

Floating Offshore Wind Technology



Jeff King
Generating Resources Advisory Committee
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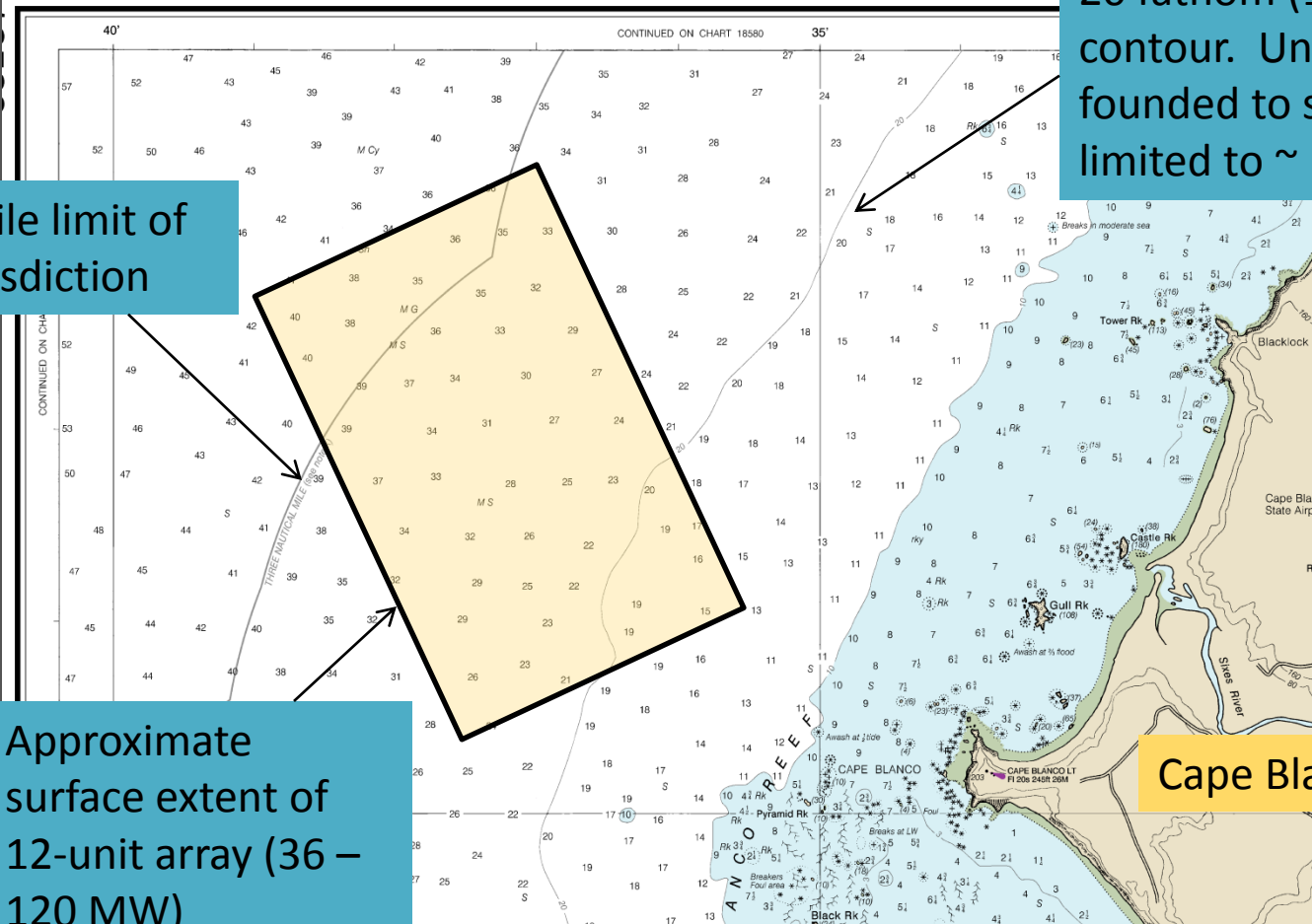
Today's Discussion

- Attributes
- Development issues
- PNW resource
- Offshore technology
- Prototypes and projects
- Cost
- Proposed 7th Plan Treatment

Why the interest in floating wind plants?

