Offshore Energy Knowledge Exchange Workshop

A Joint Workshop by the
Energy Department's Office of
Energy Efficiency and Renewable Energy
& The Department of the Interior's
Bureau of Ocean Energy Management

held on
April 11-12, 2012
Washington, D.C.

Summary Report

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1. List of Acronyms

AC – Alternating Current
ACOE – Army Corps of Engineers
AWEA – American Wind Energy Association
BOEM - Bureau of Ocean Energy Management
BSEE - Bureau of Safety and Environmental Enforcement
COP – Construction and Operations Plan
CVA – Certified Verification Agent
DC – Direct Current
DOD – U.S. Department of Defense
DOE – U.S. Department of Energy
DOI – U.S. Department of the Interior
DOT – U.S. Department of Transportation
EPAct – Energy Policy Act
EPC – Engineering, Procurement, Construction
EERE – Office of Energy Efficiency and Renewable Energy
FAA - Federal Aviation Association
FERC– U.S. Federal Energy Regulatory Commission
IEC – International Electro-technical Commission
IM – Inspection and Maintenance
IOM – Installation, Operations and Maintenance
JIP – Joint-industry Partnership
MOU – Memorandum of Understanding
MHK – Marine Hydrokinetic (Energy Devices)
MW – Megawatt
NOAA - National Oceanographic and Atmospheric Administration
OCS – Outer Continental Shelf
OEM – Original Equipment Manufacturer
O&G – Oil and gas
O&M – Operations and maintenance
OSHA - Occupational Safety and Health Administration
OTEC – Ocean Thermal Energy Conversion
PPA – Power Purchase Agreement
R&D – Research and Development
RECs – Renewable Energy Certificates
RFP – Request for Proposal
TA&R – Technology Assessment and Research Program
TIVs – Turbine Installation Vessel
TRIR – Total Recorded Incident Rating
TRL - Technology Readiness Levels
USCG – U.S. Coast Guard

2. Workshop Overview

On April 11 and 12, 2012, more than 150 experts on U.S. and European offshore renewable energy and the oil and gas industry met in Washington, D.C. to exchange information and build relationships in support of U.S. offshore renewable energy development. The Offshore Energy Knowledge Exchange workshop was a collaborative effort between the Department of the Interior's Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) with the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).

The workshop is an outgrowth of a Memorandum of Understanding signed in 2010 by Department of the Interior and Department of Energy to coordinate closely on responsible development of commercial renewable offshore energy projects on the U.S. Outer Continental Shelf.

More specifically, BOEM and EERE convened this workshop in order to: better understand the operating challenges of U.S. offshore renewable energy development; identify potential technical solutions offered by traditional offshore industries; exchange "lessons-learned" knowledge of international renewable energy development with maritime and offshore industries, as well as government agencies; and build collaborative relationships between U.S. and international industry partners, traditional and renewable energy developers, and government agencies.

The workshop consisted of introductions by key leadership figures from both the Department of Energy and the Department of the Interior, as well an overview panel. Following the introductory session, workshop speakers presented in four panels on the following topics: project design and decision making; construction and installation; safety and operations; and research and collaboration initiatives. Following these presentations, participants separated into smaller breakout groups and – focusing on the four panel topics – discussed key issues identified during each presentation.

During the two-day workshop, the maritime and offshore industries and government agencies exchanged "lessons-learned" based on international renewable energy and U.S. traditional energy development. Key areas of conversation included electrical infrastructure and sub-sea transmission, platform and foundation designs, project management and planning, installation, construction, and safety.

The four panel topics allowed a diverse cross-section of topics to be identified and discussed in detail. Among the issues identified, several emerged as key areas that need particular attention now, or will be important topics to consider in the future as offshore renewable energy developers tap into U.S. markets.

- Research and development efforts should be highly collaborative and focused on industry solutions specific to offshore renewable energy. Technology developments and development methods should be unique to the offshore environment. When possible, the results of these research efforts should be disseminated widely, or readily available via information management portals.
- Once offshore technologies, processes, and methods are developed, they should be standardized to the extent feasible. As industry benefits from standardized practices, these standards should be developed as proactively as possible.
- Proper project planning is paramount to keeping costs low and projects on schedule – this includes planning for seemingly less central aspects of wind farm development such as cable

connections, installation configurations, and competing demands for infrastructure and human resources.

- Safety should be central to the culture of offshore renewable energy. It should be a key component in the installation and day-to-day operations of offshore energy projects and should be standardized across the industry, drawing heavily on the best practices developed by the oil and gas industry.

3. Panels and Speakers

Day 1 – April 11

9:00 a.m.	Registration
10:00 a.m.	Welcome Remarks
	Bob LaBelle, Science Advisor to the Director, BOEM
	Key Note Speeches
	Tommy Beaudreau, Director, Bureau of Ocean Energy Management
	David Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, DOE
10:45 a.m.	Overview Speakers
	Johan Sandberg, DNV
	Jim O'Sullivan, Technip
	Guy Chapman, Dominion Power
11:45 a.m.	Lunch
1 p.m.	Panel 1 - Project Design and Decision-Making
	Walt Musial, National Renewable Energy Laboratory
	Kurt Thomsen, SeaRenergy-Offshore
	Finn Gunnar Nielsen, Statoil
	Bill Wall, Atlantic Wind Connection
2:15 p.m.	Panel 2 - Construction and Installation
	Joel Whitman, Global Marine
	Doug Frongillo, Knud E. Hansen
	Martyn Boyers, Port of Grimsby, UK
	Dick Porter, GL Noble Denton
3:30 p.m.	Break
3:45 p.m.	Panel 3 - Safety and Operations
	Denise Campbell, HES Improvement LLC
	Breanne Gellatly, Carbon Trust
	John Chamberlin, Siemens Wind
	Tasneem Abbasi, Genesis Oil and Gas
5 p.m.	Closing Remarks & Adjourn

Day 2 – April 12

8 a.m.	Registration
9 a.m.	Welcome
9:15 a.m.	Panel 4 - Research and Collaboration

	John Cushing, DOI, Bureau of Safety and Environmental Enforcement
	Chris Hart, Department of Energy, Wind and Water Power Program
	Breanne Gellatly, Carbon Trust Offshore Wind
	Jim O'Sullivan, Technip
	Roger Bagbey, Cardinal Engineering/DOE
10:30 a.m.	Panel Readouts & Breakout Instructions
10:45 a.m.	Breakout Sessions
12:15 p.m.	Lunch
1:30 p.m.	Reports from Breakouts & Facilitated Q&A
2:30 p.m.	Closing Panel - Summaries and Conclusions
3:30 p.m.	Closing Remarks
	Bob LaBelle, Science Advisor to the Director, BOEM
	Chris Hart, Wind and Water Power Program, DOE
4 p.m.	Adjourn

4. Keynote Speakers and Overview Panel

In opening the Offshore Energy Knowledge Exchange Workshop, leadership from both DOE and DOI spoke about the organizations' efforts toward responsible development of the offshore renewable energy industry. Following these opening keynote speakers, three overview speakers provided perspectives on the offshore energy industry including offshore renewables, their relationship to offshore oil and gas, and their role in the energy market as a whole.

Keynote Speakers

Tommy Beaudreau
Director, Bureau of Ocean Energy Management, DOI

Key points offered by Director Beaudreau:

- DOI & DOE have an MOU and a jointly issued National Offshore Wind Strategy
- DOI also has an MOU with USCG, and is working on MOU with ACOE
- BOEM's Smart from the Start initiative facilitates Atlantic offshore wind siting, leasing, and installation
- First commercial wind power lease in US: Cape Wind could provide 75% of local power
- BOEM is working across many agencies to coordinate a cross-cutting approach to offshore development addressing key issues such as siting, regulations, available services, safety, permitting, resource assessments
- BOEM's efforts and goals include:
    - Responsibly leasing areas for renewable energy development on the OCS
    - Key mandates – safety, environment, coordination with tribal governments and fair returns for BOEM
    - Delaware and Maryland resource assessments have begun, which will assist in providing the foundation data for OCS development

  - Encourage development while ensuring projects are executed in the right way, in the right places
  - Massachusetts project is underway, which will provide power to Cape Cod, Martha's Vineyard, etc.
  - 10 states are working towards offshore development (from NC through Northeast)
  - Transmission is a key piece to the puzzle – an offshore transmission from offshore New York to Virginia is being planned that will assist in gathering and transmitting offshore energy
  - BOEM is continuing outreach to organizations outside and within government agencies.

David Danielson
Assistant Secretary, Energy Efficiency & Renewable Energy, DOE

Key points offered by Assistant Secretary Danielson:

- This year DOE has invested $1.8 billion in clean energy R&D and to break down market barriers
- DOE plans to continue with the National Offshore Wind Strategy jointly announced with DOI
- There are ~4K GW of untapped wind resources off the nation's coasts
- Offshore wind presents a new industry that can develop high paying jobs and economic growth opportunities
- As there are many technical challenges to durability in harsh environments, the oil and gas industry will be a key knowledge base for offshore renewables
- Many challenges/opportunities exist for DOE to address: lower the cost of wind power, innovate to provide maintenance in harsh environments, break down market barriers, demonstrate technologies to de-risk financial investment, and promote global collaboration to learn from international offshore wind experience
- Lessons learned from the offshore wind industry will have applicability for MHK deployment
- The government's role should be to convene people as an honest broker and support industry development with funding and technical assistance
- DOE's demonstration program goal is to put four pilot projects in the water and establish efficient permitting pathways with BOEM and other agencies
- DOE's long range strategy includes:
  - Bring levelized cost of energy from $.25/kwh to $.07/kwh
  - Cut costs, decrease risks, overcome technical challenges
  - Address fabrication, O&M, and market barrier challenges
  - Partner on successful demonstration projects
  - Facilitate effective mutually beneficial international collaboration
- The DOE Wind Power and ARPA-E programs have already made serious investments in design tools; in next generation drive-train technology development including superconductivity, direct drive and single-stage gearboxes; in addressing market barriers, including resource and infrastructure assessments; and in development of demonstration projects.

Overview Speakers

Johan Sandberg, DNV

Offshore Renewable Energy

- Offshore wind turbines are larger than land-based wind turbines - blades offshore may be up to 80m long - and are generally assembled in the water due to their size.
- Currently deepest fixed bottom installations are in approximately 35-45 m of water
- Floating technologies don't necessarily face the same installation challenges as fixed bottom - they may be built in sheltered waters and towed to the site.
- Floating turbines require dynamic cables which are at this point an immature and sensitive technology and will require a lot of research. Developments in the Oil and Gas industry will benefit the wind industry, the technology can be transferred.
- Two full-scale floating turbine platforms are currently being demonstrated – Hywind (Statoil) and Windfloat (Principle Power), other technical approaches are in development.
- Capital expenditures (CAPEX) structure – the turbine is the biggest single cost driver. The substructure can be of equal magnitude (depending on its size). But it is easier to control (hedge) risk against steel price than the weather risks in the installation phase.
- Offshore turbines are immature as a purpose-built technology and are expected to decrease in per MW cost, possibly following the learning curve of onshore turbines, with further development.
- Distance from shore can be a key cost driver. Staying within ~100-150km seems to be the cost-effective strategy. High voltage AC vs. DC transmission lines are a key consideration.
- "Waiting on weather" is a major driver for installation and maintenance operations, particularly with fixed offshore systems. The cost of large installation vessels waiting for acceptable weather windows is a large cost driver for fixed systems.
- O&M can be dangerous and generally involves small vessels traveling and docking with the turbines. Larger "mother vessel" concepts are in development to improve this process at far offshore wind plants. Also, turbine development is expected to facilitate more remote control and higher "uptime" without physical visits to the turbine.
- Efficient manufacturing is a key component of offshore wind success. A great deal of steel is needed in current designs. But cost of steel can easily be de-risked with hedging, removing uncertainty.
- European Wind Energy Association analysis on offshore CAPEX indicates that it is feasible to reduce the costs of offshore below those of onshore wind.
    - Floating technology could fill a niche created by the impracticality of installing fixed bottom technology in winter months. Floating wind turbine technology has a reduced exposure to risk of large and expensive jack-uk vessels sitting idle waiting on calm weather to do offshore installations (please be aware that this might not be the case for TLP's). floating turbines also require relatively calm weather to be installed but they do not require the large vessels but only tug-boats. Tug boats are not as expensive and much more flexible, i.e. they can be used for other tasks in times of harsh weather.
- International overview:

- The UK and Germany are currently leading the industry forward (30 GW by 2030). France has recently also joined the race.
- Green jobs: in 2020 it is projected that 0.5 million jobs will be related to wind (1/3 in offshore) in Europe.
- Germany is closing their nuclear plants (24 reactors) and developing offshore wind (24 GW) by 2021.
- Japan is an exciting and aggressive market with huge potential. After the Fukoshima nuclear disaster Japan closed all its 54 nuclear reactors and have now completely changed its energy strategy for the future. Firstly, the energy use had to change dramatically and large reductions of consumption has already been achieved through energy efficiency initiatives Secondly, the most immediate energy deficit had to be replaced with imported LNG – significantly increasing the price of LNG in Asia and adding billions of dollars of fuel cost (and fuel cost risk exposure!) per month to the country . Finally, the offshore wind potential in Japan is enormous and could supply the whole country many times over without any fuel cost (or fuel cost risk exposure). Japan also realize the impact floating wind could have and its potential as an export product. Focus on renewables over nuclear is not necessarily a technical issue, but a public perception issue.

