Stakeholder Council Mtg Agenda: May 8, 2019

- Welcome & Introductions
- Recap of Resiliency session & IGP resources
- The Energy Trilemma, Elijah Pack
  **Break and pick up lunch (11:45pm –12pm)**
- ISP: Energy Mix & Infrastructure
- Break Considerations/Discussion
- Workgroup Status Updates
- Next Steps and Closing
Integrated Grid Planning

Stakeholder Council

The Stakeholder Council represents our customers and broad stakeholder interests in Hawaii. The Stakeholder Council is a key element of and one of the several stakeholder groups in the overall stakeholder engagement process essential for IGP success.

The Stakeholder Council helps ensure alignment of Hawaiian Electric’s plans with customer and stakeholder interests and facilitates the development of broadly supportive action plans. The Stakeholder Council consists of one member from the following representative stakeholder interests (in alphabetical order):

- City/County representative (one from each county)
- Community delegate (one from each island)
- Consumer Advocate
- Demand Response
- Electric Vehicles
- Energy Efficiency
- Energy Storage
- Environmental Advocate

What is Integrated Grid Planning?
Get a quick overview with our IGP handout. Learn more >
Power System Planning Challenges & Opportunities

Elijah Pack – Manager National Planning (AEMO)
May 2019
The Energy Transition

• **Changing supply technologies** – Environmental sustainability, renewables boom, ageing infrastructure, decreasing need for baseload power, growing need for energy storage and peaking.

• **Evolving consumer needs** – Rooftop PV, electric vehicles, energy storage, flat / negative demand growth, affordability.

• **The grid** – Adapting to changing needs on both sides of the supply chain

• **Structural change** – regulatory liberalisation and competitive energy markets.

AEMO

The User Requirement:
The Energy “Trilemma”

Achieve a balance of:

- Reliability and security
- Affordability (Energy Equity)
- Environmental Sustainability

Source: World Energy Council†
Reliability & Security – Supply interruptions

Affordability

Electricity Bill Components

Source: AEMC, 2016 residential electricity price trends, final report.
Affordability – Average weekly household costs

Source: Australian Bureau of Statistics
Sustainability

- LRET Target
- Paris commitment
- State based RETs
- 6.5 solar panels installed per minute
- Policy uncertainty
- Reliance on coal for baseload power
U.S. energy consumption by energy source, 2017

Total = 97.7 quadrillion British thermal units (Btu)

Petroleum 37%
Natural gas 29%
Coal 14%
Nuclear electric power 9%
Renewable energy 11%

Total = 11.0 quadrillion Btu

- Geothermal 2%
- Solar 6%
- Wind 21%
- Biomass waste 4%
- Biofuels 21%
- Wood 19%
- Hydroelectric 25%

Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, Monthly Energy Review, Table 1.3 and 10.1, April 2018, preliminary data

Source: US Energy Information Administration
Global trilemma rankings

Source: World Energy Council

Energy Performance
- Top 25%
- 25%-50%
- 50%-75%
- Lower 25%

Source: IMF
External trilemma influencers

- Geographic size
- Wealth (GDP)
- Education
- Natural resources
- Electrical neighbours
- Reliance on fuels
- Climate complexity
- Policy certainty

Source: Australian Government
Renewable Energy Zones – “REZs”

REZs are areas in the NEM where clusters of large-scale renewable energy can be developed to promote economies of scale in high-resource areas and capture geographic and technological diversity in renewable resources.

– ISP Consultation Paper (AEMO)
Renewable Energy Zone Concept

Source: Powerlink, 2018 Transmission Annual Planning Report
Real REZ example - Texas

Wind map: Wind resource estimates developed by AWS Truepower, LLC for windNavigator Web: windnavigator.com awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 14 WGS84.

Source: NREL, Renewable Energy Zones: Delivering Clean Power to Meet Demand
Candidate REZ Identification
Renewable Energy Zone (REZ) Candidate Identification

Source: DNV-GL
Renewable Energy Zone (REZ) Candidate Identification

- Resource quality
- Correlation with demand
- Land parcel density
- Land cover
- Road access
- Terrain complexity
- Population density
- Protected areas
  - Electricity network

Source: DNV-GL
Renewable Energy Zone (REZ) Candidate Identification

- **Pumped Hydro**
  - Source: ANU

- **Geothermal**
  - Source: Geoscience Australia
10 constraints for REZ identification – including resource quality

