptual design to Q2/06
- Scale model verification of commercial design Q3/06
- Detailed design of prototype to Q1/07
- Construction of prototype by Q2/08
- Installation of prototype by Q2/08
- Construction of 'first-commercial' machines Q4/08 onwards

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? The AWS is a technology that will produce electricity against a price which is comparable to offshore windturbines. In the first project the technology is going through a learning curve. For the first projects in Portugal, the Portuguese government gives a higher feed in tariff at €0.23 /kWh. AWS considers this initiative as a good financial instrument to support the "early" technology projects like AWS and invites other countries to follow this example. It will make the introduction of these new technologies viable. Following the example of other renewable systems

in the past the cost will drop once serial production starts. AWS economics follow these curves.

More detailed info on AWS can be obtained by contacting us.

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).
   The AWS is submerged at least 6m below the sea surface and therefore avoids the high storm loadings to which other devices are subjected. This reduces mooring costs and the risk of damage.

2. What are optimal siting conditions?
   The AWS is a high power generator intended for bulk power production to a utility grid. It responds best to long ocean swells. Specific site requirements are as follows:

   - Location exposed to ocean swells - e.g. western Atlantic coast of British Isles, France, Spain or Portugal
   - 80 - 90m of water depth outwith main commercial shipping lanes
   - Secure electricity power grid ashore (>50MVA fault level)
   - Industrial port within 12 hours sailing time
   - Sea-bed suitable for laying power cables to shore

   Energy capture per machine will depend upon the wave energy occurring at the site and this tends to be highest in the temperate latitudes (40° - 60° north or south).

   We fully appreciate that the oceans are used by a range of stakeholders and that the detailed siteing of wave energy parks will involve considerable consultation.

It is expected that AWS units will be deployed in arrays of several tens of units. A 50MW farm will occupy an area around 3 nautical miles long by 2 cables wide. This would generate enough electricity for 16,000 homes.

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

___

___

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

___

___

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

___

___

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

___

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Current to Current Bermuda Ltd	Name:	Erika Lunn
Name / Title:	Helen Manich – Chief Marketing Officer	Date and Time of 1st Call:	Was called back at 3:30pm 5/2/06.
Mailing Address or Web Address:	http://www.currenttocurrent.com/	Date and Time of 2nd Call:	
Phone Number:	35 Corporate Drive Burlington, MA 01803 Phone: 781-685-4992	Other:	Emailed organization 4/28/06.

http://www.solaraccess.com/rea/news/story?id=44257

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) _____The technology was developed in the U.S. by a team of scientists and technologists led by Dr. Manfred Kuehnle, who has registered several hundred inventions, including satellite technology and machine-readable technology for credit cards, stated the release.___ Current to Current is a technology development company focused in the area of electricity generation from renewable sources. Specifically, the company will be building Submersible Power Generators (SPG) that will generate electricity from the flow of water driven by ocean currents, tidal currents, and other coastal water flow.

2. Type of Technology
   Ocean Current

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works) ___Current to Current Bermuda Ltd., a subsidiary of Current to Current Corp. based in Burlington, Massachusetts, will bring its patented ocean current technology -- a large submersible, similar to a submarine, operating within a cylindrical unit that captures the energy of ocean currents to power generators. It incorporates a gearbox allowing it to provide large volume electricity production, suitable for commercial use, and differentiating it from other ocean current applications. This is to be the first deployment of the Submersible Power Generators (SPG).

5. Physical Description – size/aerial extent, MW capacity of a single unit
   _Breakthrough gearbox technology, very small footprint for sizable generation, carries load across 2 axes, 5MW unidirectional current (not tidal), uses slower moving/more consistent and regular old currents
   _10 MW unit is 150 feet long by 250 feet wide, diameter depends on needs but is roughly 100 feet for the Bermuda project. Can run on .5 m/s and north (2.5 m/s and north don't need funnel, .5 m/s – 2.5 m/s do need funnel to step up speed). Can design the units to accommodate different speeds.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)
   ___transmission line to the coast

We have looked closely at offshore wind generation. While it is viable, wind provides only intermittent power and would not replace the need for fuel oil based generation to cover the times when wind would not provide adequate supply," said Garry A. Madeiros, BELCO president and chief executive officer. "Conversely, Current to Current's technology has been designed to provide a continuous source of energy that would replace the need for fuel-powered generation."

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? ____

Although a specific site for placement of the submersible unit has not yet been determined, Helen Manich, Current to Current's chief marketing officer, said it would be located south of the Island.

"The Bermuda Biological Station for Research (BBSR) will be conducting current-flow testing at the end of next month and that information will be used to help determine the best location," Manich said. "The submersible unit will be constructed in the United States and barged to Bermuda. Once it is in place, the unit can be remotely controlled and monitored by the U.S. company, the Bermuda company and BELCO."

