Issues affecting future role of wind power

• Least-cost renewable resource available in bulk quantity
• No direct production of carbon dioxide or criteria air pollutants (SOx, NOx, etc.)
• Ecological impacts usually avoided with judicious siting
• Public perception:
  Wind projects - generally very favorable; some scenic areas excepted
  Some resistance to transmission needed to access remote resource areas
• Little peaking capacity value
  Supplemental sustained peaking capacity may eventually be needed to maintain resource adequacy
Issues affecting future role of wind power, continued

- Investment risk:
  - High capital cost (currently $2000 - 2200/kW)
  - Short development and construction lead time
  - Transmission in advance of development will be needed to access remote resource areas
- No fuel price risk
- Intermittent output incurs integration cost
  - Nature of integration costs becoming better understood
  - "Its the ramp, not the ripple"
  - Institutional, procedural, technical measures enabling full use of existing system flexibility + ramp control are available at moderate cost.
  - Capacity additions eventually needed to maintain peak sustained capacity may coincidentally provide adequate system flexibility.
  - Individual balancing authority situations may differ.

Revisions & refinements to wind assessment

1) Revised capital cost
2) Revised operation and maintenance costs
3) Revised operational integration costs
4) Revised future capital cost assumptions
5) Expanded supply curve (added resource areas)
6) Representative hourly project output by resource area
7) Optimize transmission, integration, energy production
8) Assessment of offshore wind

Draft assessment complete for #1 - #5
Data available for #6, planned for inclusion in draft 6th Plan.
First cut at implicit tradeoffs of #7 planned for inclusion in draft 6th Plan. Follow-on, more detailed assessment proposed by the Wind Integration Forum
Overview of #8 planned for January GRAC

December 18, 2008
Proposed base year wind plant capital cost

Overnight capital cost (2006 $/kW)

Reported as-built cost
Preconstruction Estimate
Lazard
EIA
Wkg Draft

2003 2004 2005 2006 2007 2008 2009 2010
Year of service

Proposed cost for 2008 service $2100/kW

Proposed 2008 cost (2009 service) $2100/kW

Overnight capital cost (2006 $/kW)

Reported as-built cost
Preconstruction Estimate
Generic Estimates
Wkg Draft

2003 2004 2005 2006 2007 2008 2009 2010
Vintage of Estimate (Service Year -1)

December 18, 2008
Thinking on future construction costs (Slightly evolved, but still provisional)

Overnight construction cost (2006$/kW)

- Costs flatten in 2008 - 2009
- Real costs decline to ~ 130% of 2004 values 2010 - 15
- 2015 > Resumption of historical real cost reduction

Operation and Maintenance Cost Elements

- Wind plant only (e.g., to point of interconnection), exclude transmission
- Each of the following, with the exception of fixed O&M and capital replacements is separately input to the Council's models

Fixed O&M
- Labor
- Routine maintenance contracts, labor and materials
- Administrative and general costs

Variable O&M
- Land rent/royalties
- Property Taxes and in-lieus
- Insurance
- Capitalized replacements over life of project
  - Gearbox, blade replacements, etc.
  - Added to fixed O&M for modelling purposes
Derivation of operation & maintenance costs

- Assume fixed O&M costs are a function of capital cost (typical approach for feasibility-level estimates)
- Scaling O&M costs of the 5th Plan by observed escalation of capital costs yielded:
  - Fixed O&M (including capital replacement) - $41.58/kW/yr
  - Property Tax at 1.4% of depreciated plant value - $6.07/kW/yr (levelized)
  - Insurance at 0.25% of depreciated plant value - $1.09/kW/yr (levelized)
- Variable O&M assumed to increase only with inflation - $1.16/MWh
- The sum of the four elements yield total O&M of 2.5% of annual capital cost - consistent w/IEA (next slide)
- Adjusting fixed O&M and variable O&M to round values while maintaining total O&M as 2.5% of annual capital cost, resulted in the following proposed values:
  - Fixed O&M including capital replacements, excluding property tax and insurance - $43/kW/yr
  - Variable O&M - $1.00/MWh

Comparisons of proposed O&M costs w/other sources

- Average of eight 2009 rate requests by Northwest utilities owning wind capacity - $33.98 (2006$) + 10% G&A allowance (approx per PGE) yields $37.38/$/kW/yr
  - Generally exclude land rent or royalties and property taxes
  - Include near-term O&M contracts and warrenties (potential longer-term capital replacements implicitly excluded).
- IEA rules of thumb:
  - 2.0 - 3.5% of annual capital cost (proposed values are 2.5%)
  - 20 - 25% of total energy cost, inclusive of capital replacement (proposed values are 22%)
- Lazard (financial and capital management advisors)
  - $40 - $50/kW/yr
  - Inclusions and exclusions not specified