Jim O'Sullivan, Technip

Perspectives from the Oil and Gas Industry

- What the oil and gas industry brings:
  - Experience developing all relevant offshore technologies except the turbines.
    - Platforms, jack-ups, transmission, etc.
  - Experience in developing an offshore workforce. There are approximately 162,000 jobs and 7,000 job openings. The challenges of the 80s and the resultant hiring freeze basically cut out Generation X. The industry is primarily comprised of Baby Boomers and Millennials.
  - There is not the built-in infrastructure of Europe in the US. The closest is the Gulf Coast, which is far from the Atlantic demand base for offshore wind.
- What lessons has the oil and gas industry learned:
  - Health, Safety and Environment is the industry's credo. This has been brought about through hard learned lessons from hurricanes, disasters, etc.
  - Regulatory and industry codes have evolved over time.
  - Oil and gas understands that any slip up is bad for the entire industry.
  - "Keep it Simple and Stupid" is the necessary mindset. Straightforwardness is key.
    - This is of obvious with construction. The concept of "stick building" should be rethought.
  - Contractors should be more than a box on a diagram and should be brought in together as early as possible.

- At present, we don't know what we don't know – this is a challenge in mitigating risk. "I know I don't know" is a big improvement.
- Evolving issues will take time. With expensive projects that are currently a small industry, it is difficult and expensive to develop technology specifically suited for offshore.

- Floating systems offer great potential – minimizing offshore operations is a huge positive.
- Offshore energy industry, both O&G and renewable, can share almost every technology/infrastructure except for the turbines.

Guy Chapman, Dominion

Offshore Wind Energy – A Utility Perspective

- Dominion Power is a regional utility (the 3rd largest utility in the United States) serving Virginia primarily
- Dominion is currently developing 284 MW in wind.
- Dominion maintains a balanced, diverse generation portfolio.
- The VA renewable mandate (RPS) is voluntary, but a key driver. Goal is 15% by 2025.
    - One of the considerations for in-state renewable development is the potential of buying cheaper to develop renewable power from other states with more favorable resources.
- LCOE is one of the decision tools for the utility. Combined Cycle is the cheapest form of renewable generation currently. The utility is considering asking customers if a premium is reasonable in order to develop and provide renewables as part of the generation mix.
- Offshore wind is one of the few renewables feasible for large scale production in VA. Onshore is only suitable along ridgelines where farms face much opposition.
- Solar costs have decreased considerably over the last two years. Construction of solar is currently much less risky than offshore energy.
- Dominion completed a study on offshore wind transmission and the interconnection to onshore.
    - Up to 1500 MW can be added without creating transmission difficulties. Relatively minor upgrades will be needed above this.
    - Not as many synergies in laying transmission lines as was anticipated. Reliability and risk management increased the projected costs.
    - High Voltage DC is not currently considered feasible. VA wind resource is 24 miles from shore.
    - Dominion is currently looking into system optimizations including best rotor diameters, the largest feasible turbine, etc. through funding from DOE.
    - Dominion has extensively examined the potential of offshore and focused on mitigating the number one hurdle for development – cost.

Panel 1 Summary: Project Design and Decisions Making

The opening panel of the Offshore Energy Knowledge Exchange focused on topics related to project design and decision making. Much like the offshore oil and gas industry and the European offshore renewable energy industry, U.S. offshore renewable energy developers will face many key questions and considerations long before construction begins. Some of these considerations will require important decisions related to design standards, contracting, cabling and interconnection, as well as other considerations specific to each project site and technology design. This panel allowed key industry experts from the offshore oil and gas industry, the European offshore wind industry, as well the nascent U.S. offshore renewable energy industry, to present on several key considerations necessary in the project design and decision making phase of the developing offshore renewable energy industry in the United States.

Keith Michel of Herbert Engineering moderated the panel, and four industry experts presented on the following topics. Walt Musial, of the National Renewable Energy Laboratory, spoke to the importance of design standards and certifications and ongoing efforts to reconcile existing standards. Kurt Thomsen, of SeaRenergy Offshore, presented on his experiences and lessons learned in Europe regarding project definition, decision-making, set-up, and execution. Finn Gunnar Nielsen, of Statoil, presented on his experience in foundations and substructures as they apply to both offshore oil and gas and offshore renewable energy. Bill Wall of the Atlantic Wind Connection spoke to current transmission issues in the United States and Europe and potential solutions for large-scale offshore renewable energy plant integration. Each panelist presented on their respective topic for approximately 10-15 minutes.

On the second day of the meeting, workshop attendees and presenters convened to discuss the current state and potential future of project design and decision making. Through these discussions and the presentations, participants identified four key areas of discussion:

The Need for Codes and Standards

A key factor to the future success of the offshore renewable energy industry will be to standardize technical decision making processes in the project design phase. Currently, due to its relatively low levels of technology readiness, the MHK industry does not have design and evaluation codes under development. On the other hand, several entities have taken up the effort of developing or identifying standards and best practices applicable to offshore wind, taking lessons from European offshore wind experience, as well as from standards regulating the offshore oil and gas industry. These codes and standards are being assimilated and expanded to address site specific U.S. considerations, such as hurricanes and ice loading, and guide developers regarding details such as loading calculations, substructure connections and evaluation of floating systems. Increased deployment, validated design tools, and the development of certification core competencies will all help to create, refine, and apply the standards and guidelines necessary to ensure success of the industry.

The Importance of Adequate Project Planning

Adequate attention to project planning prior to construction is often one of the most important yet overlooked components of project design and decision-making. Due to the relatively immature nature of the U.S. offshore renewable energy industry, an opportunity exists to learn many lessons from experienced project planners. There are many potential issues regarding contracting, weather, hardware, balance of plant, human resources, and the availability of infrastructure that could arise during the construction and installation phase of an offshore wind or MHK plant. It is important that project developers anticipate these issues and plan appropriately for them. Spending more time in the project planning phase often reduces the amount of money required to adapt to unexpected changes later on.

The Need for Site Specific Technology

As offshore renewable energy moves farther from shore and into deeper waters, it will be important to adapt by developing offshore specific technology and installation methods. Currently, floating platform oil and gas extraction is less expensive relative to production rates than fixed platform oil and gas. Offshore renewable energy has an opportunity to follow a similar pattern if the correct site specific technologies can be developed in order to adjust to unique site characteristics. This can include floating offshore wind turbines, tension leg platforms, or deep draft technologies. Different soil, wave, and weather conditions will call for site specific designs as well. Adapting to and planning for site specific factors will allow the industry to take advantage of increased energy capture and reduce risk in the operation phases.

Electricity Delivery and Grid Interconnection

Grid interconnection will be an important component of offshore renewable energy planning requirements as the industry develops. Unlike the oil and gas industry, the offshore renewable energy industry is more vulnerable to single point of failure issues that are intrinsic to grid connection and cabling. In addition, the U.S. coastline, specifically along the Atlantic Coast, may not currently have appropriate infrastructure required for a significant increase in power delivery that would result from the development of offshore wind. Finally, longer distances from shore may require the use of DC current, rather than AC. Currently, the European Union is developing a super grid that will connect farms and onshore areas to decrease transmission and single point of failure issues in Europe. Project developers should plan appropriately for cabling and grid connection issues prior to construction and installation.

Notes from the Overview Presentations

The following presentations were made to all attendees at the meeting. The project design and decision-making panel of presenters included experts from around the world and across industries. The presentation proceedings are for informational purposes and should not be considered as official views of the Departments of Energy and Interior, or attributed organizations.

Walt Musial, NREL
Designing For Renewable Energy Standards

- A broad range of rules, regulations and standards currently exist.
- A recent report by the National Academies recommends that BOEM develop core competencies to assess structural integrity of offshore wind turbines.
- Deep water (West Coast, Great Lakes, Maine), fresh water (Great Lakes) and hurricanes (East coast) pose unique technology challenges for which there should exist unique design criteria in

the standards. Certain key agencies are working to develop guidelines for these specific conditions.

- Process of offshore wind design is evolved from the point of view of land-based wind, while MHK is still in the process of maturing.
- DNV, GL, ABS, and IEC are all working to develop regulations, standards, class and/or certification guidelines for offshore wind. AWEA is currently working to stitch together relevant standards to provide a pathway forward for developers.
- Design, manufacturing, installation, commissioning, post construction inspection, and decommissioning are all key components to AWEA's developing guidelines.
- Current IEC standards don't give adequate guidance on the connection between offshore turbines and their substructures.
- Type certifications for turbines are currently driven by IEC standards and do not guarantee suitability for compliance to a particular site. Site certification compliance is handled by project certification under the IEC 61400-22 standard.
- Not much environment or human risk is involved in offshore wind when compared to oil and gas. Policy risks exist due to the potential for large scale failures.
- Current standards don't cover floating systems, but are being developed.
- Design tools need to be validated with test data.
- Proper project planning and decision making will require coordinated regulations, rules, and standards for all phases of a project including design, installation, operation, and decommissioning.

Kurt Thomsen, SeaRenergy Offshore

Project Definition

- Offshore wind in Europe applies the same emphasis on safety as oil and gas.
- Cables are the major issue, not turbines or foundations.
- The EPC route is a lot of work – seek out someone who can do the process for you. In addition, it can be hard to convince lenders if this is the route you seek.
- Currently there is a lack of experts to employ.
- Existing vessels and equipment in the United States are not fit for purpose and could become unavailable for use if a better project comes along.
- Predict method of installation: the industry needs a vessel that is self-propelled, holds everything and everyone, and comes back when it is empty.
- Think carefully about work environment and the effect it will have on your workers, many of whom will be young and spending weeks away from home.
- BOP has been more of a challenge.
- The complexity of offshore projects involves many stakeholders and many things happening at the same time.
- Experience is growing and leading to multi-contracting, bringing the costs down. In addition, less external advisors are being used, which speaks to the growing maturity of the industry.
- Check on contractors regularly – "you get what you inspect, not what you expect."
- Both mature and immature markets suffer from hardware choices and BOP economics. Supply is not adequate for demand.

  - In an immature market, there is little availability of equipment and little chance of success for a large project. In a mature market, fit for purpose equipment exists but there is a high demand, so there is a risk of availability.
- Existing construction methods aren't pretty, but they work.
- The large rig will be the method of choice for the next 10 years.
- A lot of the time is spent as down time waiting for weather.
- Project planning Do's: Secure partners early; develop organization properly; coordinate items often; involve authorities early; plan every detail with a backup; be proactive.
- Project planning Don'ts: Don't work in silos; don't budget the cheap individual components; don't rely on your partners without inspecting; don't wait to do prep; don't save money in the beginning.
- Appropriate attention to project planning will save money and time in later project phases.

