Presentation Agenda

• Where O&M Fits in the Project Process
• O&M Drivers (Why do O&M?)
• O&M Defined (O&M Categories)
• O&M Cost Trends
• Options for Conducting O&M
• Closing Thoughts
Project Development Process

1. Potential
2. Options
3. Refinement
4. Implementation
5. Operations & Maintenance
Step 5: Operations & Maintenance

Purpose: Conduct or ensure ongoing operations and maintenance (O&M), including repair and replacement (R&R)*

Task:
- O&M Plan and Budget
- System performance
- Monitoring system
- O&M Contracts and agreements
- Warranties
- Production guarantees
- Buyout Options

Outputs:
- Ensure responsible party carries out O&M/R&R*
- Measuring and tracking success
- Correlate with business plan and strategic energy plan
- Contract compliance
- Reporting of generation
- Met or exceeded energy and financial performance

*Especially if owner – role of highest O&M risk
Drivers for Improved O&M

- Increase efficiency and energy delivery (kWh/kW)
- Decrease downtime (hours/year)
- Ensure safety and reduce risk
- Extend system lifetime
- Often required in financing and warranty
What’s Included Under O&M?

O&M is often narrowly interpreted as this (maintenance)...

- **Preventive Maintenance**
  - Scheduled and planned
  - Expenditure is budgeted

- **Corrective Maintenance (repair)** [Capital Replacement]
  - Unplanned or condition-based
  - Costs tend to increase over time
  - Must be timely and effective
  - Have sufficient funds available to cover cost of major component repair or replacement

- **Monitoring**
  - Metering for revenue
  - Alarms
  - Diagnostics
  - Condition Monitoring

But can also includes this

- **Administration**
  - Billing; accounting
  - Hiring subcontractors
  - Enforcement of warranties
  - Management of budget and reserves

- **Insurance**
  - General Liability
  - Property
  - Business Income (loss of profit)
  - Equipment Protection (from breakdown)

- **Site Maintenance**
  - Mowing around the tower base
  - Snow removal from turbine driveway

- **Land Lease Costs**
How Wind O&M Costs are Described/Modeled

- O&M costs typically expressed as:
  - $/kW/yr (capacity-based)
  - $/MWh/yr or $/kWh/yr (energy-based)
  - $/yr (simple, fixed)

In reality, O&M costs are generally a mix of fixed, per-kW, & per kWh costs.
O&M Costs for Renewable Energy Technologies

http://www.nrel.gov/analysis/tech_cost_om dg.html
Operations and Maintenance Costs Varied By Project Age and Commercial Operations Date

O&M reported in figure does not include all operating costs: Statements from public companies with large U.S. wind asset bases report total operating costs in 2014 for projects built in the 2000s of ~$21-25/MWh

Source: 2014 Wind Technologies Market Report
Major Components at Risk

Equipment breaks—usually after the warranty expires

Source: Chris Walford: GEC (now DNV GL)
# O&M Options & Lifecycle

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<thead>
<tr>
<th>Timeline (Years)</th>
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<th>End of warrantee – life of project</th>
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<tbody>
<tr>
<td>0-2</td>
<td>3-5</td>
<td>Typical Warrantee Period</td>
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<td></td>
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<td>Typical Extended Warrantee Period (optional)</td>
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<td>In-house</td>
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### Notes
- Warrantee terms alter over time depending upon market conditions
- Recommended practice is to conduct an inspection prior to end of warrantee period to identify any incipient problems that can be fixed under the warrantee.
Closing Thoughts

• O&M may not be as sexy as project development and construction. However!!!!!, the O&M phase provides many opportunities to earn, save, or lose, a lot of money.

• O&M considerations should be an important consideration in turbine selection (turbine quality, cost & availability of maintenance services).

• Ensure funds are available from the project beginning to cover cost of major repairs (R&R fund).

• Develop an O&M plan as part of the overall project plan.

• Unit O&M costs likely to be higher for small (< 10 MW) projects.

• Industry-recommended best practices exist for all aspects of wind turbine maintenance. Study & understand them.

• Generally, the annual O&M costs increase over the life of the turbine, especially in later years of 20- to 25-year useful life.
Questions?