"BELCO's planning forecast anticipates that we will need to add generating capacity to our system by 2010," said Madeiros. "The timing of this project is excellent, as it allows us to adjust our plans going forward based on the actual performance and future potential of the Current to Current system."_ Has been tested in labs, computer sims.______________________________

2. Has the technology been installed (if yes, where)? ___Have a contract to install 10 MW in Bermuda, 20 year PPA______________________________

3. Is the technology in operation (if yes, where)? ______not yet______________________________

4. Total MWs installed/in operation? ______0______________________________

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)
____

6. Critical flaws or unresolved technical or operational issues?
____
___Need to work out adjusting to grid needs on the fly, moving in and out of the water flow. The submarine will be brough to the surface to service. There is a helipcopter landing pad on top of the unit and much of the system is modular to

make for safe and easy repairs. Will be lowered out of hurricane impacted depths and offline is necessary during storms____

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7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

____

__Yes definitely, and the waters of Massachusetts are pretty good for this technology based on the velocity from the NJ to ME current along the eastern seaboard. More development proposed internationally due to shorter review times, nothing in the U.S. proposed yet because of the process difference and timeframe required.____

____

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? __comparable with natural gas and diesel, hypothetically much better than wind and solar. While wind is predictable in terms of economic feasibility, technology is still very new for that. $20 million was already spent on development of the gearbox alone.____

___

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

____

_____length of transmission line

____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

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   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

_____can site 1 mile or many miles offshore, it's dependent upon the cost of the interconnection cable for the developer; sited 75-200 meters below sea surface and at least 50 m above the sea floor to establish a safe operating zone; tethered to the ocean floor via "suction cup" technology, not a monopole or piling. Can use DC cables if far offshore, considering using suberconductors because of high cost of copper and cables

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

_____Likely will be spaced ¼ to ½ mile apart in a school in the same region based on hydrodynamic studies.

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

___Helen will send me press release material and newspaper articles via email.____

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Additional Information

_No navigational or fishing impacts, acoustically quiet, no sonar or frequencies emitted, below major layer of marine lice, no visible pollution, least environmental impact._No avian issues.____

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Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Ocean Power Technologies	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.oceanpowertechnologies.com/index.htm 1590 Reed Road Pennington New Jersey 08534 USA Phone: +1 609 730 0400 Fax: +1 609 730 0404 E-mail: info@oceanpowertech.com	Date and Time of 2nd Call:	
Phone Number:		Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) OPT was formed by Dr. George W. Taylor and the late Dr. Joseph R. Burns in pursuit of their vision of harnessing the boundless energy of the world's oceans. Starting in 1994 OPT has focused on its proprietary PowerBuoy™ technology, capturing wave energy using large floating buoys anchored to the sea bed and converting the energy into electricity using innovative power take-off systems.

2. Type of Technology

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

   OPT's PowerBuoy™ wave generation system uses a "smart," ocean-going buoy to capture and convert wave energy into low-cost, clean electricity.

   The rising and falling of the waves off shore causes the buoy to move freely up and down. The resultant mechanical stroking is converted via a sophisticated power take-off to drive an electrical generator. The generated power is transmitted ashore via an underwater power cable.

Sensors on the PowerBuoy continuously monitor the performance of the various subsystems and surrounding ocean environment. Data is transmitted to shore in real time. In the event of very large oncoming waves, the system automatically locks-up and ceases power production. When the wave heights return to normal, the system unlocks and recommences energy conversion and transmission of the electrical power ashore.

5. Physical Description – size/aerial extent, MW capacity of a single unit

The PowerBuoy™ is anchored on the sea bottom using a proprietary anchoring system that avoids any damage or threat to the sea bed or sea life.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

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Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

Commencing in 1997, ocean trials have been conducted off the coast of New Jersey to demonstrate the concept of using a floating buoy to capture wave energy and convert it into electricity. The technology is on a growth curve towards full-scale commercial application, recent examples of which are the 40 kW-rated PowerBuoys installed in Hawaii and New Jersey. The PowerBuoy has undergone ocean testing in both the Atlantic and Pacific Oceans.

2. Has the technology been installed (if yes, where)?

Beginning in 2006. OPT will begin the first phase of installation of a 1.25 MW wave farm off the northern coast of Spain. The project is a joint venture with the Spanish utility Iberdrola SA. A full size demonstration plant of up to 10MW capacity is planned for installation in UK waters.

3. Is the technology in operation (if yes, where)?

Customer: United States Navy

Project Location: Marine Corps Base, Oahu, Hawaii

Status: PB-40 deployed June 2004 and October 2005. Completed extensive environmental assessment. Objective: Demonstrate Wave Power for use at US Navy bases, worldwide

Wave Park Size: Up to 1 MW

Water Depth: 30 meters

Bottom Conditions: Limestone

Customer: New Jersey Board of Public Utilities

Location: Atlantic City, New Jersey

Status: Operational October 2005

Objective: Demonstrate viability of Wave Power in New Jersey

Wave Park Size: 40 kW-rated (one PowerBuoy)

Water Depth: 18 meters

Bottom Conditions: Hard sand **Customer:** Iberdrola S.A.

Location: Santoña, Spain

Status: In development; first phase complete; expected to be operational in 2007

Objective: Demonstrate viability of Wave Power on the Northern Coast of Spain

Initial Wave Park Size: 1.25 MW+

Water Depth: 50 meters

Bottom Conditions: Sand and Rock formations

4. Total MWs installed/in operation?

___

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

___

6. Critical flaws or unresolved technical or operational issues?

___

___

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

___

___

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

   ___

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ___

   ___

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ___

     ___

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).
   The buoy is designed to be deployed in approximately 100-150 feet (30-50 meters) of water.