Finn Gunnar Nielsen, Statoil
Foundations and Substructures

- Don't think about creating a platform on which to build land-based technology – think of the entire system as an offshore system.
- To get out of 20-20 box (20m depth, 20 km from shore), one must sacrifice either shallowness or nearness.
- Floating O&G may be cheaper than fixed relative to production rate (it depends upon production rate), offshore wind could be the same.
- O&G moved from shallow water to deep water 60 years ago, and offshore wind is repeating the same general timeline.
- Offshore systems are subject to different load patterns than onshore wind. It is also different from O&G systems; the systems must account for coupled wind, wave and controller forces(In particular for floating systems).
- Different soil conditions should also be considered for site specific design considerations.
- Mitigating the wave effects is an area of interest for research and development. Research on wave forces on fixed structures in shallow water (steep, breaking waves) is also an area of research.
- Optimized as well as innovative foundation solutions are needed. Experiences gained from the offshore oil and gas industry are very relevant in developing the technology.
- Industry must consider the total costs; fabrication, installation and operation. Don't optimize just one.

Bill Wall, Atlantic Wind Connection
Building an Offshore Wind Industry in the Mid-Atlantic Region

- The Mid-Atlantic is an excellent location for offshore wind.
- The Jones Act will have an effect on the U.S. industry.
- Wind farms that are greater than 25 miles offshore will probably need high voltage DC current rather than AC.
- EU Super Grid interconnects farms and onshore areas so that if the wind isn't blowing at one farm, the cable isn't going unused.
- Connecting farms has been reported to smooth out variability by a University of Delaware study.

- Horizontal directional drilling will be needed for covering transmission cables while complying with existing environmental regulations
- Foundations, turbines, and submarine cables are mature industries.
- Cables have proven more complicated/expensive than anticipated.
- Dynamic positioning vessels are in the gulf and not in the northeast, which will cause some problems for installation.
- Turbines are interconnected by inter-turbine cables (with fibers for data acquisition and supervisory necessities), and interconnects are typically 138kv, 230kv, or 340kv.
- Getting the power onshore also presents challenges as most grid connections can't handle the full amount of generation.
- Communication cables are necessary, these can be built into multi-core cables, or piggybacked onto single core cables.
- Logistics are obviously paramount in offshore developments.
- Submarine cables have the highest number of insurance claims. It seems cabling is an afterthought for some offshore developers.

Panel 1 Breakout Discussions

Following the presentations, workshop attendees were given an additional 90 minutes to delve more deeply into the topic of project design and decision-making. In their discussions, the breakout groups identified the following unique U.S. opportunities, key challenges, and potential solutions involved with developing the U.S. offshore renewable energy industry.

What opportunities are unique to the U.S.?

- The United States has the ability to start in the industry using lessons learned from Europe and the oil and gas industries.
- Markets respond very quickly – once the technology is cost competitive without subsidies, the U.S. market will respond to demand.
- Offshore transmission may be less of a constraint than it has been for land-based power which must consider state boundaries, farther distances to dense population areas, etc.
- BOEM has the opportunity to start working now to develop core competencies for standards and clearly defined processes for permitting.

Along with these opportunities, the breakout groups also identified the following ***key challenges***:

- It will be necessary for costs to come down to a competitive level.
- Water depth poses a challenge, including both transitional depth and deep water.
- The United States currently lacks the required human resources, infrastructure, and specialized manufacturing capacity necessary for offshore wind project development.
- The Jones Act may affect the ability of the United States to import necessary installation vessels.
- A lack of metocean and geophysical data is a key challenge for project siting and design.
- Current state and federal policies, support, and regulatory guidelines can be unclear and confusing for developers and financiers.

In considering both the challenges and opportunities of the U.S. offshore renewable energy industry, the breakout groups were then able to identify or suggest a list of ***potential solutions***:

- A temporary, sector wide Jones Act waiver may help establish a domestic industry for compliant vessels.
- Demonstration projects and other R&D initiatives present a key opportunity to reduce project risk.
- Clear, internationally accepted standards will help lower risk for developers and decision-makers.
- Establishing formalized pathways for importing research results from Europe will enable the United States to most efficiently use this information.
- Establishing a clearinghouse of widely available information to include meteorological data, geophysical and geological data, and data on environmental conditions would lower risk.
- Anticipating skilled labor constraints with industry focused training programs may help reduce the impact of these constraints later on.

Panel 2 Summary: Construction and Installation

The second workshop panel focused on topics related to construction and installation. Key discussion topics included preparing shipyards and ships for offshore renewable energy development, the permitting process, coastal weather systems, transmission systems, jobs, and national security. The importance of planning emerged as a common theme in the discussion. Proper planning and contingency planning help to avoid bottlenecks and downstream effects that may result from unexpected changes or problems.

Randall Luthi of the National Ocean Industries Association moderated the panel, and four industry experts presented on the following topics during this panel. Joel Whitman, of Global Marine Energy, Inc., spoke about offshore wind installation, focusing on key planning considerations to keep in mind during the installation phase. Doug Frongillo of Knud E. Hansen presented on vessels for offshore wind installation, transportation, and maintenance, and highlighted key areas for lowering risks and costs. Martyn Boyers, of the Port of Grimsby, presented on port infrastructure, the benefits of offshore wind, and the importance of engaging local communities in early stages and prior to construction. Dick Port of GL Noble Denton spoke about lessons learned from the offshore "oil patch" and highlighted key considerations for project management. Each panelist presented on their respective topic for approximately 10-15 minutes.

On the second day of the meeting, workshop attendees and presenters convened to discuss the current state and potential future of offshore wind safety and operations. Through these discussions and the presentations, four key areas were identified:

Transmission and Cabling

Transmission and cabling are challenging obstacles for offshore renewable energy development. Increased electrical loads from potential offshore wind development off the Atlantic Coast may require significant infrastructure upgrades to include subsea grids as well as shoreline connection points. In addition, a significant percentage of all insurance claims submitted in the European offshore wind market have been related to subsea cable damage. These challenges must be considered as the U.S. industry continues to develop, and will require innovative methods for installing, maintaining, and protecting subsea cables and transmission lines.

Vessels and Transportation

Currently, the United States does not have any Jones Act compliant specialized offshore wind installation vessels. Existing ships, such as those used for oil and gas platform installation, can be retrofitted for installation and maintenance; however, this may not be the most cost effective or safest solution for the long term. In addition, weather conditions can pose significant challenges and generate high costs given that operators may need to visit each turbine up to five times annually for routine maintenance. Appropriate vessels for installation and routine maintenance will be required in order to keep operations efficient and costs down.

Ports

Development of an offshore wind farm can occur where the fishing industry is active. However, to make this an effective partnership, the ports and related businesses developing offshore wind farms need to engage stakeholders early on in the process. Job growth and business development can benefit the port area and its economy. However, these economic benefits should be properly communicated to all stakeholders as early on in the project as possible. In addition, many U.S. ports may require infrastructure upgrades in order to respond to the needs of the offshore wind industry.

Construction and Environmental Issues

While environmental issues have not halted any offshore wind farm developments in Europe, environmental aspects of a project's requirements have the potential to cause significant delays in a project schedule. Competitive uses should always be considered in the project siting and permitting phases; nearby wildlife or migratory paths, shipping lanes, fishing grounds, and recreational uses should all be taken into consideration, among others. A project that does not take these uses into consideration may face future delays as a result.

Notes from the Overview Presentations

The following presentations were given to all the attendees at the meeting. The construction and installation panel of presenters included experts from around the world and across industries. The presentation proceedings are for informational purposes and should not be considered as official views of the Departments of Energy and Interior, or attributed organizations.

Joel Whitman, Global Marine Energy Inc.

Offshore Wind Installation

- Cable transmission should not be thought of as a small part of an offshore wind plant.
- Surveys and samples don't give the full picture for transmission construction.
- A working wind farm could have 30-40 vessels out at any given time.
- Export cables are critical to bring power to shore.
- There needs to be a clear risk profile associated with cable burial depth, and the industry needs regulations or guidance for understanding the risk. Maintenance associated with cables (anchors drag over them, go down, etc.) means greater depth results in greater costs.
- J tubes (interconnection of substructure and cable) are an afterthought and designed on an ad hoc basis. Standardized configurations will reduce costs and losses.
- There is a dearth of qualified workers. Global Marine Energy has no Americans on its staff.
- Developers must understand weather risks; a typical weather window runs from April to November.
- East Coast grid is not capable of handling the potential power that can come through, and it is unreasonable to ask private developers to also upgrade the grid.
- American port facilities are not capable of handling infrastructure required for offshore wind development.
- Original focus on offshore was the turbines, however, offshore cable has caused much trouble to the industry. The United States focus should be getting lessons learned from Europe.
- Offshore cable installation should not be the focus; it should be on offshore transmission.
    - Routes are not simple to determine. Assessments and samples are insufficient for a proper, organized cable plan.

  - There is a lifecycle laid out for marine cables. Maintenance on deep cables is expensive and difficult.
  - There is a huge opportunity for developing job markets.
  - Most of the transmission was built by the federal government and forcing generators to build out for new installations is the most attractive option from the perspective of grid operations.
  - Building substations is a great option for our existing ports because the sheer size requires that they are built here.

Doug Frongillo, Knud E. Hansen

Offshore Wind Installation, Transportation, and Maintenance

- There are currently no American Jones Act-compliant specialized turbine installation vessels.
- Industry should employ engineering techniques to widen installation time window but still work safely.
- Each turbine is visited an average of 5 times per year for inspection and maintenance.
- It's possible to adapt existing available vessels for transport and installation, even though it would be preferable to have purpose-built vessels.
- Transportation is one of the most crucial aspects of turbine installation vessel selection.
- Transportation methods are normally determined by distance from turbine site to the shore.
- Situations with wave height above 1m are where difficulties arise.
  - Motions and sea fastening are keys to mitigation.
- Engineering safety is a risk reward proposition.
- Extending the operational window has significant benefit.
- Maintenance for offshore wind fields is an expensive component.
- Half of the fatigue life of the equipment is used up in transport and installation.
- Small transport vessels for maintenance are not feasible for large wind farms due to danger and the time it would take to service all the turbines in given weather windows.
- Transport and up-ending of towers is an example where ad hoc solutions have been required in the past due to the scarcity of assets suited for these tasks.

Martyn Boyers, Grimsby UK Fish Dock Enterprises Ltd.

Port Infrastructure

- Grimsby is a traditional major eastern United Kingdom Port with a long history of fishing that is still dominant, but has developed into Offshore Renewables through diversification.
- Conveying economic benefits to traditional stakeholders is key.
- Offshore wind and fishing can co-exist.
- Branding is critical.
- Mistakes are less costly in the design phase rather than in the construction/installation phase. Contractors should all meet and discuss the project together.
- Grimsby has witnessed transformational change over the last 5 years due to the offshore wind market development
- Fish industry would not keep Grimsby viable, so investment into offshore wind was a strategy for growth.
- U.K. Wind market was unclear at the beginning and still the direction is not transparent, but development of offshore wind was steady and supported.

- Positive relationships with operators are essential for customers due to the required operations and maintenance associated with 25 year turbine lifetimes.
- A can-do attitude is a primary asset in developing opportunities.
- Grimsby used the first concrete pontoon for construction of turbines
- Culture, history, and tradition should be confronted head on and respectfully.
- Permission is one of the biggest obstacles to progress. This complexity will need to be faced by the government.
- If fishing grounds are in wind farm areas, fishermen will object.
- Wind farms can be reliable and cost effective.
- By 2020, 305 O&M jobs may be created on one Grimsby contract.
- Business creation followed the redevelopment of the Grimsby port.
- Negotiations associated with offshore development can be protracted and development is difficult but profitable.

Dick Porter, GL Noble Denton

Lessons from the Offshore Oil Patch

- Project Manager needs to understand engineering, contracting.
- Get soils and survey data early.
- In the design phase, cost of mistakes is smaller than in construction/installation phase, so frontload data collection.
- Marine Warranty Surveyors work on behalf of insurance companies – get them involved early.
- Don't take shortcuts on historical weather averages to make numbers work; averages will catch up with you.
- Have installer be responsible for transportation.
- Have all contractors meet together; project management is a team sport.
- Ratios of total costs: 5% engineering, 5% PM, 35-45% Mission Equipment.
- Soils data and site surveys – get this information early for siting foundation, etc.
    - Example – In a particular project, $400k for soil surveys were not done, which cost about $7 million in downstream effects
- Avoid over-insurance – each individual contractor has their own insurance.
- Double insuring certain areas can cost an extra 1-3%.
- Check the declarations even for common items.
- Consider letting contractors provide the builders risk insurance.
- Marine Warranty Surveyors – make sure work is being done in a safe, workman like manner.
- Plan for weather down time. It will happen and will not be cheap.
- Plan for weather conditions other than wind and waves – tides, currents, fog, turbidity, combined crossing weather.
- Oil and gas and offshore have many similar values.
- Safety first – starting day 1, a safety culture should be instilled.
- Coordinating marine movements causes downtime and has financial and schedule downstream effects. Get an onsite marine coordinator.
- Subsea cables are expensive. This does not get the attention it requires. Commodity costs also come into play as well as delivery lead times and logistics.
- Managing interfaces can be the number 1 success factor. The handoffs from one contractor to another are where problems occur.