SOUNDINGS IN FATHOMS

Geographic positions referred to the North American Datum of 1927 must be corrected an average of 0.614' southward and 4.389' westward to agree with this chart.



20 fathom (120 ft) contour. Units founded to seabed limited to ~ 150ft.

Three-mile limit of state jurisdiction

Approximate surface extent of 12-unit array (36 – 120 MW)

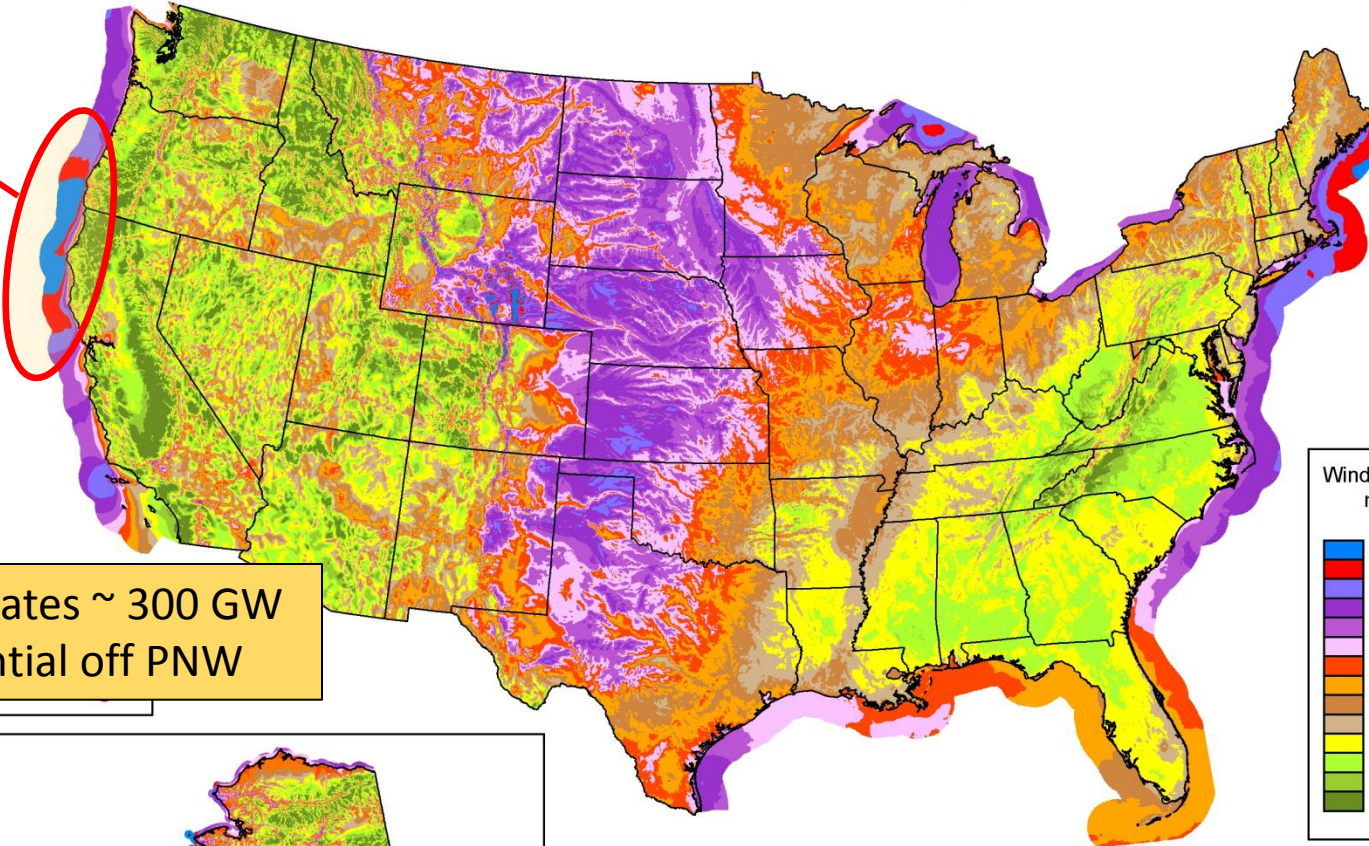
Cape Blanco. OR

Attributes

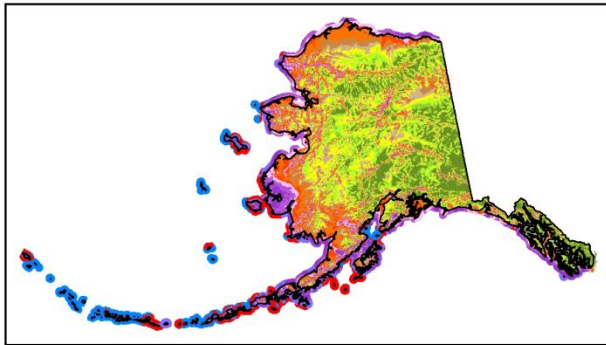
- Energetic resource (higher capacity factor)
- Reduced wind shear (shorter towers)
- Large potentially developable resource area
- Reduced visual and acoustic impact
- WTG scale economies (3 - 10 MW units)
- Marine WTGs are established commercial technology
- Floating and mooring technology transfer from offshore oil & gas industry
- On-shore fabrication & assembly (assembled unit towed to site)
- Potential interconnection to future offshore PNW <> CA intertie

United States - Land-Based and Offshore Annual Average Wind Speed at 100 m

Ave wind speed \geq 10 m/s



NREL estimates ~ 300 GW gross potential off PNW



Source: Wind resource estimates developed by AWS Truepower, LLC. Web: <http://www.awstruepower.com>. Map developed by NREL. Spatial resolution of wind resource data: 2.0 km. Projection: Albers Equal Area WGS84.

