Renewable Energy Grid Integration in New Zealand

Workshop on Grid Interconnection Issues for Renewable Energy

12 October, 2010
Tokyo, Japan
Coverage

Electricity Generation in New Zealand,

The Electricity Market,

Grid Connection Issues,

Technical Solutions,

Market Solutions,

Problems Encountered

Key Points.
Electricity in New Zealand

7 Major Generators,
1 Transmission Grid owner – the System Operator,
29 Distributors,

610 km HVDC link between North and South Islands,

Installed Capacity 8,911 MW,
System Generation Peak about 7,000 MW,
Electricity Generated 42,000 GWh,
Electricity Consumed, 2009, 38,875 GWh,
Losses, 2009, 346 GWh, 8.9%

Annual Demand growth of 2.4% since 1974
# Installed Electricity Capacity, 2009 (MW)

<table>
<thead>
<tr>
<th>Renewable Generation</th>
<th>Hydro</th>
<th>5,378</th>
<th>60.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geothermal</td>
<td>627</td>
<td>7.0%</td>
</tr>
<tr>
<td></td>
<td>Wind</td>
<td>496</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td>Wood</td>
<td>18</td>
<td>0.2%</td>
</tr>
<tr>
<td></td>
<td>Biogas</td>
<td>9</td>
<td>0.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>6,528</td>
<td>73.3%</td>
</tr>
<tr>
<td>Non-Renewable Generation</td>
<td>Gas</td>
<td>1,228</td>
<td>13.8%</td>
</tr>
<tr>
<td></td>
<td>Coal</td>
<td>1,000</td>
<td>11.2%</td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
<td>155</td>
<td>1.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>2,383</td>
<td>26.7%</td>
</tr>
<tr>
<td><strong>Total Generation</strong></td>
<td></td>
<td>8,911</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Electricity Generation 2009
### Electricity Generation, 2009 (GWh)

<table>
<thead>
<tr>
<th>Renewable Generation</th>
<th>Hydro</th>
<th>23,962</th>
<th>57.0%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Geothermal</td>
<td>4,542</td>
<td>10.8%</td>
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<tr>
<td></td>
<td>Wind</td>
<td>1,456</td>
<td>3.5%</td>
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<tr>
<td></td>
<td>Wood</td>
<td>323</td>
<td>0.8%</td>
</tr>
<tr>
<td></td>
<td>Biogas</td>
<td>195</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30,478</strong></td>
<td></td>
<td><strong>72.6%</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Non-Renewable Generation</th>
<th>Gas</th>
<th>8,385</th>
<th>20.0%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Coal</td>
<td>3,079</td>
<td>7.3%</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>8</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Waste Heat</td>
<td>58</td>
<td>0.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11,530</strong></td>
<td></td>
<td><strong>27.4%</strong></td>
</tr>
</tbody>
</table>

| **Total Generation** | **42,008** | **100.0%** |
Electricity from Renewable Energy

New Zealand has a high usage of Renewable Energy

• Penetration 67%,
• Market Share 64%

Renewable Energy Penetration Profile is Changing,

• Hydroelectricity 57% (decreasing but seasonal),
• Geothermal 11% (increasing),
• 3.5% Wind Power (increasing).

Target is 90% penetration by 2020

Renewable Energy is doing well in New Zealand
Wind Power in New Zealand

New Zealand has a very robust wind resource,
- Long coastline in the “Roaring 40s”,
- Both prevailing Westerly wind and shore breezes.

Turbines operate 4,000 hrs/year at full capacity,
- Germany 2,000 hrs/yr,
- Scotland, Wales & W. Ireland 3,000 hrs/yr,

