Electricity Transmission Challenges and Alternatives for Offshore Wind in Northern California

Presentation to:
Western Electricity Coordinating Council, Environmental Data Task Force

July 24, 2020

Presented by:
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Research Topics

Funded by Bureau of Ocean Energy Management (BOEM)

- Resource assessment
- Grid compatibility
- Subsea cable
- Economic analysis

Funded by California Ocean Protection Council (OPC)

- Environmental impact
- Port infrastructure
- Stakeholder engagement
- Policy analysis

Funded by California Governor’s Office of Planning and Research (OPR)

- Military compatibility
- Geologic / seismic
- Subsea cable environmental
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North Coast Offshore Wind Study: Resource and Transmission Assessment | 24 July 2020 | schatzcenter.org
Presentation Outline
1. Description of study scenarios
2. Offshore wind resource
3. Generation and regional load compatibility
4. Transmission upgrades and cost
5. Discussion
Main Findings

Key Takeaways

1. **Large Wind Resource:** The north coast offshore wind resource is enormous and could support progress towards meeting California’s SB 100 goals.

2. **Limited Transmission:** Transmission capacity is a major barrier for developing offshore wind on the north coast.

3. **Challenges:** There are a range of other challenges that need to be considered including port infrastructure, stakeholder, environmental impacts, seismic concerns, and others.
Main Findings

Key Takeaways

4. The transmission limitations create challenges for initial deployment and large-scale development

   • **Initial Development**: Significant investment in transmission is required even for small scale projects (50 or 150 MW) that dominate the capital costs. Transmission built to serve these projects would not contribute to supporting large scale deployments.

   • **Long-term Development**: Offshore wind needs economies of scale to become economically viable. At these scales, transmission upgrades would be built much differently (voltage and location) and require multi-billion dollar transmission infrastructure.

5. **Pathway and Timeline**: The benefit of renewable energy generation at the large scale is enormous, but smaller, initial projects are needed to demonstrate offshore wind in a California regulatory environment. What is the pathway to overcome the small-project challenges and reach the large-scale benefits?

6. **Transmission Costs**: Creative strategies are needed to minimize transmission requirements for small projects, such as curtailment and/or storage.
Offshore Wind Resource

The study includes three scales of offshore wind development.

- 50 MW footprint
- 150 MW footprint
- ~1.8 GW footprint (full build)

Average wind speed at 90 m height:
- < 7 m/s
- 7.0 - 7.5 m/s
- 7.5 - 8.0 m/s
- 8.0 - 8.5 m/s
- 8.5 - 9.0 m/s
- 9.0 - 9.5 m/s
- 9.5 - 10.0 m/s
- > 10.0 m/s
 existing transmission infrastructure

Takeaway:
- The transmission network connecting Humboldt County has limited capacity, and the region is relatively isolated from an electrical perspective.
Time Series of Power Generation

Example weeks, 144 MW wind farm, Northern California Call Area

Key Takeaways:
- Power generation varies from week to week, even within the same season.
- There are sustained times of maximum generation and low generation.
Key Takeaways:
- Full power for 32% of the year
- No power for 21% of the year
- Capacity factor is 48%
  - Accounts for losses including wake effects, electrical losses, and downtime for maintenance
Humboldt County Electricity System

Legend
- Counties
- Humboldt County
- Humboldt Call Area (OSW)
- Existing Power Plants

Existing Transmission Lines
- 33 - 82 kV
- 110 - 161 kV
- 220 - 287 kV
- 345 - 500 kV

Humboldt County Electrical System

Humboldt Bay Generating Station, 163 MW
DG Fairhaven, 15 MW
Scotia, 25 MW
Baker Station Hydro, 1.5 MW
Offshore Wind, 48, 144, or 1,836 MW
Regional Load

Humboldt-Trinity, 60 kV
Humboldt-Trinity-Cottonwood, 115 kV
Humboldt-Bridgeville-Cottonwood, 115 kV
Bridgeville-Garberville, 60 kV

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Takeaway:
- 48 MW wind farm fits within current load and generation in Humboldt region
- 144 MW wind farm needs to export 40% of electricity
- 1,836 MW wind farm must curtail the majority of power because of limited export capacity
Transmission Planning Study

Conducted by PG&E

Scope of Work
• Recommend transmission upgrades for three scales of offshore wind development
• Provide high level cost estimate

Major Assumptions
• Offshore wind generators are evaluated for full deliverability of power.
• Transmission upgrades built to eliminate overload during peak summer and off-peak spring conditions
• No curtailment of offshore wind
Transmission Upgrades: 144 MW

- **Build new 115 kV transmission**
- **Reconduct existing 115 kV transmission**
- **Install 115/60 kV transformer**
- **Reconduct existing 60 kV transmission**

**Takeaway:**
- 148 MW requires the same upgrades as 48 MW plus additional reconductoring, which adds costs.
Transmission Upgrades: 1,836 MW

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>New 500 kV from Humboldt Bay - Round Mountain - Table Mountain - Vaca-Dixon</td>
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<tr>
<td>Option 2</td>
<td>New 500 kV to Vaca-Dixon, plus upgrades in Bay Area</td>
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<td>Option 3</td>
<td>Subsea cable, nearshore, plus converter stations and interconnection</td>
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<tr>
<td>Option 4</td>
<td>Subsea cable, deep-water, plus converter stations and interconnection</td>
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</tbody>
</table>
Electrical Interconnection Findings:

- The San Francisco Bay Area has a major load where the injection of large scale renewable power could improve reliability.

