Infrastructure to Support Offshore Floating Wind

Focus on California

Figure: Principle Power

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Objectives

• Estimate navigation, vessel, and port infrastructure requirements to support Offshore Floating Wind (OOFW) development

• Focus on US Pacific West Coast and Hawaii
  -- Today: California focus

• Assess existing and potential future capability to support large-scale and demonstration-scale OFW

Note: Not focused on traditional foundation offshore wind (e.g. Block Island)
Why?

• “All ports on the Pacific Coast shall be studied that have available or planned infrastructure to support the offshore renewable industry”
• Environmental reviews and evaluations
• Inform policy decisions

Few examples of floating wind → No commercial prototypes
Basis of Analysis - Devices

Focus of Study

- Monopile: 0-30m, 1-2 MW
- Jacket/Tripod: 25-50m, 2-5 MW
- Floating Structures: >50m, 5-10 MW
- Floating Structures: >120m, 5-10 MW
Methods

• Data Collection:
  – Marine Contractors, Ports, Developers
  – Key → Literature Review.

• Port role Classification
  – Assembly/Installation, Fabrication, Quick Response, Cluster

• Conceptual-Level Engineering Analysis

• Vessel Requirements and Operational Limitations

• Prototype Analysis
  – Europe, Demonstration-Scale Floating, Oil and Gas

• Case Studies

• Assessment of Regional Port Characteristics
## Considerations

### Transport
- Nav. Channel Width
- Nav. Channel Depth
- Height Restrictions
- Device Type
- Metocean Conditions
- Vessel Availability
- Component Size
- Safe Harbor

### Infrastructure
- Skilled Labor Force
- Quayside Space
- Road/Rail Connection
- Component Size
- Device Type
- Crane Capacity
- Quayside Bearing Capacity
- Dry-dock/Shipyard
- Vessel Availability
- Vessel Berths

Source: Principle Power [Image](source: Principle Power)
Source: Siemens [Image](source: Siemens)

**Offshore Wind Turbine Size**

<table>
<thead>
<tr>
<th>Component</th>
<th>Land-based 1.5-2MW*</th>
<th>Offshore 6-8MW</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>~180ft.-220 ft.</td>
<td>250ft.-450ft.</td>
<td>May be transported in pieces.</td>
</tr>
<tr>
<td>Weight</td>
<td>~150-230 tons</td>
<td>~400 tons</td>
<td></td>
</tr>
<tr>
<td>Nacelle &amp; Hub</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>~35 ft.</td>
<td>~50ft.</td>
<td>May be transported in pieces.</td>
</tr>
<tr>
<td>Weight</td>
<td>~75 tons</td>
<td>~300-400 tons</td>
<td></td>
</tr>
<tr>
<td>Blades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>~130 ft.</td>
<td>~250ft.</td>
<td>Single piece only</td>
</tr>
<tr>
<td>Weight</td>
<td>&lt;10 tons</td>
<td>25-35 tons each</td>
<td></td>
</tr>
</tbody>
</table>

* E.g., Wild Horse Windfarm, WA
CA - Large Ports

Northern
• Humboldt Bay

Central
• SF Bay ~ 7 Deep Draft

Southern
• Hueneme
• LA/Long Beach
• San Diego
Port Classification Functions

Fabrication & Construction Port (FCP)
- Construction staging, pre-assembly, transport of hub and devices, fabrication of nacelle, blades, etc.