2. What are optimal siting conditions?
   There are many ideal locations in Europe, North and South America, Africa, South Pacific Ocean and Asia where high power densities exist close to highly populated areas. Kilowatts per meter of wave front. The PowerBuoy systems are optimized to work in sites with 20 kW/m or greater. (30 around MA coast)

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ___

   ___

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

   ___

   ___

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?
   A 10-Megawatt OPT power station would occupy only approximately 30 acres of ocean space. Buoys are spaced to maximize energy capture.

   - Rugged, simple steel construction.

   - Utilizes conventional mooring systems.

- Simple installation using existing marine vessels and infrastructure.
- Scalable to large power stations (100+ MW)

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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____

Additional Information

	OPT PowerBuoy™	Fossil Fuel	Onshore Wind	Offshore Wind	Solar
Energy Density	High. Approx. 1000 x denser than wind	Very High	Low	Moderate	Low
Predictability	High. Accurate forecasts days in advance	Dispatchable	Low except in some sites	Moderate	Unpredictable except in some sites
Load Factor	30% - 45%	50% - 90%	25% - 35%	25% - 35%	10% - 20%
Visual Impact	Minimal. PowerBuoys, in general, not visible from shore	Very High	Moderate	Low	Unobtrusive
Potential Sites	Extensive on Coastline	Extensive but permitting process can be lengthy	Limited	Limited in US, Moderate in Europe	Limited for High Energy Density, Extensive for low to Moderate Density
Cost* Per Kilowatt Hour – Remote Power	7 - 10¢	N/A	9 - 10¢	16¢	25 - 50¢
Cost* Per Kilowatt Hour – Utility Power	3 - 4¢	4¢	4 -5¢	7 - 9¢	10 - 25¢

Source: http://oceanpowertechnologies.com/compare.htm

* These costs assume high production volume. Subsidies, credits, grants will further reduce costs

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	Oceanwind Technology LLC	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	Medford, MA	Date and Time of 2nd Call:	
Phone Number:		Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Equipment Vendor/R&D

2. Type of Technology
   Wind

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

   Oceanwind Technology, LLC, Medford, MA, has developed technology for offshore wind farms using a floating platform design that eliminates on-site construction costs, reduces sea-bed disturbance, and allows for deep-sea deployment away from scenic areas. The platform design also minimizes the risks from heave and roll movement caused by extreme wave and wind conditions. Team Members include Yuki Yamamoto, General Partner, Mystic River Partners; Jack Ringelberg, President, JMS Naval Architects Salvage Engineers; Ted Colburn, Chairman, Ocean Technology Foundation; Mark Ranalli, CEO, Helium Exchange; Samuel Tolkoff, Foster-Miller; and Stephen Houghton, Student, JFK School (Harvard) and Stanford Business School, MPP/MBA joint degree candidate.

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

   ____

2. What are optimal siting conditions?

   ____

   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

   ____

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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   ____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

   ____

   ____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Ocean Power Delivery

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Ocean Power Delivery LTD	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	www.oceanpd.com	Date and Time of 2nd Call:	
Phone Number:	104 Commercial St, Edinburgh EH6 6NF, Scotland, UK. Telephone: +44 (0) 131 554 8444 Fax: +44 (0) 131 554 8544	Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Developer

2. Type of Technology
   Wave Energy Converter

3. Name of Equipment/Technology Manufacturer(s)
   Pelamis P1AWave Energy Converter (WEC)

4. General Description (How Technology Works)

   RenewableEnergyAccess.com - GE Technology Lending unit providing capital to OPD for the world's first commercial facility that will generate electricity from offshore ocean waves. The Pelamis WEC generates 750 kW of electricity from offshore wave motion. The first order is from a Portuguese consortium that will install the system begins the summer of 2006 – 2.25 MW plant to meet the needs of 15,000+ Portuguese homes.

   The Pelamis is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure oil through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the sea bed. Several devices can be connected together and linked to shore through a single seabed cable.

5. Physical Description – size/aerial extent, MW capacity of a single unit

   The 750kw full-scale prototype is 120m long and 3.5 m in diameter and will contain three Power Conversion Module, each rated at 250kW. Each module contains a complete electro-hydraulic power generation system.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

   Following construction of the prototype machine, it underwent comprehensive seatrials in the North Sea. After a successful series of trials the device was towed to Orkney where it began a test programme at the Marine Energy Test Centre. UK DTI supported testing.

2. Has the technology been installed (if yes, where)?

   The wave farm will be installed 5 kilometres off the Portuguese coast, near Póvoa de Varim. The project will have an installed capacity of 2.25MW and is expected to meet the average electricity demand of more than 1500 Portuguese households.

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

   The long-term focus of OPD Ltd will be to supply the technology to 'wave-farm' project developers.

   However, as with every new technology once it has been successfully demonstrated at full-scale, the onward development will focus on driving down the cost-of-energy produced by the system to make the Pelamis WEC fully competitive with wind energy and other renewable technologies by 2010.

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

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   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

   ____

2. What are optimal siting conditions?

   Ideally the Pelamis would be moored in waters approximately 50-60m in depth (often 5-10km from the shore). This would allow access to the great potential of the larger swell waves but it would avoid the costs involved in a longer submarine cable; if the machine was located further out to sea.