- Offshore wind from the north coast could be transmitted to the Bay Area directly in a subsea transmission cable.

- Once reaching a central converter station in the Bay Area, power from a 1,836 MW wind farm would be to be connected to three transmission systems. Not a single system can handle this much additional capacity.
Subsea Cable Options Summary

Key Takeaways

- Interconnection directly in the Bay Area is ideal from a load and transmission perspective.

- Two potential cable corridors were developed based on physical hazards and constraints. 
  More analysis needed to confirm feasibility and refine costs.

- Both corridors have a variety of different challenges:
  - Nearshore: Deep submarine canyons and subsea landslides, trenchability of substrate, environmental considerations, seismic fault line displacements, etc.
  - Further from shore: deep water (2,000 m) may require specialized cable design, deep-water power/telecom cable crossings, seismic fault line displacements, etc.

- Cable landing in the Bay Area appears to be challenging:
  - Geophysical challenges with cable routing
  - Suitable land area for converter station(s)
  - Environmental and permitting challenges
  - Stakeholder concerns and perspectives
Transmission Summary

Key Takeaways:
- Small-scale (50-500 MW) projects are a necessary first step for offshore wind development in California.
- However, the transmission upgrade costs at these scales is disproportionately expensive to their output.
- Transmission built for smaller scales at 115 kV will not contribute directly towards the 500 kV capacity needed to deliver large-scale offshore wind power to major load centers.

Follow up Question:
- How can transmission costs be overcome to support near-term projects while building the experience needed to develop large-scale projects?
Key Takeaways

1. The offshore wind resource on the north coast is enormous.
   
   A 1,836 MW wind farm in the Humboldt Call Area would produce 3.8% of California’s electricity generation.

2. Transmission challenges are different depending on the scale of development.
   
   - Initial projects face disproportionately high transmission investment costs but are a necessary first step for California offshore wind.
   
   - Future, large-scale development would require significant investment and coordination at the state planning level.

3. Strategies need to be developed to reduce transmission costs for the first project.

4. In parallel, long-term planning efforts need evaluate the value of offshore wind and interconnection strategies.
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Questions and Discussion
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www.schatzcenter.org/wind

Photo credit: Maia Cheli
Appendix

Additional slides for reference
Key Takeaways:
- Prevailing winds are from the north and south.
- 36% of the time, wind speed is within the rated wind speed for a 12 MW turbine.
Daily Wind Speed Pattern

Key Takeaways:
- The wind speed has significant variation between each year and season.
Time of Generation

1. Enormous wind resource can generate lots of power to contribute to state targets

   Full build out of Humboldt Call Area (1,836 MW) can provide 3.8% of California’s current energy generation.

2. Time of generation could be a useful compliment to solar and land-based wind.

   Offshore wind has relatively consistent output throughout all seasons and throughout the day

Key Takeaways:
- Offshore wind has a high capacity factor compared to other renewables.
- Offshore wind is more consistent throughout the day and between different seasons.
Economic Viability

Economies of Scale

- Larger wind farms become more competitive in state electricity markets.
- Developers can start small but want a pathway to larger projects.

Average California wholesale prices
Source: CAISO, 2019

Notes: Modeled using single owner financing.
Includes port infrastructure development costs.
Costs do not include transmission upgrades.
Humboldt Electricity Generation Portfolio

Key Takeaways:

- Existing electrical infrastructure meets regional demand with 75% local generation and 25% imports.
- HBGS could be dispatched to displace imports and stay within technical operating limitations.
Regional Load Compatibility: 48 MW Offshore Wind

**Scale:** 48 MW Offshore Wind Farm

### Annual Profile:

- **Energy, MWh**
  - 0, 20,000, 40,000, 60,000, 80,000
  - **Power, MW**
  - Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

### Example Days:

- **Low Wind Day**
- **Variable Wind Day**
- **High Wind Day**

**Key Takeaways:**

- Can operate in tandem with HBGS and replace imported electricity.
- 48 MW offshore wind farm is sized to contribute to regional demand without exporting power.

**Legend:**

- Curtained OSW
- Exported OSW
- Locally Utilized OSW
- HBGS
- Scotia
- DG Fairhaven

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Regional Load Compatibility: 144 MW Offshore Wind

**Scale:** 144 MW Offshore Wind Farm

**Annual Profile:**

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**Example Days:**

- **Low Wind Day**
- **Variable Wind Day**
- **High Wind Day**

**Key Takeaways:**

- A 144 MW wind farm exceeds regional demand at periods of high wind speed.
- HBGS is used to meet load for low and variable wind speed days.
- 3% of offshore wind must be curtailed if there is no additional transmission capacity.

**Legend:**

- Curtailed OSW
- Exported OSW
- Locally Utilized OSW
- HBGS
- Scotia
- DG Fairhaven
Regional Load Compatibility: 1,836 MW Offshore Wind

Scale: 1,836 MW Offshore Wind Farm

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<table>
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<td>Dec</td>
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Example Days:

- Low Wind Day: Power, MW
- Variable Wind Day: Power, MW
- High Wind Day: Power, MW

Key Takeaways:
- A 1,836 MW wind farm far exceeds regional demand and transmission capacity.
- HBGS is still needed to meet regional load during low and variable wind speed days.
- 88% of offshore wind power would be curtailed without additional transmission capacity.

Legend:
- Curtained OSW
- Exported OSW
- Locally Utilized OSW
- HBGS
- Scotia
- DG Fairhaven