Technology Frontier: Floating Offshore Wind

Dr. H. J. Dagher, P.E.
Director, AEWC Advanced Structures and Composites Center
University of Maine
(207) 581-2138  hd@umit.maine.edu

DeepCwind Consortium

NEBHE
April 23, 2010
1. Does it bring the cost $/kWh down?
2. Does it enhance public acceptance?
Mosaic of Energy Solutions Needed: Renewables + Conventional

$5 Billion/year
Leave Maine

Fossil Fuels

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Maine Family Budget

“Family Energy”\(^1,2\) = 50% Transportation
40% Heating
10% Electric Power

\(^1\) Source: Dr. George Hart, UMaine
\(^2\) Based July ’08 energy costs
\(^3\) Assumes that health care costs do not grow past 30% of the average family budget in 2008-2018
Deepwater Wind: Largest US Ocean Energy Resource

Dr. H. J. Daghe
(207) 581-2138
hd@umit.maine.edu

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
## US Offshore Wind Initiatives

<table>
<thead>
<tr>
<th>Project</th>
<th>State</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capewind</td>
<td>MA</td>
<td>468</td>
</tr>
<tr>
<td>Hull Municipal</td>
<td>MA</td>
<td>15</td>
</tr>
<tr>
<td>Buzzards Bay</td>
<td>MA</td>
<td>300</td>
</tr>
<tr>
<td>Rhode Island (OER)</td>
<td>RI</td>
<td>400</td>
</tr>
<tr>
<td>Winery</td>
<td>NY</td>
<td>12</td>
</tr>
<tr>
<td>New Jersey (BPU)</td>
<td>NJ</td>
<td>350</td>
</tr>
<tr>
<td>Delmarva</td>
<td>DE</td>
<td>350</td>
</tr>
<tr>
<td>Southern Company</td>
<td>GA</td>
<td>10</td>
</tr>
<tr>
<td>W.E.S.T.</td>
<td>TX</td>
<td>150</td>
</tr>
<tr>
<td>Cuyahoga County</td>
<td>OH</td>
<td>20</td>
</tr>
<tr>
<td>DeepCwind Consortium</td>
<td>ME</td>
<td>Demo</td>
</tr>
<tr>
<td>Total MW</td>
<td></td>
<td>2075</td>
</tr>
</tbody>
</table>

None Installed Yet

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**Source:** Walter Musial (NREL), 4/09
US is Behind:
Offshore Wind Projects Planned by 2015
Europe and North America

40,616-MW

Sweden; 3312
Spain; 1976
Poland; 533
Norway; 1653
Netherlands; 2833.8
Italy; 827.08
Ireland; 1603.2
Germany; 10927.5

United States; 2073
United Kingdom; 8755.8
Belgium; 1446
Canada; 1100
Denmark; 1276
Finland; 1330
France; 1070

Source: Walter Musial, NREL
"The offshore wind industry is at the heart of the UK economy’s shift to low carbon and could be worth $120 Billion and support up to 70,000 jobs by 2020."

Prime Minister Gordon Brown
January 8, 2010
Offshore Wind Classification by Water Depth

- **Land-based Technology**
  - No exclusions assumed for resource estimates

- **Shallow Water Technology**
  - Maine 6.4 GW
  - Commercial Technology: 0m-30m US 430-GW

- **Transitional Depth Technology**
  - Maine 10.4 GW
  - Commercial Technology: 30m-60m US 541-GW

- **Deepwater Floating Technology**
  - Maine 133.0 GW
  - Commercial Technology: 60m-900m US 1533-GW

*Source: Walter Musial (NREL, 2008)*
Shallow Monopile Foundations: 2-30 m, Drilled or Driven, Most Common

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Shallow Gravity Foundations

Thornton Bank 60 x 5MW
12-27.5 m water depth

Middelgrunden 27x 2MW
4-8 m water depth

1Source: TU Delft

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Shallow Gravity Foundations: Seabed Preparation and Installation

Source: TU Delft

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Shallow Gravity Foundations: Tower, Turbine and Blades Installation

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Transitional Waters Foundations (30-60m): Tripod

Pile

Pile

Pile

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Installed Foundation Types (2008)

Monopiles (most common)

Gravity

Multimember

Sources: TU Delft

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Floating Wind Turbines (> ~200ft): Building on the Offshore Oil and Gas Experience

Source: Technip
Deepwater Floating Turbines (> ~200ft): Design Space Based on Stability

Source: NREL
The Hywind concept
Developed by StatoilHydro
Combines known technologies
Floating concrete or steel hull
"Standard" offshore turbine
Deep water, depth > 100 meters (328 ft)
Harsh environment
Assembled in sheltered waters, towed to field

Relies upon experience from:
Floating platforms
Electrical power production
Onshore wind turbines

Technical data
WTG: 2.3 MW
Turbine weight: 138 tons
Turbine height: 65 m (213 ft)
Rotor diameter: 82.4 m (270 ft)
Draft hull: 100 m (328 ft)
Displacement: 5300 m3 (17388 cuft)
Diameter at water line: 6 m (20 ft)
Diam. submerged body: 8.3 m (27 ft)
Water depth: 120-700 m (400 - 2300 ft)
Mooring: 3 lines

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Statoil Hywind Spar
2.3 MW
20'-27' Diam.
213 ft to hub
Rotor Diam 270'

Dr. H. J. Dagher
(207) 581-2138
hd@umit.maine.edu
Offshore Wind Slender Tubes Compared to Oil & Gas Designs

Statoil Hywind Spar (20'-27' Diam.)

149' Diam.

Dr. H. J. Dagher
(207) 581-2138
dhd@umit.maine.edu
While Turbine Sizes Growing (Clipper 10 MW), Need Lighter Turbines for Floating Offshore

\[1\] Source: Garrad Hassan
DeepCwind Consortium Membership Map
Over 30 Consortium Members Nationwide
1/3d Scale Model Test off Monhegan 2011-2012
Phase 2: Single Full-Scale Test in 2011-2013

Technical Goals:
- Predictive models
- Cost optimization ($3.5/W):
  - Manufacturability
  - Deployment logistics
  - Composites
- Durability:
  - corrosion/fatigue.
- Maintenance
- Survivability (extreme events)
- Platforms, Structures & Foundations
- Class 6 and 7 winds
25 MW Stepping Stone Floating Wind Farm
Expand to larger Commercial Farm

Maine Bill LD1810 for 20-year PPA
Passed Committee Unanimously 3/24/10

- Design
- Build
- Monitor
The Maine Plan: Over-the-Horizon Farms: A National Electrification Model

OFFSHORE WIND
$20 billion, 15,000 jobs

5 GW

Smart Grid

Maine

Export to NE

LAND-BASED WIND
$7 billion

3 GW

5 GW of additional wind needed to electrify heating and transportation in Maine

HOME HEATING
• Save 40-60%
• Weatherize, 30 years
• Heat pumps, 30 years
• $1 Billion revolving loan

TRANSPORTATION
Save 40-60% PEHV, 30 years

Dr. H. J. Dagher
(207) 581-2138
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Economic Opportunities for Maine
15,000 jobs if we maximize supply chain