December 18, 2008
Wind power operating and maintenance costs

<table>
<thead>
<tr>
<th></th>
<th>5th Plan</th>
<th>Proposed 6th Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine O&amp;M + capital replacement</td>
<td>$23/kW/yr</td>
<td>$43/kW/yr</td>
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<tr>
<td></td>
<td></td>
<td>Fixed - Cap Rep treated as an expense</td>
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<tr>
<td>Land &amp; ROW rent/royalties</td>
<td>$1.16/MWh</td>
<td>$2.00/MWh</td>
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<tr>
<td></td>
<td></td>
<td>Variable</td>
</tr>
<tr>
<td>Property Taxes</td>
<td>1.4%/yr of depreciated investment</td>
<td>Unchanged</td>
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<td></td>
<td>&quot;Regional average&quot; Common to all resources</td>
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<tr>
<td>Insurance</td>
<td>0.25%/yr of depreciated investment</td>
<td>Unchanged</td>
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<tr>
<td></td>
<td>Common to all resources</td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>$5 - 10/MWh</td>
<td>$8.70 - 11/MWh</td>
</tr>
</tbody>
</table>

Planning assumptions - Basic wind project

- 150 MW project
- $2100/kW overnight development and construction cost (2008 base)
- Plant capital cost stable through 2009, declining to 130% (real dollar terms) of 2004 costs by 2015, then resuming historical (pre-2004) learning curve through 2025 (provisional assumption)
- Operating costs:
  - Fixed O&M - $43.00/kW/yr
  - Variable O&M - $1.00/MWh
  - Integration - $8.70 (near-term) - $10.90 (long-term) per MWh
- 36 mo from conceptualization to service (minimum)
  - 18 mo Development phase (site identification through completion of permitting) - 2% of TPC
  - 9 mo Preparation phase (turbine order through turbine shipment) - 12% of TPC
  - 9 mo Construction phase (turbine shipment to commercial operation) - 86% of TPC
- Earliest service for new Northwest project ~ 2011
  - Construction initiated at permitted site 2010
Elements of wind energy cost

Effect of historical and forecast cost trends
Transmission assumptions

- Incremental transmission system cost fully allocated to wind energy transfer (no network reliability credit).
- Transfer capacity provided for 100% of project output.
- Transfer costs based on typical capacity factor (30 - 38%) operation.
- Estimates based on line miles and substations proposed for B2H, applicable Gateway and MSTI segments.
- Lines assumed to be single-circuit 500kV AC w/1500 MW transfer capacity
- Line and substation unit costs from Bonneville Nov 2008.
- ROW, communication, EPC, owner's cost and O&M cost percentages are from MSTI proposal.
- Losses are from 2006 NTAC Canada-Northwest-California study

Montana wind to S. Idaho, Oregon & Washington

December 18, 2008
Wind supply options
2020 Service

- Transmission & Losses
- System Integration
- Plant costs

**Point-to-point transmission included**
No federal production tax credit
Assumes Boardman or Bell > OR/WA @ embedded cost
All other segments at full incremental cost

Estimating quantities for 2020 supply curve

- **Montana Local**: 300 MW - 30% of est. 2020 NWE hourly peak less current wind capacity
- **Columbia Basin**: 3500 MW - Preliminary estimate of remaining BPA BA integration capability
- **Idaho Local**: 1200 MW - 30% of est. 2020 S. ID hourly peak less current wind capacity
  - MT > S. ID - Preempted by ID Local
  - WY > S. ID - Preempted by ID Local
  - AB > WA/OR: 1500 MW - Capacity of single-circuit 500kV AC line
  - MT > WA/OR: 1500 MW - Capacity of single-circuit 500kV AC line
  - WY > WA/OR - Preempted by MT > WA/OR
Additional wind analysis

1. Improved production estimates and understanding of seasonal value
2. Sustained peaking capacity needs
3. Tradeoff: Incremental transfer capacity cost vs. incremental energy value
4. Value of locating generation or storage at wind resource area
5. Impact of geographic diversity on short-term volatility of wind power production, including ramping events

3 - 5 are Wind Integration Action Plan Action 15 - Framework for long-term regional wind development

Further analysis, e.g. subhourly, likely needed to achieve full understanding of 3 -5

6th Plan Action item may be needed for further refinement