- Keep an eye on risk.
- The key successes are the interfaces. Will contractors work together? Involve all the contractors early.
- Allowing the installer to control the transportation of components to the site is an effective method for avoiding delays.
- Things can be fast, cheap, or well-made; however, you can only have two out of the three at one time.

Tom Coates, HR Wallingford, UK (not in attendance)
Environmental Issues During Construction – UK Perspective

- No applications have been turned down due environmental reasons, but it has delayed nearly all of them.
- Select the cable and wind farm area route carefully to avoid issues (e.g., shipping routes, military radar, recreational sailing areas, etc).
- Use soft start piling and avoid working when marine mammals are observed within the defined mitigation zone; consider gravity bases and jackets.
- Bury cables to minimize risks (snagging, Electro-Magnetic disturbance), use cable laying methods that minimize sediment disturbance, minimize bed preparation for foundations, and minimize propeller wash in shallow water.
- Consider directional drilling to avoid coastal /intertidal habitat, etc.

Panel 2 Breakout Discussions

Following the presentations, workshop attendees were given an additional 90 minutes to delve more deeply into the topic of construction and installation. In their discussions, the breakout groups identified the following key challenges and potential solutions involved with developing the U.S. offshore renewable energy industry.

What are some key challenges the U.S. industry will face?

- Cabling presents risks due to its depth, standardized turbine positions, and configurations. Additionally, acquiring the commodities for cable manufacturing and steel will present a challenge.
- Weather conditions such as hurricanes and O&M require that safety standards be developed. Weather also influences many financial factors of installation.
- The transmission grid is antiquated and needs to be upgraded.
- The lack of availability of met-ocean and geophysical data is a challenge.
- There are no Jones Act-compliant purpose-built installation vessels.
- The U.S. lacks experienced workers and may need to import expertise, at least initially.
- The lack of defined policy makes it very difficult to do costing. And, the policy for the East coast is not necessarily good energy policy for the West coast or the central part of the country.
- The lack of connection between lease and off-take agreement is a challenge.
- TIVs are valuable and their use is specific to each installation project. If a vessel is jacked up and installing but not transporting equipment, it's considered 'in port' in the United States and not a Jones Act violation. The ruling was adapted from oil and gas.
- The market definition for offshore wind is unclear. It's currently isolated as individual projects, and there is no properly defined *market* that the industry wants to go after. There still isn't

national agreement that global warming exists, so there is no concrete, agreed-upon market for renewable energy within the powers that be in the United States.

- Financing is a challenge as power utilities determine costs based on the market demand. Return is dependent on capital investments, which are in the public interest. This is the most critical component.

In considering the challenges faced by the U.S. offshore renewable energy industry, the breakout groups were then able to identify or suggest a list of ***possible solutions:***

- Collaborative research and development and global exchange could help move the market.
- Performance-based regulations and memorandums of understanding (MOUs) between agencies may speed up regulatory and permitting processes.
- World leaders and the United States federal government should lead the charge on a unified offshore wind strategy.
- Short-term subsidies could be an immediate solution to encourage investments.
- The federal government could act as the proxy to ensure that states work together and create a sense of urgency for offshore wind as a national security issue.
- DOT could help ramp up the construction to create port infrastructure.
- DOE should continue to do demonstration projects.
- Delaying Great Lakes offshore development until there are successful offshore projects in other regions should be considered because of challenges with icing, the weather window, and the St. Lawrence Seaway.
- The United States has tremendous ship yard assets, and as DOD funding is cut, there is a prime opportunity to put the shipyard resources (foundries, heavy lifts and other large manufacturing) into use in offshore wind.
- The federal government could create a one stop-shop for permitting where there is no difference between leasing offshore wind with OCS than with any other technology, on shore wind, etc. Forums could be held where the invested agencies would help with streamlining permitting. BOEM could potentially serve as the coordinator.

Panel 3 Summary: Safety and Operations

The third panel of the Offshore Energy Knowledge Exchange focused on the topics of Safety and Operations. Safety considerations encompass every phase of offshore wind development from design and construction through decommissioning, but it is of particular importance in operations and maintenance where workers may perform duties at dangerous heights over rough seas. While the U.S. may lag behind Europe in offshore wind development, this presents a unique opportunity to apply lessons learned from these other countries as well as from other, more mature industries. European attendees identified some of the key challenges they have faced, such as their difficulty in finding vessels well-suited for O&M tasks, and oil and gas industry attendees shared their experiences in developing a worker safety curriculum that applies the best available safety standards.

Michele Mihelic of the American Wind Energy Association moderated the panel, and four industry experts gave safety and operation presentations during this session. Denise Campbell of CSP presented on the best practices and operational strategies of the oil and gas industry. Breanne Gellatly of the Offshore Wind Accelerator in the UK described the innovation-minded competition they have developed to find solutions to some of the key operational and safety challenges. John Chamberlin of Siemens spoke to the logistical and safety challenges associated with the construction of offshore wind turbines. Tas Abbasi of Genesis Oil & Gas gave a talk on the tools and procedures that can be used and developed in project management that can improve operations and safety.

On the second day of the meeting, workshop attendees and presenters convened to discuss the current state and potential future of offshore wind safety and operations. Through these discussions and the presentations, four key areas were identified:

Safety and Operations Costs

It is estimated that 25% of a wind farms costs are related to Operations and Maintenance, highlighting the criticality of this area. Costs for safety and O&M come in a number of forms and it was noted that, in the experiences of Oil and Gas representatives, making safety a priority from Day 1 is essential for managing the lifetime safety and O&M costs for offshore projects. Prescriptive and performance-based standards must be weighed so that accidents are either mitigated or the impacts are minimized. Once the standards are in place, proper and constant training is required to maintain a healthy and efficient workforce. A focus on safety and operations could help drive down capital costs of certain components, insurance costs for projects, operations and maintenance costs, and costs associated with project down-time while making the industry safer and more sustainable.

Safety and Operations R&D Opportunities

Offshore environments are among the harshest on earth. Accessing facilities, performing work in the ever-changing elements, and creating facilities further from shore are among the many R&D opportunities to gain significant improvements in the safety and O&M of offshore wind facilities. The UK Offshore Wind Accelerator has recognized these challenges and developed a competition for innovative solutions to offshore wind turbine access systems. While this is still ongoing, a number of conclusions have been reached: confirmation that the necessity for improved access systems is a high priority, the conclusion that solutions have the potential to drive down facility costs, and streamlining regulations will be just as important as sound designs. Another R&D opportunity currently being explored is increased data capture at offshore facilities. By remotely accessing the performance data of offshore facilities, operational issues can be diagnosed and sometimes remedied without accessing the facility. Multi-core cables that include data and power transmission is one communication method currently in development. Increasing the safety of accessing facilities, while decreasing the frequency of necessitated visits, are near-term R&D opportunities with documented potential to drive down safety and operations costs

Necessity for Standardization

Like the other focus areas for the offshore wind industry, the development of standards and best practices is a key driver for reducing the costs and improving the performance for safety and O&M. The U.S. offshore wind industry is in a unique position to gain lessons learned from the mature oil and gas industry as well as the European offshore industry. Representatives from the oil and gas industry shared the development of their experience, which has led to the adoption of the best available standards. With this mindset, the oil and gas industry has worked towards standardization and developed certifications to ensure that the highest levels of safety and O&M are adhered to industry-wide, leading to excellent performance in Total Recorded Incident Rates (TRIR). Despite the high standards, the uniformity has led to cost reductions as ad hoc questionnaires and training programs can be minimized, and the continual improvement loop helps to constantly evolve the process to stay current with the industry environment.

Safety and Operations Tools

Safety and O&M data sets from the oil and gas industry are beginning to be maintained in a data warehouse, which has opened the ability to analyze the safety trends of contractors. This has led to a steady decline of incidents over the three years since its inception. Communication was also identified as a critical tool. These projects involve many contractors from a variety of companies and industries. A clear, developed work plan should be agreed upon by all stakeholders before the process starts. This has been found to mitigate safety concerns and expensive downtime, while improving project scheduling and O&M. These cornerstones of project management form the basis of Integrity Management (IM), which was identified as a tool for safely and effectively managing the barriers to offshore wind projects. In this approach, the IM plan, a living document throughout the project lifecycle, is developed in the project design phase and addresses planning, implementation, execution, data, anomalies, and remediation. Clear data-handling procedures are essential at implementation, in order to allow for more seamless shifts in project design, operations, management, and safety. This continual feedback loop and project status database can mitigate project risks and increase operational efficiencies through defined project management goals and clarified project communication.

Notes from the Overview Presentations

The following presentations were given to all the attendees at the meeting. The safety and operations panel of presenters included experts from around the world and across industries. The presentation proceedings are for informational purposes and should not be considered as official views of the Departments of Energy and Interior, or attributed organizations.

Denise Campbell, CSP

Best Practices and Operational Strategies from the Oil and Gas Industry

- There is a need to understand prescriptive versus performance based standards: A prescriptive standards example would be fall protection by restricting height-specific activities through regulations. A performance based standards would involve measures targeted at preventing injury from falls.
- Standardization needs to occur where possible
  - For example, oil and gas has a mindset of taking the best available standards.
  - An overwhelming number of Gulf of Mexico contractors go to the highest common denominator – establish standardization opportunities and require a validation of certifications. A process burden existed when questionnaires were ad hoc. Standardization saved much time and resources. Orientation process was standardized (Safe Gulf). Short Service Employees were required to wear visual documentation of their inexperience – the definition of SSE was standardized.
- Offshore has an opportunity and advantage to use the best available technology and take advantage of the fact that there is no legacy.
- Contractor database for oil and gas gives a good data warehouse to analyze safety trends of contractors. Through monitoring, a steady decrease of incidents has been realized over the last 3 years.
- Contractors with experience have demonstrated a continual improvement loop that drives improvement over time.
- When compared to contractors across all industries, oil and gas have better measured Total Recorded Incident Rates (TRIR).

Breanne Gellatly, The Carbon Trust

The Offshore Wind Accelerator

- O&M is 25% of the cost of energy in wind farms, so it is a huge area of interest.
- The UK's Round 3 wind farms will be further from shore, in deeper waters and consist of more turbines - an extreme example is Dogger bank which is 77-180 miles from shore in 59-206 feet deep water with a target capacity of 9GW
- Access solutions are a large part of the research efforts of The Carbon Trust because Round 3 will require access solutions which can extend the weather window in spite of increasingly challenging site conditions
  - One such example is a port-based safe haven or mother-ship, i.e. a floating management facility that could dock or launch service vessels.
- Innovation will be crucial in reducing O&M time, requirements, etc.
- For the US, there are many lessons from other industries as well as Europe to be leveraged.
- Harmonizing vessel codes and increase standardization has the potential to reduce costs.
- The research competition was an effective way to identify innovative solutions, which will be critical for the industry.

John Chamberlin, Siemens
Offshore Wind

- There are two facilities in Denmark that produce wind components.
- There is a lot of crane work involved in wind turbine construction.
- Sitting down to talk to all contractors can mitigate risks at the start. In general, contractors think all other contractors are less competent.
- In safety, one of the biggest faults is the duration of the decision time between recognizing an issue and finding a solution. More than a couple weeks is too long. The field often wants a 100% solution but a 60% solution is better than nothing. These intermediate solutions should be communicated and discussed for limitations and opportunities.
- Working in elevated conditions is a primary offshore wind industry risk.
- Siemens operates in a zero-harm environment. Nothing is so urgent that we cannot do it safely.