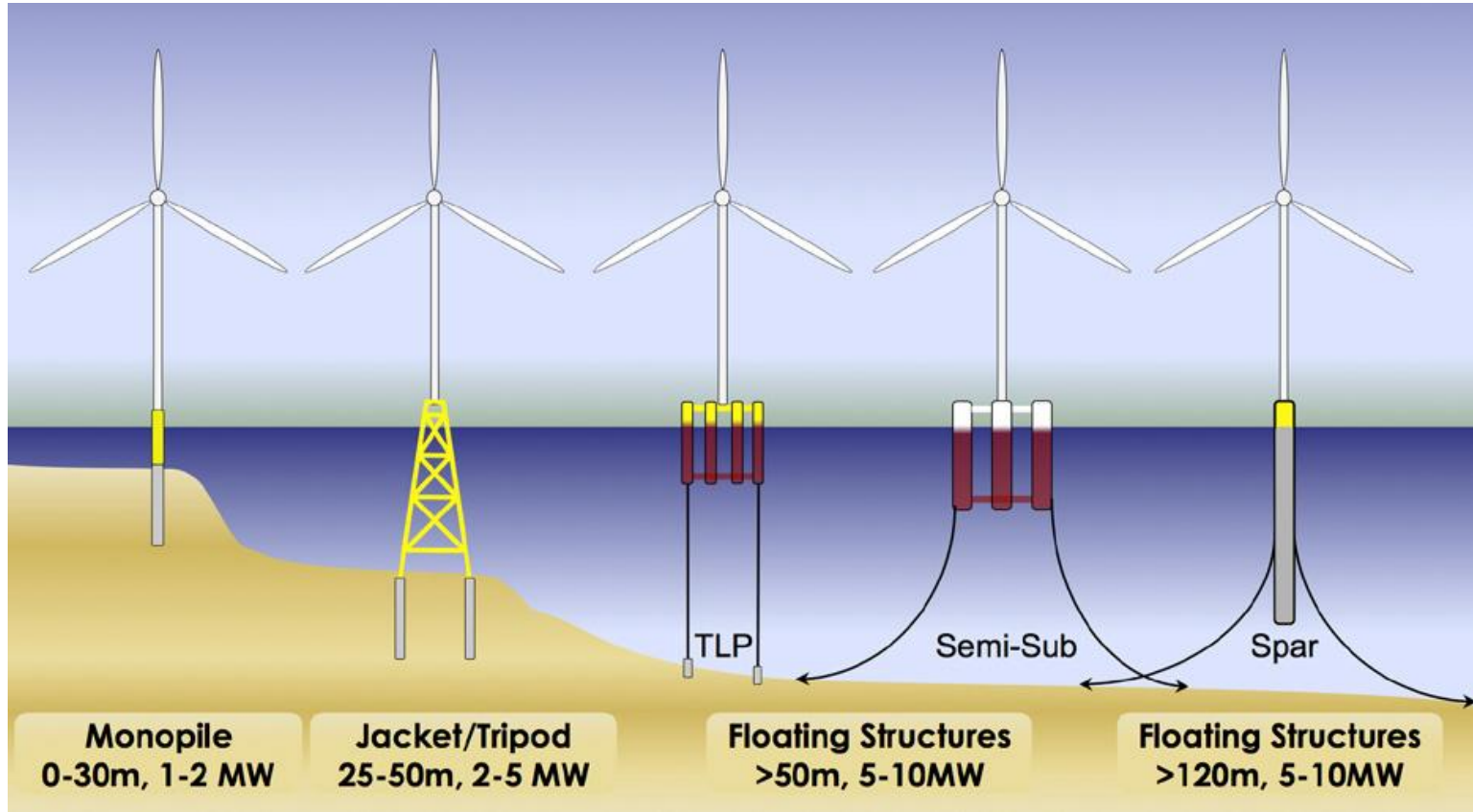


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Development issues

- Several platform concepts in conceptual to prototype stages of development, issues include:
 - Stabilization (wind and wave motion)
 - Corrosion & fatigue
- Electrical interconnection
 - Floating substation operation
 - Riser cable fatigue (wind, wave and tidal motion)
 - Distance to shore-side interconnection
- Seaspaces conflicts (fishing, navigation, military)
- Ecological impacts (marine & avian)
- Maintenance and repair access
- Probable high capital and O&M costs

Offshore WTG Founding Concepts



Principal Power (principlepowerinc.com)