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

   ____

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations
   The machine can be installed in a range of water depths and sea bed conditions. The machine has been conceived with survivability as the key objective.

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

When evaluating a site for a possible 'wave farm' development the following key issues will have to be examined:

- **Wave Resource** The wave levels will naturally dictate the possible electrical output of the Pelamis ; it is therefore desirable to select a site which has high annual levels of wave energy. Wave energy is generally measured in kW per meter wave face and in energetic areas of the world the annual average energy level can exceed 50kW/m.
- **Bathymetry** Pelamis is designed to be moored in water depths of about 50m. It is also important to know whether there are obstacles on the sea bed that might reduce wave energy, or prove hazardous to the installation and operation of Pelamis and its moorings.
- **Electrical Grid Connection and Cable Routing** The proximity of any site to an electricity grid with suitable capacity available is an important factor in determing required cable lengths for connection between site and grid. This will contribute to project costs and also transmission losses.
- **Onshore facilities** A dock facility capable of accomodating a Pelamis (~ 150m length) is required for maintenence, as this is all done off site.
- **Other water users** When selecting a site a consideration for other water users must be shown - this would require a comprehensive consultation. Some users that should be considered are; MOD, merchant shipping, fishing fleets and recreational bodies. This should take place in addition to a full Environmental Impact Assessment.

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

UK Department of Trade and Industry (DTI)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	UK Department of Trade and Industry (DTI)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.dti.gov.uk/energy/	Date and Time of 2nd Call:	
	Department of Trade and Industry Response Centre 1 Victoria Street London SW1H 0ET		
Phone Number:	**020 7215 5000** or **020 7215 6740 (Minicom)**	Other:	Emailed the general inquiry line ('dti.enquiries@dti.gsi.gov.uk') and John Overton (offshore wind)/John Spurgeon (wave and tidal) on 5/1/06.

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   The DTI's Energy Group deals with a wide range of energy related matters, from its production or generation to its eventual supply to the customer._ The Group is committed to working with others to ensure competitive energy markets while achieving safe, secure and sustainable energy supplies. Its role is to set out a fair and effective framework in which competition can flourish for the benefit of customers, the industry and suppliers, and which will contribute to the achievement of the UK's environmental and social objectives. These include the alleviation of fuel poverty, and maintaining the security and diversity of the UK energy sources.

2. Type of Technology
   Wave Energy/Offshore Wind

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

   As ocean waves are created by the interaction of wind with the surface of the sea, waves have the potential to provide unlimited source of renewable energy. Wave energy can be extracted and converted into electricity by wave power machines.

They can be deployed either on the shoreline or in deeper waters offshore.

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Guidance on Consenting Arrangements in Engladn and Wales for A Pre-Commercial Demonstration Phase for Wave and Tidal Stream Energy Devices (Marine Renewables)
The UK has a UK Renewable Energy Zone (REZ)
UK is recognized as a global leader in technologies to generate renewable energy from waves and tidal streams (marine renewables)

Future Offshore published by the DTI in 2002 proposed competitions for site leasese in defined areas of sea which would be subjected to strategic environmental assessment (SEA). Primarily focused on wind, also anticipated that in the case of wave and tidal stream devices, competitive rounds would be preceded by a phase in which there were requests from developers for sites from demonstration projects and stated that these would be considered on their merits.
Marine renewables industry in pre-commercial stage which requires sites for installation of demonstration decices to validate the technologies used and advance industry learning with the aim of driving down costs.
DTI Technology Programme has already committed 20m pounds to single dvice projects. Under the DTI Wave & Tidal Stream Energy Demonstration Scheme 50m pounds has now been allocated by the Government for multiple device projects.

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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United States Army Corps of Engineers (USACE)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	USACE	Name:	Jeff Brandt
Name / Title:	Cape Wind DEIS EOEA #12643	Date and Time of 1st Call:	
Mailing Address or Web Address:	New England District	Date and Time of 2nd Call:	
Phone Number:		Other:	

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Regulatory
2. Type of Technology
   Photovoltaics
3. Name of Equipment/Technology Manufacturer(s)
   NA

General Description (How Technology Works) Photovoltaic systems used to generate electricity include: concentrator technology, which uses an arrangement of photovoltaic cells that includes a lens to contrite sunlight on small area cells; and 2) flat –plate technology, which uses an arrangement of photovoltaic cells mounted on a rigid flat surface with the cells exposed freely to in coming sunlight.

Based on the systems currently in operation, flat plate systems range in size from 50 kW – 200 kW and concentrator sizes range between 2kW-200 kW; well below the Applicant's proposed project size of approximately 454 MW. At these lower power generation levels, photovoltaic applications are most feasible and economical for off-grid and consumer applications. Currently there are 299 operational photovoltaic projects representing approximately 1052 kW of capacity installed in Massachusetts, with another 105 projects representing an additional 410 kW registered for funding through the Massachusetts Technology Collaborate (MTC), but not yet operational. Additional MTC co-funded projects that are in early stages of design will add another 500 – 600 kW of capacity. Thus, the combined total of all currently operating and proposed photovoltaic installations in Massachusetts is estimated to be approximately 2 MW (MTC, 2004).