Tas Abbasi, Genesis Oil and Gas
Asset Integrity Methodologies

- An integrated approach to asset management and asset integrity should be taken.
- Integrity management has numerous definitions, but all relate to failure in-service of an asset.
- What can cause failure in service and how do we mitigate it?
- It is important to make integrity management efforts a priority and part of the organizational safety culture.
- Barrier approach – if barriers are defined well, then measures can be lined up to prevent events.
- Steps: Assess Failure modes -> Develop barrier analysis -> Specify Barrier Requirements -> Manage health of barriers
- The Inspection, Maintenance, and Report Process (IMRP) is very expensive. Automation can reduce costs and monitoring can help fix issues before failure.
- Lifecycle risk management needs to be started from day 1 and should be included in design, construction, and in-service.
- Risk management, operator requirements, regulatory requirements, vendor input, and practical aspects are all important components in integrity management planning.
- Make sure vendors are not specifying lifetime requirements. These should be inputs into the process design.
- IM must be developed in the design phase, the earlier the better.
- An IM plan is a living document and is integrated and updated through all stages of development.
- IM Cycle – Plan, Implementation, Execution, Data, Anomalies, and Remediation – all tie into databases. Databases are key and should be considered early in the process so all the data has somewhere to go.
- Fragmented approach to risk management currently exists. This should shift to a design integrated approach.
- Avoid equipment specifications that are not addressing reliability targets.
- Barrier health is not verified before starting service, which puts projects at risk.
- Another project risk is failure to consider changes in the configuration or usage that require barrier reliability targets to be updated.
- Project communication is key so that operations personnel are aware of the necessary planning steps.

Panel 3 Breakout Discussions

Following the presentations, workshop attendees were given an additional 90 minutes to delve more deeply into the topic of safety and operations. In their discussions, the breakout groups identified the following unique U.S. opportunities, key challenges, and potential solutions involved with developing the U.S. offshore renewable energy industry.

What opportunities are unique to the U.S.?

- Deep water - two thirds of the water available for energy is in deep water. It is a shift from the European experience, which primarily operate in shallower water in the North Sea.
- New developers with new installations need to work under new safety standards. The oil and gas industry has more established standards but there is nothing specific currently for wind. Establishment of standards should be a priority.
- There is not active expertise in the US because we have no offshore turbines in place. This is of particular importance with regards to inspectors and regulators.
- There is a lack of regulatory certainty in the U.S.
- There is a lack of vessels and infrastructure in key areas (e.g. Great Lakes and Northeast) to support offshore wind. This is of particular concern with respect to Jones Act restrictions.
- Regulation is driving the decision making with regards to safety. This should be reconsidered, as safety-oriented priorities should drive the establishment of meaningful regulations. There is an established regulatory decision making in Denmark and the UK. It is not clear whether their experiences are exportable to the US. They are bringing in other types of equipment to work around the current regulations, which may decrease safety.
- There is an opportunity to update the existing regulations to better reflect the current situation and maintain a priority on safety and operations.
- Intergovernmental cooperation (e.g. BOEM, Army Corps of Engineers, Coast Guard, and etc.) is important to improve safety and consistency in projects. Due to the infancy of the offshore wind industry, there is a fantastic opportunity to share recommendations and information among all stakeholders.
- We should look at existing O&M methodologies and protocols for safety and diligence in high voltage and current areas. We have a lack of experience in creating new regulations for new technologies. There are multiple regulators in this area and they need to work together.
- People skills, training, and mentorship are needed. Lessons could be learned from the oil and gas industry but other industries should be consulted as well.
- Extreme weather conditions, such as hurricanes and freshwater ice, are important considerations. We may be able to take lessons learned with onshore turbines (e.g. severe winters in North Dakota) to help offshore standards.
- Avian and marine regulatory considerations should be developed; the turbines may need to be shut down during migratory periods.
- We could also look at how Europe and the U.S. handled lessons learned in other marine applications.
- Does the U.S. regulate more heavily than Europe? Other countries are more competitive, which has led to the U.S. falling behind in the development of offshore wind.
- There is a patchwork of regulations, so can be difficult to see how they work together. Collaboration is necessary to maintain a clear regulatory framework.

- For issues involving other users of the waters, the U.S. should look to Europe to see how those stakeholders are addressed in offshore wind. We also have some good examples in the Gulf of Mexico where the oil and gas, fish, navigation, and DOD industries are working together.

Along with these opportunities, the breakout groups also identified the following ***key challenges:***

- Training the workforce. Who funds and handles the training? Do they go to Europe or do we build the capacity in the US? Iowa, Delaware, and California have institutions that perform renewable energy training and could be expanded to offshore. Commissioners from offshore could come from Germany and Denmark to mentor US counterparts.
- Transportation is very expensive and time consuming. It would be helpful to have offshore accommodations (e.g. the floating hotel deployed in the UK) for projects far off shore.
- Advancements are needed in remote condition monitoring and may help reduce the need to be physically at the turbine. We already have monitoring capabilities but they could be improved.
- Regarding safety and regulations, we need to look at what exists and where things go wrong. The goal for industry leaders is zero accidents. Look at hazards on shore, what Denmark and UK have experienced offshore, and what regulations exist that apply to those. Look at whether there are roadblocks in place to mitigate hazards and address those.
- An onshore wind energy plant is considered a *29 CFR 1910* power generation facility and specific OSHA standards are applied. Most of the same conditions apply offshore, though additional challenges include the addition of water hazards.
- We should have industry standards bodies/regulatory partnerships to use industry best practices and challenges to inform regulations. E.g. changing the schedule to accommodate species migration can affect technical requirements/standards.

In considering both the challenges and opportunities of the U.S. offshore renewable energy industry, the breakout groups were then able to identify or suggest a list of ***possible solutions:***

- The Jones Act is a challenge – the solution is legislative. We could consider waiving the Act for a few years specifically for offshore wind projects, or we could consider modifying part of the Act. However, there are organizations and agencies that would not support this approach. The Department of Homeland Security administers the Jones Act. Industry groups could lobby Congress to aid in developing the industry through possible legislative amendments.
- Skilled workforce is a challenge – this influences safety and cost. A potential solution would be to work with European institutions to encourage knowledge transfer. We could develop a certification process. We need to ensure the workers are fit for duty. Sharing across industries is also important (e.g. learn from the offshore oil and gas industry). Multiple organizations would implement the training – government, academia, businesses, etc.
- The lead time between a safety problem and a solution is a challenge. There may be a difference in performance vs. prescriptive standards and solutions. Performance based may be more flexible and better able to handle situations. But prescriptive standards are less subjective and workers can be held to objective criteria.
- A potential solution to ensuring safety could be to have a controlling government entity be the lead for reviewing issues and working with sister entities. An MOU may accomplish some of this but we may also need legislative authority for the entity. The key would be defining

responsibilities so that there is one lead on issues like safety (one entity to call), as well as a prescribed time window in which to accomplish things.

Panel 4 Summary: Research and Collaboration

The fourth panel of the Offshore Energy Knowledge Exchange focused on the topics of research and collaboration. Current and future research efforts in offshore renewable energy have the potential to significantly impact the costs and risks associated with all aspects of the industry including the technology, installation, maintenance, environmental impacts, and so on. The offshore oil and gas industry has learned that in many cases, joint industry efforts can help maximize the dollars spent on research and ensure that results are propagated widely. Similarly, more coordinated research efforts for offshore renewable energy will help the industry move forward as a whole.

Fort Felker of NREL's National Wind Technology Center moderated the panel, and five industry experts gave presentations during this session. John Cushing, of the Bureau of Safety and Environmental Enforcement, gave an overview of some of DOI's research efforts in offshore renewable energy. Christopher Hart presented on the offshore wind research portfolio of DOE's Wind and Water Power Program. Breanne Gellatly gave an overview of The Carbon Trust's Offshore Wind Accelerator. Technip's Jim O'Sullivan presented on the joint industry project approach of the oil and gas industry. Roger Bagbey of Cardinal Engineering presented on the Ocean Energy Systems Annex of the International Energy Agency.

On the second day of the meeting, workshop attendees and presenters convened to discuss the current state and potential future of offshore wind research and collaboration. Through these discussions and the presentations, four key areas were identified.

Joint Industry Project (JIP) Potential

A dominant theme to both the panel discussion and the subsequent breakout panel was the potential for joint industry project (JIP) models – historically used to fund technical development projects in the oil and gas industry – to be applied to collaborative offshore renewable energy research and development projects. By utilizing a joint industry project model, the offshore renewable energy industry would maximize research funding and results by pooling resources and disseminating results widely across a larger number of participants. Joint industry projects could focus on areas of the industry that would not necessarily benefit from competitive advantage, but would benefit all stakeholders and may be too expensive or difficult to pursue independently.

Existing Research and Collaboration Initiatives

Workshop participants, in their presentations on and discussions surrounding research and collaboration, identified a host of different organizations, agencies, and private companies that are currently funding or plan to fund research opportunities that will advance the development of the offshore renewable energy industry. Many of these projects are collaborative in nature, and represent a broad spectrum of topics, from technical to environmental to operational. In addition, many of these projects will have publicly available research results that can benefit the industry as a whole.

Disseminating Research Results

Despite the large amount of funding available for offshore renewable energy projects, research results are often not disseminated widely or made as readily available for the industry to utilize. One of the most important components of industry research is the dissemination of research results, and organizations should focus on facilitating the exchange of this information. Research portals, databases, and other types of information management tools will be key in disseminating research results so that they can have the most impact on the industry as a whole.

Lessons to be learned from O&G

The offshore renewable energy industry is following a very similar development timeline as the offshore O&G industry: both industries began as land-based industries that moved offshore, and both have undergone similar transitions as the technology moved into deeper water farther from shore. Many of the operational and safety concerns are similar, and currently, offshore renewable energy is mimicking some of the infrastructure and installation methods used in offshore oil and gas. Due to these similarities, this industry has the opportunity to take many of the lessons learned from O&G and apply them to developing the renewable energy industry.

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John Cushing, Bureau of Safety & Environmental Enforcement

DOI Renewable Energy Research and Collaboration

- The Bureau of Ocean Energy Management (BOEM) within DOI supports Environmental Studies work in support of their permitting mission.
- To inform the technology and safety regulation responsibilities of BSEE, the Technology Assessment and Research (TA&R) Program assesses safety of technology and promotes development and dissemination of new technology & operational safety research.
- The BSEE website has a specific renewable energy research page. Most reports have to do with offshore wind, but there are 2 MHK studies.
- Study topics have included comparative study of offshore turbine standards, inspection of facilities, accident history of onshore & offshore wind, applicable design standards, workshop proceedings of potential certification verification agents, and mitigation of underwater noise.
- To collaborate with other key stakeholders, DOI has interagency MOUs/MOAs with DOE, USCG, and FERC. It is involved in several interagency workgroups and committees, and collaborates with industry and the public organizations such as AWEA.

Chris Hart, U.S. Department of Energy

DOE's Offshore Wind Research and Collaboration Efforts

- DOE has an aggressive cost-of-energy target – make offshore wind power competitive with other energy sources
- Three focus areas for offshore wind strategy are reflected in DOE's investments: demonstrate next generation and innovative technologies; support technology R&D; and remove market barriers
- March 1, DOE announced advanced technology demonstration funding opportunity (FOA) of $180 million to install ~50 MW that reflect regional differences

- DOE considers what the future US offshore wind industry will look like, is anxious to learn from the European experience, and wants to capitalize on US market potential – ~2000 GW potential, and 2/3 of that is in deep water
- DOE recognizes potential for joint MHK/wind development and has funded projects to that end.
- With respect to future R&D initiatives - the new DOE Assistant Secretary fully supports the National Offshore Wind Strategy and will continue moving technology development in the direction outlined therein

Breanne Gellatly, The Carbon Trust

Carbon Trust Offshore Wind Accelerator

- The Offshore Wind Accelerator (OWA) is a £45M collaborative R&D demo program which is two-thirds funded by industry, one-third funded by the Department of Energy and Climate Change (DECC) and Devolved Administrations. The Carbon Trust's OWA industrial partners are eight international energy companies with to develop 30GW in UK waters (60% market share). Those companies include:
    - DONG Energy, leading Danish offshore wind farm developer with over 20 years' experience
    - E.ON, Germany's largest utility
    - Mainstream Renewable Power, founded by Dr. Eddie O'Connor and Fintan Whelan, the former CEO and CFO of Airtricity
    - RWE Innogy, Europe-wide renewables business of the German RWE group
    - Scottish Power Renewables, UK's largest onshore wind farm developer
    - SSE Renewables (formerly Airtricity), the renewable energy development division of Scottish and Southern Energy
    - Statkraft, the Norwegian state owned utility
    - Statoil, Norwegian international energy company
- To meet the EU's 15% renewable energy target for the UK, over 18GW of offshore is likely to be required by 2020, a 9-fold increase over the 2GW installed to date – the Carbon Trust believes that mass deployment of offshore wind will be critical to bridge the UK's energy gap and to meet the targets for security of supply, carbon reduction and renewable energy.
- Costs must come down - current technologies are too expensive to fill the long term gap without further innovation
- The OWA funds common R&D as well as discretionary project (e.g., the Keystone foundation demonstration with a met mast)
- The objective of the programme is to reduce cost of energy by 10% in time for Round 3
- Program protects innovators' IP, is focused on commercial development
- Foundations, access systems, wake effects, and electrical systems & cable installation are currently the 5 research areas for OWA
- Stage 1 of the OWA started in October 2008 with five partners. This stage of the OWA primarily consisted of R&D and concept development.