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Wind</th>
<th>Solar</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind resource</td>
<td>35%</td>
<td>-</td>
<td>30%</td>
</tr>
<tr>
<td>Solar resource</td>
<td>-</td>
<td>30%</td>
<td>-</td>
</tr>
<tr>
<td>Demand matching</td>
<td>5%</td>
<td>-</td>
<td>5%</td>
</tr>
<tr>
<td>Electrical network</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Cadastral parcel density</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Land cover</td>
<td>5%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Roads</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Terrain complexity</td>
<td>10%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Population density</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Protected areas</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: DNV GL Report
REZ Candidates
Selection – Wind correlation
Selection – Solar correlation

![Solar correlation diagram showing correlation between different solar power stations in various states: NSW, QLD, SA, VIC. The diagram is color-coded to indicate the strength of correlation.](image-url)
Western Victoria REZ

Short term: present to 2021.
- Minor transmission line upgrades on the Red Cliffs to Wemen to Kerang to Bendigo, and Moorabool to Terang to Ballarat, 220 kV transmission lines.

Medium term: 2021 to 2025.
- The following major transmission network augmentations (staged):
  - By 2024: New 220 kV double circuit transmission lines from Ballarat to Bulgana.
  - By 2025: New 500 kV double circuit transmission lines from Sydenham to Ballarat connecting two new 1,000 MVA 500/220 kV transformers at Ballarat.
Integrated System Plan

Elijah Pack – Manager National Planning (AEMO)
May 2019
The Finkel Review

• Independent Review into the Future Security of the National Electricity Market
• 49 out of 50 recommendations accepted by COAG
• Clean Energy Target still being debated
• Recommendation 5.1:

  By mid-2018, the Australian Energy Market Operator, supported by transmission network service providers and relevant stakeholders, should develop an integrated grid plan to facilitate the efficient development and connection of renewable energy zones across the National Electricity Market.
Energy mix and infrastructure are transforming

A profound transition of the NEM is underway:

FROM
A static world:
- Predictable demand growth
- Predominantly based on coal and gas resources
- A power system designed around bulk energy transport on main highways from major (synchronous) gen centres

TO
Rapidly changing world:
- Consumption flat, but demand peaks even more pronounced under extremes
- Supplies involve geographically dispersed, technologically diverse resources
- Requiring:
  - Flexible dispatchable plant
  - Energy storage
  - Visibility and controllability of resources, including embedded
  - Efficient re-configuration of the transmission system to support
Jurisdictional Planning Coordination
Power System Requirements

Operability
• Dispatchability
  (Controllability, Firmness, Flexibility)
• Predictability

Technical
• Resource adequacy and capability
• Frequency management
• Voltage management
• System restoration
Modern power systems are giant, multi-faceted machines. To operate the complex ‘system of systems’ in Australia’s National Electricity Market (NEM), AEMO oversees in aggregate millions of separate electricity supply and demand decisions in real time, all day, every day.

– Power System Requirements (AEMO)
<table>
<thead>
<tr>
<th>Service description</th>
<th>Supply side</th>
<th>Transfer between regions</th>
<th>Network</th>
<th>Stabilising devices</th>
<th>Demand side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>Centralised generation</td>
<td>Transfer between regions</td>
<td>Transmission and distribution networks</td>
<td>Grid reactor, grid capacitor, static VAR compensator</td>
<td>Load</td>
</tr>
<tr>
<td>Centralised generation</td>
<td>Synchronous generator</td>
<td>Non-synchronous generator</td>
<td>DC interconnection</td>
<td>AC interconnection</td>
<td>Static synchronous compensator</td>
</tr>
<tr>
<td>Decentralised resources</td>
<td>Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>Solar PV</td>
<td>Battery storage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Resource adequacy
- **Provision of sufficient supply to match demand from customers**
  - Bulk energy: System wide
  - Strategic reserves: System wide
- **Capability to respond to large continuing changes in energy requirements**
  - Operating reserves: System wide
- **Services to transport energy generated to customers**
  - Transmission & distribution services: Local

### Frequency management
- **Ability to set frequency**
  - Grid formation: Regional
- **Maintain frequency within limits**
  - Inertial response: Regional
  - Primary frequency control: Regional
  - Secondary frequency control: Regional
  - Tertiary frequency control: Regional

### Voltage management
- **Maintain voltages within limits**
  - Fast response voltage control: Local
  - Slow response voltage control: Local
  - System strength: Local

### System restoration
- **Ability to restore the system**
  - System restart: Local
  - Load restoration: Local
Scenarios and sensitivities

The ISP focuses on seven scenarios/sensitivities:

• Two base cases:
  • Neutral, and Neutral with storage initiatives.