Photovoltaic arrays employ modular construction designs and are therefore relatively easy to construct/install. Once installed, photovoltaic modules have an average lifetime of 25 years, and are characterized by low operation and maintenance (O&M) costs during that period.

Despite their prevalence in consumer applications, photovoltaics have the highest cost of energy among renewable energy sources (greater than $0.20/kWh in 2002)*. The high cost of energy may be attributed to the costs of producing the materials in photovoltaic cells and modules, which is very energy intensive. In addition, photovoltaic technology is not very efficient. Currently, crystalline technologies, which are among the most efficient photovoltaic systems, are only approximately 13% efficient. Photovoltaic technology developments being pursued are expected to increase the efficiency of crystalline photovoltaic cells up to 18% by 2010.

Efforts are being made to reduce the costs of photovoltaic modules. Unfortunately, the gains that may be made in cost reduction will likely be offset by accompanying decreases in module efficiency. For example, thin film technologies being developed will result in lower module costs but will also result in lower efficiencies. Table 3-2 summarizes the state of photovoltaics research.

As indicated above, the high capital costs associated with photovoltaics, coupled with low efficiencies, make this technology economically unfeasible on a large scale. While the cost of energy of other renewable energy sources averages approximately $0.15/kWh, photovoltaics remain significantly higher. Although advances in the development of new materials are expected to reduce the cost of energy generated by photovoltaic technology to $0.21-0.50/kWh, these developments have yet to be achieved or demonstrated in practice.

* NREL Energy Analysis Office. www.nrel.gov/analysis/doc/costs curves 2002.ppt

4. ____

5. Physical Description – size/aerial extent, MW capacity of a single unit

____

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Photo voltaic systems produce power intermittently because they work on when the sun is shining. Photovoltaic systems are not well suited for use in the New England region as a reliable source of large scale electricity due to lower direct insolation than levels found in other area of the country such as Florida and the Southwest. Insolation values in the Northeast result in average duty cycles of approximately 1,500 hours per year in Massachusetts , versus average duty cycles of approximately 2,200 hours per year in high insolation areas____

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

____

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2. What are optimal siting conditions?

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3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

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4. Technological Limitations-- water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

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5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

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6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

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Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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UMASS Renewable Energy Research Lab

- **Email from Sally Wright, PE**
- **Conversation with Sally Wright, PE and Kris Alkinton**
- **Conversation with Jim Manwell**

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	UMass	Name:	Jeff Brandt
Name / Title:	Sally Wright, PE 4	Date and Time of 1st Call:	May 15, 2006
Mailing Address or Web Address:		Date and Time of 2nd Call:	
Phone Number:	413-545-3914	Other:	

Ms. Wright stated the following regarding water depths suitable for offshore siting of energy facilities:

Current maximum in operation: 30m
Current preferred for best economics: 10-20m
In planning: 45 m (see http://www.beatricewind.co.uk/Uploads/Downloads/Scoping_doc.pdf)
NREL goal: 600'

Please feel free to contact us if you have any questions.

Regards,

Sally Wright, PE

Renewable Energy Research Laboratory
University of Massachusetts, Amherst
www.ceere.org/rerl/
413-545-3914

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	UMASS Renewable Energy Research Lab at 413-545-4359,	Name:	Jeff Brandt
Name / Title:	Sally Wright, and /Kris Alkinton, Jim Manwell	Date and Time of 1st Call:	left message on May 2, 2006 regarding information on offshore wind technology Spoke with both Sally and Kris both on May 9, 2006
Mailing Address or Web Address:		Date and Time of 2nd Call:	
Phone Number:		Other:	

Sally Wright, PE called back and said that from what their office has seen and discussion with experts in the field, the current preferred depth for economics is 10 to 30 meters. Fewer than 10 meters becomes difficult to build because the equipment is barge mounted. She said the deepest facilities are currently at about 30 meters, and NREL's goal for anchor mounted facilities (more than 10 years away) is up to 600 feet.
She suggested talking with Kris Alkinton, PHD 413-577-2644 for further information.

Kris said that the maximum depth of installed facilities is actually under 20 meters (not 30). He said a rule of thumb for minimum offshore wind speed would be in the neighborhood of 7 to 8 meters per second average wind speed at hub height. For further information, he suggested consulting the following web sites:
Opti-owecs (info on siting contraints)
Offshorewindenergy.org – (info on windspeed req)
Windpower.org (good for calculating wind speed based on ground speed)

*** This information with respect to minimum water depth has since been revised based on correspondence with Jim Manwell, Director of UMASS Renewable Energy Research Laboratory – see separate Questionnaire Form**

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)

   ____

2. Type of Technology

   ____

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

2. What are optimal siting conditions?

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	UMass	Name:	Jeff Brandt
Name / Title:	James Manwell, Director	Date and Time of 1st Call:	Email correspondence June 20, 2006
Mailing Address or Web Address:		Date and Time of 2nd Call:	
Phone Number:		Other:	

In response to an email question from TRC, Mr. Manwell provided the following information:

Brandt, Jeff wrote:

I am working on a state CZM funded study to inventory reasonably foreseeable offshore energy facilities in Massachusetts. I am trying to determine the minimum economically viable water depth for installing offshore wind turbines. Sally Wright and Kris Alkinton of your office have advised me this is approximately 10 meters in depth. However,
I've notice many of the European offshore projects are constructed at much shallower water depth - in the neighborhood of 4 to 5 meters. Do you have any thoughts on what a reasonable minimum water depth would be? I assume there is a point where water is too shallow and thus construction is more costly and disruptive? Thank you.