- Stage 2 of the OWA saw the addition of three new partners. This stage will run until at least 2014 and focuses on commercialising the most promising concepts from Stage 1, often using demonstration.
- Will soon validate wind resource assessment wake models on an actual farm in Denmark, could bring down financing costs by decreasing risk associated with modeling uncertainties
- More international collaboration is needed to increase efficiency and reduce duplication
- To prioritize efforts within the five research areas, technical working groups (i.e., technical experts from each of the OWA Partner) review potential projects, then present them to the steering committee (also comprised of OWA Partner representatives) which establishes priorities and set the budget
- In work to date, projected positive cost impacts in certain areas have already exceeded prior predictions.

Jim O'Sullivan, Technip

The Oil and Gas Joint Industry Project Approach

- Oil and gas (O&G) joint industry partnerships (JIP) have been very successful for collaboration on technical development
    - There are specific programs dedicated to certain technologies or regions
    - Programs are very targeted, to look at the arctic exploration for example, small in number and focused in scope
- What drives the industry to do cooperative research?
    - Spread the cost: We deal with large items that are big and expensive
    - To come up with a consensus: Most results make their way into codes and best practices
    - To distribute the intellectual property generated: Operators will have multiple contractors to go to for supply of technology
- For areas of activity such as work in the Arctic, JIPs are formed by the participating operators, to help build knowledge base and solve common problems.
- In some cases the government is one of the partners rather than the lead in funding or defining scope - that may be how JIP's eventually develop in offshore wind.

Roger Bagbey, Cardinal Engineering

IEA-OES Annev V Exchange and Assessment of Ocean Energy Device Project Information and Experience

- Annex V - *Exchange and Assessment of Ocean Energy Device Project Information* is part of the International Energy Agency - Ocean Energy Systems (IEA-OES) implementing agreement
- Participants include governments, industry, research institutions and academia
- Annex goal is to accelerate technical success, commercial deployment
- Stakeholders recognize that the risks to the industry of not collaborating are too great

- Common understanding and approaches provide confidence for power purchasers and investors.
- A series of workshops facilitate information sharing:
  Planning Sessions -> Data Definition Working Groups -> Data Exchange Workshops
- Participation by the U.S. is driven by DOE's Technology Readiness Advancement Initiative and associated investments
- UK and Ireland are leading the global MHK industry, US started funding in 2008 and Portugal, Spain, Norway, Korea, Japan, China, Australia, and New Zealand are also involved
- International government-funded technical development to date has not included significant data sharing requirements. Therefore willingness of developers to share data has been limited.
- In 2010 DOE began requiring that data on funded programs must be shared and the international community is beginning to emulate that approach.

Panel 4 Breakout Discussions

Following the presentations, workshop attendees were given an additional 90 minutes to delve more deeply into the topic of research and collaboration. In their discussions, the breakout groups identified the following suggestions:

Key Messages:

- Think about when collaboration makes sense and when it doesn't for competitive advantage/proprietary information reasons.
- Collaborate on data gathering: actual atmospheric data, interaction between wind and wave, baseline environmental data, G&G conditions. We have an opportunity for a pre-development data gathering campaign.
- Collaboration with O&G: there is much experience, capability and knowledge in offshore O&G. But minimizing cost for structures is paramount for wind (not as great in O&G), wind needs mass production techniques, not custom-built nature of most O&G platforms.
- Take a systems engineering approach for offshore wind. Treat entire system as a whole instead of existing stovepipes.
- Learn from the European experience, and from Asia. Collaborate to the East and West.
- In general, MHK has been under-represented at this meeting – we need to be proactive about including them in the future, especially in collaborative R&D and data sharing.

Models for research and collaboration:

- Offshore Oil & Gas Industry's Joint Industry Program, UK's Carbon Trust Offshore Wind Accelerator, DOE's R&D Strategy.
- American Wind Wildlife Institute is a collaboration of NGOs and state and federal agencies on land-based wind. They look at siting challenges, pool resources and generate common strategies. The government is not a driving force.
- The IOOS model works well because of its regional nature (MHK and wind are regional). It brings together government and universities. Universities provide incubators for innovation. Resources are limited in the US for IOOS. Explore this approach of developing a national backbone of

observations. The IOOS regions have been talking to wind developers, and developers ask what value they will get out of sharing data.

- Clean Energy States Alliance (an NGO) has provided coordination services: they arranged for Principal Investigators to meet and talk at this year's AWEA Conference so that the four reports that are generated on specific issue areas can speak to each other.
- Lloyd's Register North America has the following resources: 1) Educational Trust based in the London office, working with and funding Rice University's engineering "design kitchen" where students collaborate on projects together. There is a need for this type of mix of technical people. 2) Lloyd's Register is located in the Houston energy corridor and has the capacity to host collaboration between O&G technical experts and wind industry. 3) Lloyd's wants to place technical personnel in collaborative activities (looking to join).

Cost Sharing:

- Cost sharing creates a different environment for information sharing, which is very important.
- 50% cost sharing for new projects in DOE's Wind initiative. DOE manages the cost sharing now, what about basically a new entity to take over cost sharing management?

Institutional Mechanisms for Collaboration:

- Examples:
    - Competitive Funding Awards
    - Joint Industry Projects
    - Carbon Trust Model
    - DOE R&D Strategy with DOI
- The National Laboratories are the research arm of DOE.
  Q: What are comparable entities (pure research) in DOI?
  A: BOEM contracts out studies to academia/consultants, no in-house research.
- National Weather Service does work for entities outside NOAA and provides all data that's publicly funded for anyone to use.
- There are only two points offshore on the East Coast actively gathering publically available data, so there are limited in-situ observations that can validate predictions used by industry. One can't really extrapolate into lower troposphere (rotor level) from existing buoys. There is no way to validate 80-m offshore atmospheric predictions. NWS wants data-sharing agreement with non-disclosure so NOAA can benefit from site assessment and validate their models.
- A big gap exists between what's needed for the leasing process and what's needed to build the farm. Investors want more certainty.
- A caution on collaboration with O&G: don't pin yourself down to a way of working that was developed for very specific use. Ex: over-designing wind structures by using O&G standards, and adapting O&G to wind. Evaluate whether O&G solutions are worth modifying or if wind should start from scratch.
- On the East Coast, the wind industry needs O&G's open water expertise, but must also recognize that the economic drivers are very different. Long-term power costs must be a leasing consideration.

- Find a way to reward people who are willing to make investments in conditional data gathering.

Geo-technical, Geophysical and Other Conditional Data:

- Cost of offshore foundations is huge. Foundation design starts with soils, and very little is known about offshore geotechnical conditions. Need high-density sampling for wind farms. UK soils are relatively uniform but this is not necessarily so in the US.
- Private companies are willing to collaborate on gathering soil data. Currently, offshore wind structures are being designed without conditional data, whereas getting that data should be the first step. There are people willing to acquire that data, but there is no mechanism for them to retain the value of that data through the collaborative process. Private industry needs that collaboration mechanism with government. Effective data gathering and sharing could compress the offshore wind timeframe.
- Early European projects had to build custom foundations because of soil “surprises”. They used the most conservative estimates in absence of soil data, but still encountered unexpectedly high costs.
- Geotechnical and geophysical is probably the most expensive data. A good academic question is whether G&G data gathering methods could be mixed to cover a wider area with high resolution. A private consortium is spending 95% of their time on that question. G&G is where you can get the largest gains on cost.
- With conditional data, industry can begin to design foundations that are more robust in response to varied conditions.
- Can there be a quasi-public entity to build met towers and buoys?
- The US offshore wind industry is in difficulty and one of the reasons is that the current process has PUC approval as one of last steps. PUC approval needs to be one of first steps like in Europe.
- Currently, there isn’t a market for repeatable G&G work because there is no mechanism for getting the value of the data back to investors.
- “Environmental data” is a misnomer. The wind and G&G data is inextricably tied to economics and that often gets lost in the conversation.

International Collaboration:

- In the US, there can be huge constraints on trans-Atlantic collaboration. Bi-lateral arrangements have had some success (e.g., the existing wave power collaboration between US & Ireland). Think about what issues you want to examine, then consider bi-lateral agreements.
- It is hard for funds to cross the Atlantic. Lloyd’s Register North American has broken this barrier with its Educational Trust – the London office can fund Rice University’s activities with European money. There is also the Keystone demo project: Keystone is an American company that received funds through Carbon Trust.
- DOE and NREL have several trans-Atlantic partnerships in process. IEA is a mechanism for partnership, but no funds are exchanged.
- There is potential for collaboration with Japan at U.S. universities, but it is also needed at the application/demonstration level. Japan is changing its power policies and now has an aggressive

wind energy department. They are starting a fixed structure project this year, will start floating project next year. Japan encourages U.S. visitors to see their projects.

- Open-source innovation is a good way to share ideas. One model is an internet competition on a specific problem the industry needs solved.

Existing information:

- The industry needs a gateway for information that already exists. It would help to clarify who is doing what and who to talk to.
- Not collaborating creates risk of duplicating effort. Management of collaboration and information could be its own research line item.
- Pacific Northwest National Laboratories is developing Tethys, a potential solution to information sharing.
- The Offshore Wind Hub is in development as a document repository. It will have state policies & procedures, regional programs, federal information, and outputs of siting studies, starting with the Atlantic.
- AWS TruePower will also develop an information portal.
- To be cost-effective, a portal needs to have usable data for building foundations, not just a data dump.

Integrated Systems:

- The industry has an opportunity to develop integrated systems, instead of separate foundation and turbine components.
- Additionally, examine the entire offshore wind development process as a whole. The sequence of leasing, power purchase agreement acquisition, and everything else needs to be reordered. Set up institutional partnerships for private money to come in and everyone benefits from data acquisition.
- Take a fresh look at the whole system configuration, what makes sense in the marine environment?
- Don’t forget social factors. E.g., Cape Wind’s public objections. These are often overlooked because conversations focus on technical issues, and there’s a lot to learn in government about public perception.
- Re-examine the use of conventional onshore turbine designs in the offshore environment. Support turbine manufacturers in implementing innovations and tradeoffs in design/efficiency/ease of installation.

Appendix A. Brief Biographies of Presenters

April 11/12, 2012

Brief Biographies of Presenters

1. Tasneem Abbasi, Genesis Oil and Gas (panelist)
2. Roger Bagbey, Cardinal Engineering (panelist)
3. Tommy P. Beaudreau, Director, BOEM
4. Martyn Boyers, Port of Grimsby (panelist)
5. Denise Campbell, HES Improvement (panelist)
6. John Chamberlin, Siemens Wind (panelist)
7. Guy Chapman, Dominion Power (overview speaker)
8. Tom Coates, HR Wallingford (panelist – unable to attend)
9. John Cushing, BSEE (panelist)
10. David Danielson, Assistant Secretary, DOE
11. Fort Felker, National Renewable Energy Laboratory (panel moderator)
12. Doug Frongillo, Knud Hansen, (panelist)
13. Breanne Gellatly, Carbon Trust Offshore Wind Accelerator (panelist)
14. Chris Hart, DOE (panelist)
15. Bob LaBelle, Science Advisor to the Director, BOEM
16. Randall Luthi, President, NOIA (panel moderator)
17. Keith Michel, Herbert Engineering (panel moderator)
18. Michele Mihelic, American Wind Energy Association (panel moderator)
19. Walt Musial, National Renewable Energy Laboratory (panelist)
20. Finn Gunnar Nielsen, Statoil (panelist)
21. Dick Porter, Noble Denton (panelist)
22. Johan Sandberg, Det Norske Veritas (overview speaker)
23. Kurt Thomsen, Sea Energy-Offshore (panelist)
24. Bill Wall, Atlantic Wind Connect (panelist)
25. Joel Whitman, Global Marine (panelist)
26. Jose Zayas, DOE (panel moderator)

Tasneem Abbasi – Genesis Oil and Gas

Tasneem Abbasi has previous experience in: project management and engineering management of integrated turn-key solutions for hard environments of subsea and Space; multi-client and multi-vendor interface management of major domestic and international oil and gas monitoring projects; integrity management systems for oil and gas subsea assets; offshore equipment and subsea monitoring system design and delivery; and reliability and feasibility assessments of fault tolerant electrical and fiber optic equipment and interconnect solutions.