• Three additional scenarios:
  • Slow change, Fast change, and High DER.

• Two additional sensitivities to explore key opportunities or risks:
  • Increased role for gas, and Early exit of coal-fired generation.
Key inputs

Resource Quality
- Wind and solar resource data from DNV-GL

Technology
- Technology costs and forward projection of costs primarily from CSIRO – confirmed by AEMO work and stakeholder consultation
- Pumped storage costs from ANU study
- Gas prices from Core Energy adjusted in early years to market prices
- Coal prices from Wood McKenzie
Key Inputs – NEM Energy Consumption
Key Inputs – Coal fleet operating life

Note: Data is based on announced closure dates, assumption based on age and coal type, and mine rehabilitation guarantees.
Network constraints

Network limits

• Thermal capacity
• Voltage stability
• Transient stability
• Oscillatory stability
• Rate of change of frequency
• System strength and fault levels
REZ Candidates
Scale – deep network upgrades

RENEWABLE ENERGY ZONES
0  Far North Queensland
1  North Queensland Clean Energy Hub
2  Northern Queensland
3  Barcaldine
4  Isaac
5  Fitzroy
6  Darling Downs
Victoria to NSW options
ISP modelling process

Capacity Outlook Model

Gas Supply Model
- GPG demand projections
- Refine gas supply capability and cost

Network Development Outlook Model
- Intra-regional transmission
- Generation and transmission built
- Refine Generation connection cost

Time Sequential Model
- GPG demand projections

Demand forecasts, Fuel, carbon, LRE, etc. (Scenario demand, Scenario drivers, Pool of generation projects, Pool of transmission projects)
A few key insights

• Maintaining existing coal-fired generation up to the end of its technical life is a key element of a least-cost approach.

• A portfolio approach to replacing thermal generation:
  • Utility-scale renewable generation, energy storage, distributed energy resources (DER), flexible thermal capacity including gas-powered generation (GPG), and transmission.

• The crucial role of transmission to connect geographically dispersed renewable generation, establish REZs, and share surplus energy across the NEM

• DER can greatly reduce the total cost of supply, and will benefit from more interconnection.

• Focus on event-based timing and managing risks of unplanned events.
Projected change in resource mix

Installed capacity by NEM region over the 20-year plan horizon
NEM Energy Outlook (Results)
Growing need for energy storage

Neutral vs Neutral with Storage Initiatives
Selection – REZ Priority Assessments

Candidate REZs for prioritisation
**Example – Darling Downs**

The Darling Downs REZ covers a wide area of South West Queensland (SWQ). The existing network is strong and could support around 3,000 MW of new generation without requiring major upgrades. The MLFs are robust.

### Renewable Resources

<table>
<thead>
<tr>
<th>Resource Quality</th>
<th>Solar</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential (MW)</td>
<td>4,000</td>
<td>2,785</td>
</tr>
<tr>
<td>Diversity</td>
<td>F</td>
<td>B</td>
</tr>
</tbody>
</table>

### Demand Matching

<table>
<thead>
<tr>
<th>Now</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

### Network Limitations

<table>
<thead>
<tr>
<th>Network Capacity (MW)</th>
<th>Existing</th>
<th>Upgraded</th>
<th>Network Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,000</td>
<td></td>
<td>-</td>
<td>The existing network is strong and around 3,000 MW of new generation could be connected without requiring major upgrades. The MLFs are robust compared to the other Queensland REZs, because this REZ is located near the 330 kV interconnector to New South Wales and the South East Queensland load centre. Long-term modelling identified retirement of 1,400 MW of coal-fired generation in the SWQ zone from 2037. This would enable additional solar generation to connect in Darling Downs REZ within the existing transmission capacity.</td>
</tr>
</tbody>
</table>

### Long-Term Market Simulation Scenarios

<table>
<thead>
<tr>
<th>Generation Built (MW)</th>
<th>Neutral</th>
<th>Neutral with Storage</th>
<th>Slow</th>
<th>Fast</th>
<th>High DER</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,400</td>
<td>3,400</td>
<td>2,700</td>
<td>4,700</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Timing</td>
<td>&gt;2040</td>
<td>&gt;2040</td>
<td>&gt;2040</td>
<td>&gt;2040</td>
<td>&gt;2040</td>
</tr>
</tbody>
</table>
20 year integrated development plan