Mr. Manwell wrote:

Perhaps they misunderstood your question. The minimum depth should be less than 10 m. The issues have to do with ship or jack-up barge access. Some jack-ups will work in water as shallow as 1 m. Vindeby (the first offshore wind farm) as I recall had a minimum depth of about 2.5 m. I believe that Scroby Sands, which is more recent, is also in the 2.5-5.0 m range. A more complete answer would involve looking at the details of a particular offshore turbine and its support structure, and seeing what the options are for installing it. There is also a lot of adaptability in the offshore construction industry, so if there is a good reason to go particularly shallow (and a large enough project to just the expense if special purpose equipment if needed), I presume one could go pretty shallow.

WAVEGEN

- Limpet Technology
- Breakwater Turbine Technology
- SeWave Technology

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Wavegen	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.wavegen.co.uk/	Date and Time of 2nd Call:	NA
Phone Number:	011-44-1463 238094	Other:	**Limpet**
Fax Number:	44 (0)1463 238096	Email addresses:	david.gibb@wavegen.com; tom.heath@wavegen.com; david.langston@wavegen.com

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
Engineering, scientific and commercial skills.

2. Type of Technology
Wavegen develops and operates Limpet (**Land Installed Marine Powered Energy Transformer**), the world's first commercial-scale **wave energy device** that generates wave energy for the grid. Limpet uses the principle of an oscillating water column (OWC).

3. Name of Equipment/Technology Manufacturer(s)
Limpet (Land Installed Marine Powered Energy Transformer). Limpet 500 installed in 2000 in Islay, Scotland (November 2000).

4. General Description (How Technology Works) Limpet is a shoreline unit and ideally placed to generate electricity in areas exposed to strong wave energy. Limpet uses the principle of an oscillating water column. The Limpet unit on Islay has an inclined oscillating water column (OWC) that couples with the surge-dominated wave field adjacent to the shore. The water depth at the entrance to the OWC is typically seven metres. The design of the air chamber is important to maximise the capture of wave energy and conversion to pneumatic power. The turbines are carefully matched to the air chamber to maximise power output. The performance has been optimised for annual average wave intensities of between 15 and 25kW/m. The water column feeds a pair of counter-rotating turbines, each of which drives a 250kW generator, giving a nameplate rating of 500kW. The Limpet's design makes it easy to build and install. Its low profile gives low visibility, so it doesn't intrude on coastal landscapes or views. The nearshore OWC rests directly on the seabed and is designed to operate in the nearshore environment in a nominal mean water depth of 15m.

   Within the chamber the water column is oscillating, raising and falling due to the wave motion, and thus compresses/ de-compresses the enclosed volume of air. The energy generated from this pressure differential is with the aid of a Wells turbine and a generator transformed into electricity and fed into the grid.

5. Physical Description – size/acrial extent, MW capacity of a single unit
   Generator – 250kW. Limpet = 500kW.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Water (waves)

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?
   Yes. On land/nearshore ocean. Islay, Scotland.

2. Has the technology been installed (if yes, where)? Yes. On land/nearshore ocean. Islay, Scotland.

3. Is the technology in operation (if yes, where)? Yes. Installed in 2000 on the island of Islay off Scotland's west coast.

4. Total MWs installed/in operation? 500kW

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

   ____

6. Critical flaws or unresolved technical or operational issues?

   ____

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"? NA

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? "The reality is that th e only long term problem is making the technology work at a cost of power which a consumer is willing to pay." Capital expenditure typically accounts for more than 90% of the cost of producing wave power.

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

     ____

     ____
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).
   - Not sure if requirements, but Limpet: water depth of 7 meters, nearshore designed to operate in nearshore environment in a nominal mean water depth of 15m.
   - Performance has been optimized for annual average wave intensities between 15 and 25kW/m.

2. What are optimal siting conditions?

Exposed to strong waves. Nearshore "optimum performance will be achieved when driven by a long ocean swell "generated over a fetch of more than 400km. Lesser seas may also produce satisfactory performance."

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

4. Technological Limitations-- water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

Further developments/projects include: Developing technology used in Limpet to build a series of commercial power generators; investigating housing units in breakwaters; and installing a new variable pitch turbine, which will increase Limpet's power performance.

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Wavegen	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.wavegen.co.uk/	Date and Time of 2nd Call:	NA
Phone Number:	44 (0)1463 238094	**Other:**	**Breakwater Turbine**
Fax Number:	44 (0)1463 238096		

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   See above.

2. Type of Technology
   Small power takeoff modules for incorporating into breakwaters, coastal defences, land reclamation schemes and harbour walls.

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works) The modules are very simple and rugged; the blades are fixed onto the rotor, have no pitching mechanism, no gearbox and have no contact with seawater.

5. Physical Description – size/aerial extent, MW capacity of a single unit The 18.5kW power modules consist of a Wells turbine, valve and noise attenuator. The complete modules weigh less than a tonne so installation or removal is easily achievable using a small mobile crane.