Quick Reaction Port (QRP)
- Crew Transfer, O&M, Pre-installation

Assembly Port (AP)
- Final assembly, marine tow to final location, large staging/storage

Combinations

Bremerhaven
Prototype – Assembly & Installation

Assembled upright at Port. E.g., Semi-Submersible

Towed to sea for assembly. E.g., Spar
Prototype Port - Assembly

Lisnave Shipyards
- Wide Dry-dock: 250 ft. (76m)
- Heavy-lift Crane: 500 tons
- Support Cranes: 100 tons
- Air-draft Restriction: None
- Draft: 25ft. (7.6m)
Ports – Air draft Restrictions

Limits Assembly Location and Installation Method
## Metocean Conditions – Open Ocean

### PACIFIC OCEAN

<table>
<thead>
<tr>
<th>WA, OR, CA, HI Average, Typ.</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hs (ft.)</td>
<td>9-10ft.</td>
<td>6-7ft.</td>
</tr>
<tr>
<td>Tp (sec)</td>
<td>11-12 sec</td>
<td>9-10 sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block Island(^1), (Atlantic) Typ.</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hs (ft.)</td>
<td>5-6ft</td>
<td>~3ft.</td>
</tr>
<tr>
<td>Tp (sec)</td>
<td>7-8 sec</td>
<td>7-8 sec</td>
</tr>
</tbody>
</table>

1. NOAA Buoy 40097

### Harsh Environment:
- At-sea construction
- Assembly location
- Installation method
- Long waves
Key Findings – Prototype

- Utilize Existing Equipment, Vessels, Infrastructure
  - Minimize capital expense

- Combination of locations
  - Broad geographic reach (Within and beyond CA)

- Large tow distances possible
  - Common in energy sector
  - Block Island prototype
Key Findings – Commercial Production

- **3 Port Classification Types**
  - Fabrication
    - Medium to large Ports
    - Good transportation connections
    - Inland or coastal
  - Assembly
    - Most Restricted
    - Navigation Requirements (Channel & Air Draft)
  - Quick Reaction
    - Coastal Ports
    - Proximity to installation
    - Min 12’ depth channel

- Incentive for Infrastructure investments
Key Findings - Infrastructure

Commercial Scale Infrastructure
- Limited wide (200’) dry dock facilities and marine railways
- Wind-specific assembly facilities don’t exist

Navigation
- Air Draft restricts final assembly location
- Limited choices of ports with large quayside & deep draft channel

Ocean Navigation
- Tow Distance less critical than infrastructure; demonstration
- Safe Harbor Distance
Key Findings - Infrastructure

Ocean Conditions
- Wave height, length
- Operability Limitations
- Downtime
- Specialty Equipment

Transportation
- Overland connections for smaller component
- Large components fabricated at Port

Port Infrastructure
- Few Large Heavy Lift Cranes (>500 ton)
- High capacity wharf
- Quayside upland area
- Throughput
FABRICATION PORTS: California

**Long-Term Commitment - May Require Purpose-Built Facilities**

**Quayside Space Limited - May Require Land (Re)development**

- **Navigation**
  - Good channel access & berth facilities
  - Air draft considerations

- **Upland Infrastructure**
  - Large upland space; limited availability
  - Good transportation & supply chain connectivity
  - High Capacity Wharf; limited availability

- **Port Network**
  - Good regional and inland network
  - Good access to supply chain
  - Marine Port Dependent

- **Dry Dock Facilities**
  - Currently Exist ~ Air draft restrictions; width optimized for vessels; marine rail system?

- **Workforce**
  - Large skilled workforce for fabrication

**Yellow: Investments Likely Required**
**ASSEMBLY PORTS: California**

**Port Facilities Require Upgrades**

- **Navigation**
  - Deep draft channels available
  - Air draft limit considerations
  - Assembly & Installation method dependent

- **Met Ocean Conditions**
  - N. Coast restrictions on vessel & assembly operations; downtime
  - Protected Harbor or alternative installation scheme

- **Port**
  - Largest West Coast Ports
  - Upland space exists; limited appropriate dedicated laydown areas
  - Good experience handling wind farm components
  - Single facility w/ attributes for large scale project not currently avail.

**Red: Navigation Height Limit**
**Yellow: Investments Likely Required**

Ports of Interest in Purple
Thank You

Contact: shane.phillips@mottmac.com
Detailed Report: www.boem.gov/BOEM-2016-011/

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