GROUP 1

Near-term construction to maximise the economic use of existing resources
As soon as practicable

IMMEDIATE DRIVERS:
- Support east of VRET and GRET
- Improve reliability to NSW below invaded FS retirement

GROUP 2

Developments in the medium term to enhance trade between regions, provide access to storage, and support extensive development of REZs
To mid-2020s (indicative)

DRIVERS TO MID-2020s:
- Continuing VRET and GRET
- System security in SA
- Firming supply
- Improve wholesale market competition in SA, reducing fuel costs

GROUP 3

Longer-term developments to support REZs and system reliability and security
To 2040 (indicative)

DRIVERS TO 2040:
- Firming and energy storage required as renewable generation continues to connect
- Increased need for transfer VIC-NSW
- Gladesville PS reaches end of technical life in QLD
- Coal-fired generation reaches end of technical life in VIC and NSW

- Increasing renewables
- Minor transmission augmentation in QLD
- SnowyLink (VIC-NSW)

Base plan with storage initiatives
Near-term construction

Maximise economic use of existing resources
Group 2

Developments in the medium term
Enhance trade between regions, provide access to storage, and support extensive development of REZs
Group 3

Longer-term developments

Support REZs and system reliability and security
Economic assessment - Neutral

Present value of market benefits for Base development plan (Neutral)
## Early coal exit

<table>
<thead>
<tr>
<th>New South Wales coal power station closure</th>
<th>Interconnector upgrades</th>
<th>NSW</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Plan</td>
<td>Medium</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
<tr>
<td>Base Plan with SnowyLink</td>
<td>Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
<tr>
<td>Base Plan with Snowy 2.0 and SnowyLink</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Victorian coal power station closure</th>
<th>Interconnector upgrades</th>
<th>NSW</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Plan</td>
<td>Very Low</td>
<td>Very Low</td>
<td>High</td>
<td>Very Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Base Plan with SnowyLink</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Medium</td>
<td>Very Low</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Base Plan with Snowy 2.0 and SnowyLink</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

---

**Risk Levels:**
- **High**
- **Very Low**
- **Medium**

---

**Interconnector Upgrades:**
- NSW: New South Wales
- QLD: Queensland
- SA: South Australia
- TAS: Tasmania
- VIC: Victoria
Reliability outlook

Average Unserved Energy (%)

- NSW
- SA
- VIC
- Base Case
- ISP
- Reliability Standard

2018-19 to 2027-28
ISP Published

Published during project:
• Consultation Paper
• Consultation submissions & summary
• Assumptions workbook

Published in July 2018:
• ISP report with Appendices
• Methodology
• Input data and results
• Interactive map
Status Update on IGP Working Groups

**SCWG – Model GSPA filed on March 29, 2019 for Commission approval.**

**CPWG Meeting 2 – April 16, 2019:**
CPWG Scope, Deep Dive on Current Procurement Processes, examine examples of other utility competitive procurement processes; identify any “best practices” trends and learning

**Upcoming CPWG Meeting 3 – June 25, 2019 morning:**
Examine and discuss relevant feedback and learnings from other Working Groups; Deeper discussion of Competitive Bidding Framework

**Upcoming SEOWG Meeting 1 – May 9:**
Kick-off Meeting & Overview of IGP, SEOWG challenges and key issues, prioritization of topics
Status Update on IGP Working Groups

**Upcoming FAWG Meeting 2, 3 – May 22-23, 2019:**
Panel discussion on DER, EoT, energy efficiency and demand response to support the development of assumptions

**Upcoming Resilience WG Meeting 1 – end of May/early June:**
Kick-off Meeting, working group purpose and composition, overall schedule

**DPWG Meeting 3 – April 25, 2019 morning:** Joint with GSWG regarding Soft Launch
Presentation of NWA analysis and the opportunity that will be made available through the soft launch RFP

**Upcoming DPWG Meeting 4 – May 30, 2019:** Joint with GSWG regarding Soft Launch
Review of the soft launch RFP with stakeholders
Next Steps

◆ Next meeting – August 21, 2019

◆ Follow-up questions ...
  • Email: IGP@hawaiianelectric.com
  • Colton Ching @ 543-7986 or Lisa Giang @ 543-7982
Mahalo!