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility:

8. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? Wave tank testing and full scale field test (Islay test programme 2004 on Limpet plant). A further turbine has been built and will be tested on the plant during summer 2005.

9. Has the technology been installed (if yes, where)? ?? Summer 2005 Wave News states, "Wavegen is performing wave tank testing for EVE, the Basque Energy Board, to enable definition of a breakwater incorporating 16 off 30kW 'breakwater turbines' into the new structure.

10. Is the technology in operation (if yes, where)?

11. Total MWs installed/in operation?

12. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

13. Critical flaws or unresolved technical or operational issues?

14. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility:

4. Is Cost of Technology competitive with other technologies?

5. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

6. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

7. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	Wavegen and SEV	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.wavegen.co.uk/news_cliffbased.htm	Date and Time of 2nd Call:	NA
Phone Number:		**Other:**	**SeWave - Cliff Based Wave Power**

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association) Joint Venture between Wavegen and SEV (Faroese national utility SEV), SeWave.

2. Type of Technology Cliff based wave power.

3. Name of Equipment/Technology Manufacturer(s) __________

4. General Description (How Technology Works) The Faroese (SeWave) device will be based on the existing oscillating water column technology used in Wavegen's Islay plant. The key innovative feature is the use of tunnels cut into the cliffs on the shoreline to form the chamber which captures the energy.

5. Physical Description – size/aerial extent, MW capacity of a single unit __________

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Water and land to create tunnel.

Technological Feasibility:

15. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? __________

16. Has the technology been installed (if yes, where)? __________

17. Is the technology in operation (if yes, where)?

18. Total MWs installed/in operation?

19. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

20. Critical flaws or unresolved technical or operational issues?

21. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"? The new power plant (cliff based power in the Faroese Islands) could be generating power as early as 2006 and is likely to be followed by more, larger scale plants.

Economic Feasibility:

7. Is Cost of Technology competitive with other technologies?

8. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

9. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

7. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

8. What are optimal siting conditions?

9. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

10. Technological Limitations – water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

11. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

12. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

8. What are optimal siting conditions?
breakwaters, coastal defences, land reclamation schemes and harbour walls

9. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)
The complete modules weigh less than a ton so installation or removal is easily achievable using a small mobile crane.

10. Technological Limitations-- water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

11. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

12. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

The Wind Turbine Company (WTC)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		TRC Representative	
Organization/Group/ Company:	The Wind Turbine Company (WTC)	Name:	Tricia Foster
Name / Title:	NA	Date and Time of 1st Call:	NA
Mailing Address or Web Address:	http://www.windturbinecompany.com/	Date and Time of 2nd Call:	NA
Phone Number:	425.637.1470	Email:	mileslw@windturbinecompany.com

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   Design, manufacture and sell wind turbines.

2. Type of Technology
   Wind Turbines

3. Name of Equipment/Technology Manufacturer(s)
   2-blade, downwind wind turbine

4. General Description (How Technology Works) WTC's proprietary technology is a hydraulically controlled, hinged-blade system that allows the blades to "flap" in the out-of-rotating-plane direction, causing the cone angle between the blades to vary continuously with changing wind and rotational speeds. This feature results in an enormous reduction of the blade-root bending loads. Reducing these loads allows us to safely reduce the amount of material employed in the blades, drivetrain, and throughout the turbine. This patented innovation, based on a concept previously employed in the helicopter industry, was the result of a thorough system level design of the 2-blade downwind turbine. The wind will bend the tower and rotor blades in the direction it is blowing. Upwind machines must resist bending, but downwind blades and towers can be allowed to bend. Downwind turbines have another compelling advantage--the tower can be allowed to bend in the wind, permitting the use of guy-cables to hold it upright. Unlike freestanding towers, the guy-cable supported tower is a pipe--a manufactured product. Pipe sections are shipped to the site and joined together like a pipeline. The foundation supports the weight; the guy-cables keep the tower upright, permitting downwind turbines to more economically employ taller towers to take advantage of generally higher wind speeds found aloft. Higher winds result in more electricity production. WTC can also employ a freestanding tower where use of guy-cables is inappropriate.

5. Physical Description – size/aerial extent, MW capacity of a single unit

   1st prototype – 250 kV, 2nd prototype – 500 kW, Working (?) on 3rd prototype – 750 kW. 750 kW turbine will have a 60 meter rotor

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc) Wind, transmission

Technological Feasibility:

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])? 250 kW first prototype has been in testing since May 2000 at the Department of Energy's National Wind Technology Center near Boulder, Colorado. 500 kW second prototype was installed in December 2001 in northern Los Angeles County, California.

2. Has the technology been installed (if yes, where)?

   ____

3. Is the technology in operation (if yes, where)?

   ____

4. Total MWs installed/in operation?

   ____

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

   ____

6. Critical flaws or unresolved technical or operational issues? In March 2002, WTC grid connected its 500kW second prototype turbine. This turbine operated successfully in testing for approximately two months before an electronic device failure and a control system software glitch caused a blade to strike the tower. This accident caused an undetected crack in the turbine's rotorshaft and led to a second accident in June 2003. The machine has been dismantled and will be repaired and returned to operation in 2005.