Roger Bagbey – Cardinal Engineering

Roger Bagbey has over 30 years of experience in systems engineering and management on programs for naval ships and submarines, and marine energy generation. As both a government program manager and industry executive, he has led a number of major projects related to survivability and reliability of electromechanical systems subjected to severe marine environments. With an emphasis on conceptual design, R&D programs, and the transition to deployment and operation, Roger has conducted programs combining computational analysis with laboratory and in-situ test demonstrations to bring technology to bear in the achievement of critical national missions. Roger holds a Bachelor of Science degree in Civil Engineering from Iowa State University.

Tommy P. Beaudreau – Director, Bureau of Ocean Energy Management, DOI

Tommy P. Beaudreau is the first director of the Bureau of Ocean Energy Management (BOEM), which is responsible for overseeing the environmentally and economically responsible development of the Nation’s offshore resources. BOEM manages the conventional and renewable ocean energy and mineral resources on 1.7 billion acres of the U.S. Outer Continental Shelf (OCS).

Mr. Beaudreau joined the Department of the Interior in June 2010 to help develop and lead the Department’s aggressive reforms of offshore energy management and oversight following the Deepwater Horizon blowout and oil spill, including the reorganization of the former Minerals Management Service. He served as the senior advisor to the director of the Bureau of Ocean Energy Management, Regulation and Enforcement, where he played an integral role in designing and implementing the Bureau’s broad reform agenda with respect to the regulation of offshore oil and gas development.

BOEM was established in October 2011. The agency’s responsibilities include leasing, plan administration, environmental studies, National Environmental Policy Act (NEPA) analysis, resource evaluation, economic analysis and the offshore renewable energy program. Prior to his work at Interior, Mr. Beaudreau was a partner at the law firm Fried, Frank, Harris, Shriver & Jacobson LLP, where his practice focused on, among other things, internal investigations, including reviews of government agencies pursuing reform. Mr. Beaudreau is a graduate of Yale University and received his law degree from the Georgetown University Law Center.

Martyn Boyers – Grimsby Fish Dock Enterprise Ltd

Martyn is from a family background of fish merchants and was involved in the Industry from an early age. From 1981 he ran his own fish processing business and during that time became Chairman and then Chief Executive of the Grimsby Fish Merchants Association Ltd. Grimsby Fish Dock Enterprise Ltd appointed Martyn as their Chief Executive in 2001. He has responsibility for a Port operation whose core business is 'Grimsby Fish Market'. Included are a number of established ancillary businesses associated to Port and Fishing activities. He is also driving new business in Operations and Maintenance in Offshore Wind through the 'Port of Grimsby East' brand. Martyn is currently Chairman of the British Ports Association, Fishing Ports Working Group and also President of the European Association of Fishing Ports and Auctions.

Denise B. Campbell, CSP

Denise Campbell is an independent consultant having been employed by several major oil and gas companies including Chevron, BP, Phillips and Oxy. She has held various positions within these companies. Denise has led many industry efforts including SEMS Audit Protocol with Center for Offshore, RP 76, Contractor Safety efforts in the Gulf of Mexico, and HES Data Standardization with the Oil and Gas Producers. Denise is past chapter president of American Society of Safety Engineers and past president of Gulf Coast Safety and Training Group. She is currently the Assistant Administrator of the Oil and Gas Practice Specialty of ASSE.

Denise is a Texas A&M at College Station graduate and has worked in the oil and gas industry for over 30 years. Denise has had a unique career in HES in that she has worked upstream and downstream, domestically and internationally, offshore and onshore. She is a long time safety professional earning her CSP in 1987. At various times in her career she has specialized in Safety, Environmental and Industrial Hygiene.

Guy Chapman - Dominion

Mr. Guy Chapman is currently responsible for leading Dominion's renewable energy technology research and development activities, including developing the company's offshore wind development strategy. As part of this strategy, he is involved in all aspects of offshore wind technology evaluation, analysis, and due diligence. Mr. Chapman has 13 years of experience in dispatching, optimizing and maximizing the economics of power generation facilities. He has designed and programmed comprehensive cost and revenue models using real option valuation techniques for power generation technologies.

John Chamberlin, CSP, Siemens Wind Power America

Mr. Chamberlin, EHS Specialist for: Cranes & Rigging, Lift trucks, Aerial Lifts, Fall Protection and Scaffolding, is a Certified Safety Professional (CSP). He works as an Environmental Health and Safety Specialist (EHS) for Siemens Wind power Americas specializing in cranes, rigging, fall protection, scaffolding and electrical safety. The EHS Americas organization has oversight responsibilities for wind turbine project sites and two assembly plants here in the US. HE also provides safety support to Siemens offshore wind projects development in the Americas. He was previously employed for 6.5 years at the Kennedy space center in ground operations safety for Space Shuttle Processing and also 11 years as a consultant for material handling safety. He has served as an expert witness in over 50 material handling related legal actions. He is a former Army helicopter pilot and Army Safety Officer. He received a MBA from the University of Central Florida concentrating in Human Factors and BS from Embry-Riddle Aeronautical University.

Tom Coates – HR Wallingford

Tom Coates has over 20 years experience of near-shore, coastal and estuarial projects, combining site investigations and consultations, desk studies and computational and/or physical modeling, throughout the UK and internationally in Italy, France, Malta, India, Thailand, China, Mauretania, Angola and throughout the Middle East. In his current role as Technical Director at HR Wallingford he acts as Project Manager or Project Director for commercial and research projects, ensuring high technical standards and quality of service to clients. Previous senior positions at the company have included Manager of the Coastal Group and Business Manager for Marine Renewable Energy.

John Cushing – Bureau of Safety and Environmental Enforcement, DOI

John Cushing is a senior technical advisor and structural engineer for the U.S. Department of the Interior’s Bureau of Safety and Environmental Enforcement (BSEE). He has been working in the Inspection and Enforcement Branch at the BSEE Headquarters office in Herndon, Virginia, since July 2008. Previous job experience includes 24 years as a U.S. Coast Guard officer, where he has extensive experience as a vessel inspector and marine engineer. He has three engineering degrees – a B.S. in Civil Engineering from the U.S. Coast Guard Academy; and two M.S. degrees from the Massachusetts Institute of Technology, one in Mechanical Engineering and one in Naval Architecture & Marine Engineering.

David Danielson, Assistant Secretary, Energy Efficiency & Renewable Energy, DOE

Dr. David Danielson has been a Program Director at the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) since 2009. Prior to joining ARPA-E, Dr. Danielson was a clean energy venture capitalist at General Catalyst Partners, a Boston-based venture capital fund. He co-founded the firm's clean energy investment practice and helped build and grow startups in various clean energy technology areas including solar power, wind power, advanced biofuels, bio-gas, carbon capture and storage, and advanced lighting. Dr. Danielson is a co-founder of the New England Clean Energy Council. He has authored more than 20 scientific articles in the field of advanced materials. While at the Massachusetts Institute of Technology (MIT), Dr. Danielson was the founder and President of the MIT Energy Club, and was a founding Director of the MIT Energy Conference. For his work in building a strong multidisciplinary energy community at MIT, he was awarded the Karl Taylor Compton Prize, MIT's highest student award. Dr. Danielson holds a B.S., summa cum laude, in Materials Science and Engineering from the University of California, Berkeley and a Ph.D. in Materials Science and Engineering from the Massachusetts Institute of Technology.

Fort Felker - NREL

Ph.D., Mechanical Engineering, Stanford University
M.S., Mechanical Engineering, Stanford University

B.S., Aeronautics and Astronautics, Massachusetts Institute of Technology

Dr. Felker is the Director of the National Wind Technology Center, the principal research center for wind energy in the United States. He directs a team of 100 scientists, engineers and technicians working to develop the next generation of wind energy systems. Prior to becoming director of the NWTC in 2009, Dr. Felker was the co-founder and Vice President of Winglet Technology, a company that commercialized his patented design of "elliptical winglets" for business aircraft. Before his 6-year stint as an entrepreneur, Felker was an engineering analyst at the Lawrence Livermore National Laboratory, where he developed the underlying theory and computational modeling for the hypersonic flow about re-entry vehicles undergoing extreme maneuvers. From 1994-1996, Felker worked in senior engineering positions at Kenetech Windpower. As manager of engineering modeling, he was responsible for developing wind turbine engineering analysis tools. Later as director of engineering analysis and test, he played a key role in the development of the KVS-45 wind turbine, and led a team of engineers and technicians in the testing of large wind turbine systems. His early experience includes nine years with NASA Ames Research Center and six years with the U.S. Army Research and Technology Labs, working on rotorcraft analysis and testing.

Felker holds one patent and is the author of 35 publications.

Breanne Gellatly – Carbon Trust

Breanne joined the OWA to follow her passion for the development of the renewable energy industry. She started her career with GE Energy in the Operations Management Leadership Program where she worked with technical and supply chain experts in the wind and hydro businesses to deliver high quality engineered products in the most efficient and safe ways possible. She later joined a small start-up wind resource assessment company where she managed the complexities of designing wind farms within the constraints of government incentive schemes and regulations. Just prior to joining the OWA, Breanne worked for a strategy consultancy, Booz & Company, as an Associate in the Operations practice.

Chris Hart – Wind and Water Power Program, DOE

Dr. Christopher G. Hart graduated from the United States Naval Academy with a degree in Naval Architecture, Ocean, and Marine Engineering and immediately accepted a commission as a Special Operations Officer in the US Navy. After ten years of naval service, during which he saw combat deployments in Operations Iraqi and Enduring Freedom, Dr. Hart began his graduate school studies at the University of Michigan. In the ensuing 44 months, Dr. Hart earned a PhD and MSE in Naval Architecture and Marine Engineering, along with an MBA. Dr Hart has served as the Offshore Wind Lead at the United States Department of Energy (DOE) since June 2010. During his tenure at DOE he has worked to create an offshore wind energy industry in the United States by building a team of innovative, committed civil servants and contractors.

Robert LaBelle – Science Advisor, Bureau of Ocean Energy Management, DOI

Robert LaBelle recently served as the acting Deputy Director for BSEE and as the Associate Director for Offshore Energy at BOEMRE. As Science Advisor, he contributes to management of key facets of the US offshore renewable energy program. Mr. LaBelle is also the Federal Co-Chair of the Northeast Regional

Ocean Council, a state/federal partnership to advance ocean planning and related science in New England. He previously served as the Environmental Division Chief and as the Technology Assessment and Research Program Chief. Mr. LaBelle earned degrees from the University of Massachusetts, Dartmouth (BS, Biology), the University of Maryland (MS, Biology), and Loyola College, MD (MBA, Management). He received the DOI Citation for Distinguished Service (2008) in recognition of his career scientific and management accomplishments.

Randall Luthi

President, National Ocean Industries Association (NOIA) Randall Luthi became President of the National Ocean Industries Association (NOIA) on March 1, 2010.

An attorney and rancher from Freedom, Wyoming, Luthi has had an exciting career holding various positions ranging from Wyoming Speaker of the House, to director of a Federal agency, to legislative assistant in the U.S. Senate, to an attorney at both the Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA), where he worked on natural resource damages following the Exxon Valdez accident. Luthi most recently served as the Director of the Minerals Management Service (MMS) at DOI from July 2007 through January 2009. There Luthi oversaw offshore lease sales and collection and distribution to the States and Federal government of mineral revenues and royalties. He also oversaw the expansion of a renewable energy office at MMS, which manages development of wind, wave and current energy in the U.S. oceans.