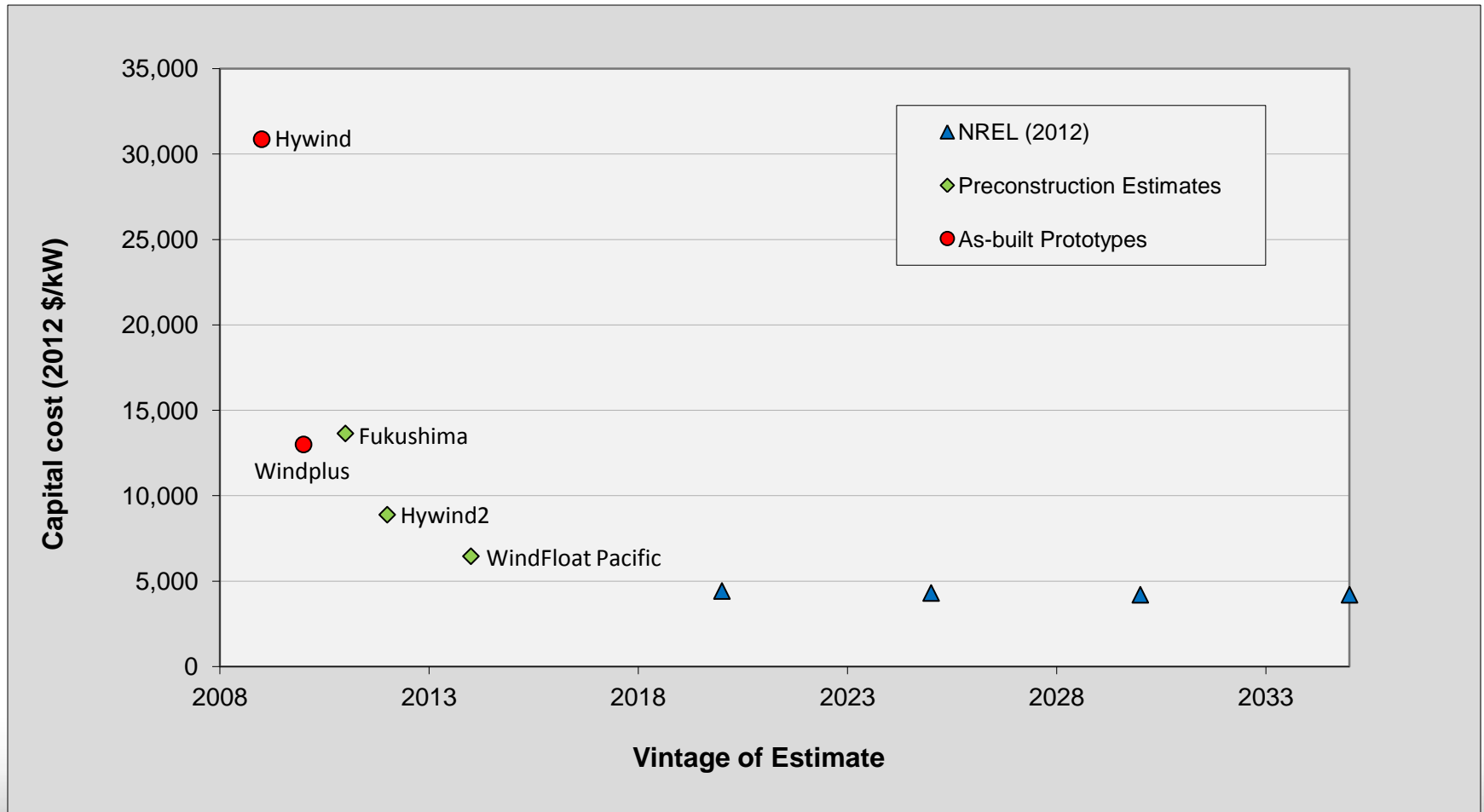
TLP – Tension-leg platform

Notable Projects



| Project | Location | Type | WTG/Platform | Operation | Status |
|-------------------|----------|------------------|---|-----------|------------------------|
| HyWind | Norway | Prototype | (1) 2.3 MW Siemens, spar | 2010 - | Operating |
| WindPlus | Portugal | Prototype | (1) 2MW Vestas, semi-sub | 2011 - | Operating |
| Fukushima | Japan | Prototype /Pilot | (1) 2MW Hitachi, semi-sub (1) 7MW Mitsubishi, spar (1) 7MW Mitsubishi, semi-sub | 2013 - | Hitachi unit operating |
| Kincardine | Scotland | Pilot | (8) Units, semi-sub | 2017 | Proposed |
| HyWind2 | Maine | Pilot | (4) Units, spar | | Suspended |
| WindFloat Pacific | Oregon | Pilot | (5) 6MW WTG, semi-sub | 2017 | Proposed |

Reported & Projected Capital Cost



Proposed 7th Plan Treatment

- In the plan
 - Technology & resource description
 - (Very!) preliminary cost projections
 - Commercialization issues (focus on PNW)
- Action plan (model on OWET actions?)
 - Resource assessment?
 - Site identification?
 - Integration assessment?
 - Possible development incentives?

Selected Literature

- Black & Veatch. (2012) *Cost and Performance Data for Power Generation Technologies*. Prepared for National Renewable Energy Laboratory (Technology cost & performance estimates).
- National Renewable Energy Laboratory. (2010) *Large-scale Offshore Wind Power in the United States*
- National Renewable Energy Laboratory. (2012) *Renewable Electricity Futures Study*.
- Navigant. (2013) *Offshore Wind Market and Economic Analysis*. Prepared for U.S. Dept. of Energy (Economic effects).