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

   ____
   ____
   ____

Economic Feasibility:

1. Is Cost of Technology competitive with other technologies? "Our goal has always been to produce a utility-scale wind turbine that does not need subsidies in order to compete in electricity markets. Our target is to reduce the unsubsidized cost of generating wind energy to 3.0¢/kilowatt-hour in large windfarm applications. Then we'll see some real growth in the use of wind energy!"

   "A lower priced wind turbine is only part of our advantage. Our 750 kW turbine will feature a 60-meter rotor--very large for its' rated capacity, but ideal for low wind speed regimes--reaching rated capacity in 11.5-meter/second winds. When mounted on our cost effective guy-cable supported tower, a configuration upwind machines cannot use, the rotor can be economically elevated higher above ground to take advantage of higher winds aloft to produce more electricity.

   Lower turbine prices together with higher productivity and low operating costs will enable our turbines to produce electricity for 30% or more below today's most economic wind turbines, when installed on sites with wind shear and when standard financing charges are applied. When in full production, we are confident our turbine will be capable of producing power for an unsubsidized price of 3.0¢/kWh or less. At this price wind energy will be the lowest cost source of new electricity generation."

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

   ____

   ____

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   ____

   ____

   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements:

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

   ____

2. What are optimal siting conditions?

   ____

   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

Additional Information

"In the final stage of our development effort we will design a new rotor blade to optimize turbine performance. This will allow us to increase rated capacity of the turbine platform to 750kW. Once these new blades have been tested, we will deploy turbines in several small demonstration installations in North America and prospectively overseas, and then be ready to offer our turbines commercially."

World Wind Energy Association
(WWEA)

Questionnaire and Information Needs Form

THIS CONVERSATION TOOK PLACE BETWEEN:

Organization/ Group/Company/Individual Contacted		**TRC Representative**	
Organization/Group/ Company:	World Wind Energy Association (WWEA)	Name:	Erika Lunn
Name / Title:		Date and Time of 1st Call:	
Mailing Address or Web Address:	http://www.wwindea.org/	Date and Time of 2nd Call:	
	Charles-de-Gaulle-Str. 5 53113 Bonn Germany Tel. +49 228 369 40 80 Fax +49 228 369 40 84		
Phone Number:		Other:	Emailed secretariat@wwindea.org on 5/1/06.

Many of the WWEA papers are not available electronically for free and must be purchased. One paper/speech online to the Organizing Conference of the American Council for Renewable Energy titled "Renewable Energy in America" on July 10-11, 2002 in Washington was available, but proved unhelpful to the CZM search. Offshore technologies was not specifically highlighted and it was written in very general terms. Additionally, the DENA Project Steering Group did a grid study called "Planning of the Grid Integration of Wind Energy in Germany Onshore and Offshore up to the Year 2020" which is only specific to Germany's policy, environment, and long-term goals..

General Information:

1. Type of Organization/Group/Company (Vendor, Non-profit, Trade Association)
   International members from all over the globe including corporations and scientific organizations, holds international conferences on wind energy.

2. Type of Technology
   Promotes renewable/wind energy, not exclusively offshore projects though

3. Name of Equipment/Technology Manufacturer(s)

4. General Description (How Technology Works)

5. Physical Description – size/aerial extent, MW capacity of a single unit

6. Technology Requirements (oil, gas, coal, water, transmission line, electric converter,etc)

Technological Feasibility: NA

1. Has the technology been tested anywhere (if yes, where [lab, river, ocean])?

2. Has the technology been installed (if yes, where)?

3. Is the technology in operation (if yes, where)?

4. Total MWs installed/in operation?

5. Total length of time (days/weeks/years) the technology has been operational? (Note, just because the technology has been installed does not mean it has been operational for the entire period it has been installed)

6. Critical flaws or unresolved technical or operational issues?

7. If the technology is not existing, is it reasonably "Foreseeable": i.e. "technologies that have been identified by a credible source with a likelihood of occurring in the next 10 years"?

Economic Feasibility: NA

1. Is Cost of Technology competitive with other technologies?

2. When does the Technology no longer become cost competitive (i.e. length of transmission line, low wind speeds, low wave height, etc).

3. If possible compare technologies based on:
   - Capital Cost (Purchase cost) Per MW hour of electricity produced

   ____

   ____
   - Estimated Total Installed Cost Per MW hour of electricity produced

Key Siting Requirements: NA

1. What are minimum site requirements for operation (i.e. what is the minimum wind speed/ocean current/wave height to be economical).

   ____

   ____

2. What are optimal siting conditions?

   ____

   ____

3. Construction Requirements/Constraints (Materials, Installation timeframes, etc,)

   ____

   ____

4. Technological Limitations– water depth/substrate/geological conditions/wave height other physical oceanographic limitations or meteorological limitations

   ____

   ____

5. Any limitations in terms of siting multiple units in one area (i.e. they need to be spaced a certain number of feet apart or they need to be spaced together)?

   ____

   ____

6. If applicable, enquire as to data resources to obtain wind, depth, wave height, current, and geological data for the study area

   ____

   ____

Other Contacts

What are other contacts/information sources if information is still outstanding on this technology?

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Additional Information

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Appendix D

Oversized Maps

Provided as Separate Attachment