Wind Load Factor 51-54%,
- Average over all energy forms is 45% in NZ,

Theoretical penetration is 35%,
Theoretical Market Share is 20%

An attractive Renewable Energy Prospect
## Electricity from Renewable Energy

<table>
<thead>
<tr>
<th>Name</th>
<th>First Commissioned</th>
<th>Operator</th>
<th>Installed capacity (MW)</th>
<th>Projected capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awhitu</td>
<td>Proposed</td>
<td>Genesis Energy</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Chatham Island</td>
<td>Proposed</td>
<td>CBD Energy</td>
<td>0</td>
<td>0.4</td>
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<tr>
<td>Hau Nui</td>
<td>1997</td>
<td>Genesis Energy</td>
<td>8.8</td>
<td>8.8</td>
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<tr>
<td>Hauauru maraki</td>
<td>Proposed</td>
<td>Contact Energy</td>
<td>0</td>
<td>540</td>
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<tr>
<td>Hawke’s Bay</td>
<td>Proposed</td>
<td>Hawkes Bay Wind Farm Ltd</td>
<td>0</td>
<td>225</td>
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<tr>
<td>Horseshoe Bend</td>
<td>Under Construction</td>
<td>Pioneer Generation</td>
<td>0</td>
<td>2.5</td>
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<tr>
<td>Kaiwera Downs</td>
<td>Proposed</td>
<td>TrustPower</td>
<td>0</td>
<td>240</td>
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<tr>
<td>Long Gully</td>
<td>Proposed</td>
<td>Mighty River Power</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Mahinerangi</td>
<td>Proposed</td>
<td>TrustPower</td>
<td>0</td>
<td>200</td>
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<tr>
<td>Mill Creek</td>
<td>Proposed</td>
<td>Meridian Energy</td>
<td>0</td>
<td>71</td>
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<tr>
<td>Mount Cass</td>
<td>Proposed</td>
<td>MainPower</td>
<td>0</td>
<td>69</td>
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<tr>
<td>Project Hayes</td>
<td>Proposed</td>
<td>Meridian Energy</td>
<td>0</td>
<td>630</td>
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<tr>
<td>Project Central Wind</td>
<td>Proposed</td>
<td>Meridian Energy</td>
<td>0</td>
<td>130</td>
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<tr>
<td>Project West Wind</td>
<td>Under Construction</td>
<td>Meridian Energy</td>
<td>0</td>
<td>142.6</td>
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<tr>
<td>Puketiro</td>
<td>Proposed</td>
<td>RES NZ</td>
<td>0</td>
<td>150</td>
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<tr>
<td>Rototuna</td>
<td>Proposed</td>
<td>Meridian Energy</td>
<td>0</td>
<td>500</td>
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<tr>
<td>Tarawera</td>
<td>1999</td>
<td>TrustPower</td>
<td>160</td>
<td>160</td>
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<td>Te Apiti</td>
<td>2004</td>
<td>Meridian Energy</td>
<td>90.8</td>
<td>90.8</td>
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<td>Te Rere Hau</td>
<td>2006</td>
<td>NZ Windfarms</td>
<td>2.5</td>
<td>48.5</td>
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<td>Te Uku</td>
<td>Proposed</td>
<td>WEL networks and Meridian Energy</td>
<td>0</td>
<td>84</td>
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<tr>
<td>Te Waka</td>
<td>Proposed</td>
<td>Unison Networks and Roaring 40s</td>
<td>0</td>
<td>102</td>
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<tr>
<td>Turitea</td>
<td>Proposed</td>
<td>Mighty River Power</td>
<td>0</td>
<td>360</td>
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<tr>
<td>Waitahora</td>
<td>Proposed</td>
<td>Contact Energy</td>
<td>0</td>
<td>177</td>
</tr>
<tr>
<td>White Hill</td>
<td>2007</td>
<td>Meridian Energy</td>
<td>58</td>
<td>58</td>
</tr>
</tbody>
</table>

**Total:** 320.1 4024.6
The Electricity Market

There are three official markets

- The Wholesale Electricity Market,
- The Reserve Market, 50 MW,
- The Frequency Keeping Market, also 50 MW,
  - One in each island due to HVDC link between,

Bids for 30 min supply 24 hrs ahead at 244 nodes,

- Revision up to 2 hours before dispatch,

Penalties for default,

About 15% of electricity traded, rest on direct contract,

*Provides access to a large electricity pool*
Grid Integration Issues

Relatively small load cf. Grid Size,

- No external links,
- Load is split into two by HVDC link,

Issues to be addressed:

- Frequency Management,
- Short term Variations,
- Generation Scheduling,
- Wind Farm Clustering,
- Formulation of Standards and Regulations.

Challenges rather than Barriers
Technical Solutions employed

Improved Generator Technology for:

- Voltage control at the output terminals,
- Maintaining consistent output during grid faults,
- Maintaining output over a range of grid frequencies,

Intra-Generator load balancing,

- Primarily with Hydro and Geothermal,
  - Virtual Hydro storage,
  - Turbine interconnection,
- Dynamic Reactive Power reserve,
  - Sale of VARs to large variable loads.
Technical Solutions (continued)

Wind Forecasting,

Energy Storage

- Battery Storage – Electric Cars/Hybrids,
- Pump water to storage (35% energy loss),
- Super Condensers, new technology.

System Strengthening,

- Up-rating hydro/stations,
- Grid Strengthening,
- Strengthening Fault ride-through requirements.

There are a number of options
Inter-Generator load balancing through the market,

- The Wholesale Electricity Market,
- The Reserve Market, 50 MW,
  - Non essential load disconnected instantaneously,
- The Frequency Keeping Market, also 50 MW,
- Virtual Hydro storage,

Updating Electricity Market Governance Rules (EMGs)

*The Market is the key!*
Ongoing Issues

Generally integration works well with few problems,
but:

Wind flow forecasting is not perfect,

Electricity replacement may be at different nodes,
  • Contract default issues may arise,

Wind Farm Clustering must be addressed,
  • Need for Grid strengthening,

Good Industry Standards and Market Rules are essential.

*Wind Power Integration is not a major Issue in NZ!*
Key Points

New Zealand has a high usage of Renewable Energy,

Wind Power installations increasing very rapidly in NZ,

Grid Integration issues are addressed primarily by:

• Individual Generator actions and generation balancing,

• Balancing using the Electricity Market Pool,

Two innovative Wind Power Storage options:

• Electric/Hybrid vehicle batteries,

• “Virtual” storage in Hydro Lakes.

*Market solutions are the key instruments!*
Thank You!