Immediately before directing MMS, Luthi served as the Deputy Director of the Department's Fish and Wildlife Service (FWS).

In 2000, he started the law firm of Luthi & Voyles, LLC, in Thayne, Wyoming, which helped pay for his working ranch which consists of a cow/calf operation and the growing of hay and barley.

Luthi's career in the Wyoming House of Representatives began in 1995 with his name being drawn from a cowboy hat by Governor Mike Sullivan to declare him the victor in a tie vote. He served as Speaker of the House in 2005 and 2006.

Keith Michel - Herbert Engineering

Mr. Michel is Chairman of Herbert Engineering Corp. and its subsidiary Herbert-ABS Software Solutions Inc. For the last 37 years, he has been engaged in the design of commercial ships and related research at Herbert Engineering. Mr. Michel recently served as chair of a NAS committee tasked with evaluating the adequacy of standards and regulatory approaches applicable to the design, fabrication and installation of U.S. offshore wind installations.

Michele Mihelic - AWEA

Michele Myers Mihelic joined the American Wind Energy Association in March 2009. As the Manager, Labor, Health and Safety Policy, Michele focuses on worker safety and health, workforce development and education issues that impact the wind energy industry. Michele staffs AWEA's Environmental, Safety and Health Committee and Workforce Development, Training and Education Committee.

Prior to joining AWEA, Mihelic was the Director, Safety and Health at the Associated General Contractors America (AGC). Michele's responsibilities at AGC included developing workforce safety and health policy and programs for the construction industry. Before AGC, Michele was the Government Affairs Manager at the Voluntary Protection Programs Participants' Association (VPPPA). Michele received a Bachelors' of Science degree in Public Policy from Pennsylvania State University.

Walt Musial

Walt Musial is a principal engineer and the manager of Offshore Wind and Ocean Power Systems at National Renewable Energy Laboratory (NREL) where he has worked for 23 years. In 2003 he initiated the offshore wind energy research program at NREL and now leads that program for NREL. Recently he served on a committee to the National Academy of Science which wrote a report titled "Structural Integrity of Offshore Wind Turbines" which was published in 2011. Before NREL, Walt was employed in the commercial wind energy industry in California. He studied Mechanical Engineering at the University of Massachusetts at Amherst, where he earned his Bachelor's and Master's Degrees and specialized in renewable energy and energy conversion with a focus on wind energy. He has over 50 publications and one patent.

Finn Gunnar Nielsen - Statoil

Senior Advisor, Platform Technology, Statoil, (2010-present); Chief Researcher, Field development technology in Statoil (2007-2010)

- Several positions within Norsk Hydro R&D prior to 2007.
- Adjunct Professor, Geophysical Institute, Univ. of Bergen. Marine renewable energy (2009-present)
- Adjunct Professor Department of Marine Technology, Norwegian University of Science and Technology (NTNU). Amongst other Teaching "marine operations" at NTNU. (1988-2009)
- Visiting professor, Dept. of Ocean Engineering, MIT (1995-1996)
- PhD. Marine Hydrodynamics, NTNU 1980.
- Has mainly worked within R&D mostly within Norsk Hydro, now Statoil. Has in addition to R&D been involved in several major offshore oil and gas development projects (e.g. the Troll and Ormen Lange developments).
- Headed the R&D activity resulting in the floating offshore wind turbine Hywind.
- Member of several national and international committees, e.g.:
- Member of the Scientific Committees of the two Norwegian Research Centres on offshore wind (NOWITECH and NORCOWE), 2010-.
- Chairman of the Special Committees for Marine Renewable Energy in ISSC
- (International Ship and offshore Structure Congress) 2006 and 2009.
- Member of TPWind, offshore wind committee.

Richard D. Porter

Vice President, Project Management Services at GL Noble Denton.

Mr. Porter has over 35 years experience in international Oil & Gas Engineering and Construction encompassing divisional management, project management, construction operations, and market development. This includes numerous upstream and downstream EPIC projects as well as many marine pipeline projects. Several of the projects exceed $500 million in value. International experience includes projects in North Sea, Middle East, Asia, India, West Africa, Mediterranean, and South America. Resided abroad for a total of 15 years in Europe, Middle East and South East Asia. Identified strategic partners and negotiated numerous consortium and joint venture agreements as well as agency agreements for various foreign locations.

Education: Georgia Institute of Technology, Bachelor of Mechanical Engineering

Johan Sandberg

Johan has a Master of Science degree in mechanical engineering from the Lund's Institute of Technology in Sweden and an MBA in Energy Management from Nanyang in Singapore and Oslo BI.

He has been working with Risk Management his whole career - first with Banks & Financial Institutions based out of London, later with Oil, Gas and Maritime, and since two years he is leading the Renewable Energy team at DNV's headquarter back in Norway.

Kurt E. Thomsen

Kurt E. Thomsen is the co-owner and Managing Director of SeaRenergy Offshore GmbH & Cie.KG. He is based in Århus Denmark. The company is focused on supplying EPC services to the offshore wind farm industry exclusively, with the primary focus on transport and logistical solutions, design, build and operation of offshore wind farm installation vessels.

The services provided by the company include development and implementation of methods, rules and guidelines for offshore wind farm work, setup and execution of the installation process for offshore projects, validation of equipment and auditing of same, contract negotiations and implementation of same to projects as well as development of new installation methods and vessels for the abovementioned companies in order to execute their project portfolio.

Prior to joining SeaRenergy Offshore, Kurt E. Thomsen owned and managed the company Advanced Offshore Solutions which he established in 2006. Prior to this, Mr. Thomsen was Business Development Manager for the company A2SEA A/S, a company originally started by Kurt E. Thomsen himself in 2000. A2SEA A/S is a privately held company specializing in delivering transport, logistical solutions as well as installation vessels for the offshore wind industry. The basis of the company is a patent for a semi jacking installation vessel, originally designed and patented by Kurt E. Thomsen.

Mr. Thomsen has recently published the book Destination Offshore, a comprehensive guide to plan, install and operate offshore wind farms.

Mr. Thomsen received his Bsc. in architecture and construction from the Via University in Horsens Denmark in 1990. He has a leadership diploma from Århus Business Academy as well as Bachelors degree in Strategic Management. He is a qualified Crane specialist.

Bill Wall - Atlantic Wind Connection

Bill Wall has spent nearly 40 years in the submarine cable industry. Starting at British Telecom (then GPO) Wall then spent 12 years with Cable & Wireless Marine Staff (now GMSL) where he was very active in the development of cable burial ROV systems. He was a member of the original Scarab 1 operations team. Wall then spent 18 years at Margus Co where he was VP Operations. His next assignment was Business Development Manager at Caldwell Marine International. He then joined the offshore wind industry as VP of Marine Operations at Deepwater Wind based in Hoboken NJ.

He has a broad background in sub-sea technical operations and submarine cable project management including Shore Ends, HDD, ROV operations, Plowing, Survey operations, cable repair etc. He is currently Director, Marine Operations at The Atlantic Wind Connection based in Chevy Chase, MD just outside Washington, DC.

Joel Whitman – Global Marine Energy, Inc.

Joel Whitman was appointed CEO of Global Marine Energy, Inc. in 2011. Global Marine Energy Inc., is an American-owned company recently founded to address the growing demand for offshore power cable installation in North America. Joel recently served as the Director Corporate Strategy, Marketing and Communications for Global Marine Systems Limited, the world's largest independent provider of submarine cable installation and related engineering services, and a pioneer in the field of subsea cabling since the mid-1800's. Joel joined Global Marine in 2005 and in his years with Global Marine, he has worked alongside his colleagues to solidify the company position in its core markets, such as Telecommunications and to diversify the 160 year old Global Marine business into new and emerging markets. Prior to joining Global Marine, Joel worked with a wide range of organizations ranging from large blue chip high-tech and retail clients to start-ups. His areas of experience include extensive business strategy and planning, corporate repositioning and turnarounds.

Jose Zayas – Wind and Water Power Program, DOE

Jose Zayas is the Program Manager for the Wind and Water Power Program, U.S. Department of Energy. In this role, he manages efforts to improve performance, lower costs, and accelerate deployment of wind and water power technologies, which can play a significant role in America's clean energy future. Working with U.S. Department of Energy national laboratories, academia, and industry, the program funds research and development and deployment activities aimed at reducing the overall cost of energy of these systems and addressing key market barriers.

Appendix B. Offshore Energy Workshop Participant List

hosted by the U.S. Department of Interior & Department of Energy

April 11-12, 2012

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Appendix C. Panel Overview and Presentation Links

U.S. Department of the Interior

U.S. Department of Energy

April 11-12

Washington, DC

Panels

Overview Speakers

	Topic	Name	Affiliation
Overview Speaker 1	International Offshore Renewable Energy Industry Offshore Renewable Energy	Johan Sandberg	DNV
Overview Speaker 2	The Perspective from Traditional Offshore Industries *Presentation not available*	Jim O'Sullivan	Technip
Overview Speaker 3	Offshore Renewables in the Future Energy Mix Offshore Wind Energy – A Utility Perspective	Guy Chapman	Dominion Power

Panel 1 – Project Design and Decision-Making

Moderator		Keith Michel	Herbert Engineering
Speaker 1	Designing for Renewable Energy Designing For Renewable Energy Standards	Walt Musial	National Renewable Energy Laboratory
Speaker 2	Project Definition Project Definition	Kurt Thomsen	SeaRenergy-Offshore
Speaker 3	Foundations and Substructures Foundations and Substructures	Finn Gunnar Nielsen	Statoil
Speaker 4	Electrical Infrastructure Building an Offshore Wind Industry in the Mid-Atlantic Region	Bill Wall	Atlantic Wind Connection

Panel 2 – Construction and Installation

Moderator		Randall Luthi	National Ocean Industries Association
Speaker 1	Cabling Considerations Offshore Wind Installation	Joel Whitman	Global Marine
Speaker 2	Vessels and Marine Engineering Offshore Wind Installation, Transportation, and Maintenance	Doug Frongillo	Knud E. Hansen
Speaker 3	Supporting Infrastructure Port Infrastructure	Martyn Boyers	Port of Grimsby, UK
Speaker 4	Project Management Lessons from the Offshore Oil Patch	Dick Porter	GL Noble Denton
(Unable to Attend)	Environmental Issues During Construction Environmental Issues During Construction – UK Perspective	Tom Coates	HR Wallingford, UK

Panel 3 – Safety and Operations

Moderator		Michele Mihelic	American Wind Energy Assoc.
Speaker 1	Best Practices and Operational Strategies Best Practices and Operational Strategies from the Oil and Gas Industry	Denise Campbell	HES Improvement LLC; Gulf Coast Safety & Training Group
Speaker 2	Optimized Access Systems The Offshore Wind Accelerator	Breanne Gellatly	Carbon Trust Offshore Wind Accelerator
Speaker 3	Offshore Turbine Operations and Safety Offshore Wind	John Chamberlin	Siemens Wind
Speaker 4	Asset Integrity Methodologies *Presentation Not Available*	Tas Abbasi	Genesis Oil and Gas

Panel 4 – Research and Collaboration

Moderator	International R&D Collaboration	Fort Felker	National Renewable Energy Laboratory
Speaker 1	DOI Renewable Energy Research and Collaboration DOI Renewable Energy Research and Collaboration	John Cushing	Bureau of Safety and Environmental Enforcement
Speaker 2	DOE Offshore Research and Collaboration DOE's Offshore Wind Research and Collaboration Efforts	Chris Hart	Department of Energy
Speaker 3	European Offshore Research Initiatives Carbon Trust Offshore Wind Accelerator	Breanne Gellatly	Carbon Trust Offshore Wind Accelerator
Speaker 4	O&G Joint Industry Project Approach *Presentation Not Available*	Jim O'Sullivan	Technip
Speaker 5	MHK: OES Annex V IEA-OES Annev V Exchange and Assessment of Ocean Energy Device Project Information and Experience	Roger Bagbey	Cardinal Engineering/DOE

Panel 5 – Summaries and Conclusions

Moderator	Introduction and Synthesis	Chris Hart	DOE Wind and Water Power Program
Speakers 1-4	Moderators of Panels 1 - 4		