MEMORANDUM

TO: Power Committee
FROM: Gillian Charles
SUBJECT: Natural Gas Reference Plants for draft 2021 Power Plan

BACKGROUND:

Presenter: Gillian Charles

Summary: As part of the development of inputs for the draft 2021 Power Plan, staff develops generating resource reference plants as resource options – along with energy efficiency and demand response – for the Council’s power system models to select to fulfill future resource needs. A generating resource reference plant is a collection of characteristics that describe a realistic and likely implementation of a given technology within the region. It includes estimates of costs, operating and performance specifications, and developmental potential.

Staff presents reference plants for review and discussion with the Generating Resources Advisory Committee (GRAC) and incorporates feedback before bringing the reference plant to the Council for review.

At the February Council Meeting, staff will present the reference plants for natural gas technologies.

Relevance: Development of inputs for the 2021 Power Plan

Workplan: A.4.1 Develop generating resource reference plants for 2021 Power Plan
Natural Gas Reference Plants for the 2021 Plan
February 11, 2020 -- Power Committee
Gillian Charles

Today’s Agenda

• Proposed draft 2021 Power Plan reference plants for natural gas technologies
• Proposed draft 2021 Power Plan reference plant for conventional geothermal

❖ Today’s presentations wrap up series of presentations to the Power Committee on the generating resource reference plants for the draft 2021 Power Plan
Power Committee Meetings

- **May 2019**: Development of generating resource reference plant
- **July 2019**: Proposed categorization of generating resources for 2021 Plan
- **October 2019**: Reference Plant: Solar PV, Reference Plant: Battery Storage
- **November 2019**: Reference Plant: On-shore Wind
- **December 2019**: Reference Plant: Pumped Storage
- **February 2020**: Reference Plant(s): Natural Gas, Reference Plant: Conventional Geothermal

Note: The work products that staff presented to the Power Committee have all been vetted with the Generating Resources Advisory Committee (GRAC).

Lay of the Land
Resource Additions and Retirements

New gas and wind dominate resource additions pre-Seventh Power Plan
- West Coast Energy Crisis
- RPS enacted in 2005-2007
- Tax credits

On average, coal generation has been declining while natural gas generation has been increasing

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CO₂ Emissions (lbs CO₂/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>205 - 228</td>
</tr>
<tr>
<td>Petroleum/Oil</td>
<td>161</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>117</td>
</tr>
</tbody>
</table>

Data source: Council’s project database
Natural Gas Plants in Operation and Planned

- ~48,000 MW new installed capacity across the US over the past four years
- Mostly CCCT, 53 plants (~160 units)

- ~2,400 MW new installed capacity in the WECC over the past four years
- Primarily gas peakers – LMS100 units in CA and AZ

Data source: S&P project database
• Through 2027, about 80,000 MW planned* new installed capacity across the US
  * Planned does not mean confirmed; view w/ grain of salt!

• Of the 80,000 MW planned in US, only ~8,000 MW in the WECC

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Overall, coal operating in the WECC falls from about ~34GW in 2019, to ~15GW in 2036
Additions and Retirements since the Seventh Power Plan
(incl. announced planned retirements)

Planned retirements based on agreements, announcements, IRPs; subject to change
Idaho Power intends to end its participation in North Valmy 1 in 2019
Uncertainty remains over timing of Jim Bridger 1, 2 potential accelerated retirements
Hardin Generating Station was sold to an out-of-region cryptocurrency company; therefore no longer “counts” towards the region
Colstrip 3, 4 should be considered very tentative

Data source: Council’s project database

Renewable & Clean Energy Standards

29 States + DC have a Renewable Portfolio Standard, 3 states have a Clean Energy Standard
(8 states have renewable portfolio goals, 2 states have clean energy goals)

Image source: DSIREUSA.ORG
Council’s latest electricity forecast - summary of gas builds w/ and w/o limitations

(From Nov 2019 presentation to Council)

Observations:
Huge first year diverse renewable and storage build, followed by consistent investment in clean energy sources with some gas

Observations:
Huge first year gas build, followed by consistent investment in gas, lower renewable build

Technology & Cost Trends
Nationwide Gas vs. Coal

U.S. natural gas-fired combined-cycle capacity surpasses coal-fired capacity

- In terms of installed capacity, gas surpassed coal in April 2018
- Also in 2018, gas generation overtook coal generation for the first time (on an annual average) – although this first occurred monthly in 2015

Technology Trends: Performance and Efficiency

- Net output (performance) has been increasing and heat rate has been declining (meaning efficiency is improving) - both within class and among classes
- Leads to significant capital cost ($/kW) improvements
Market & Cost Perspectives

• In general, 2019 cost estimates declined from slight increase in 2018
  • Continued low natural gas prices
  • Less demand for gas turbines as demand increases for renewable energy and storage... therefore manufacturers are competing for fewer bids
    • Leads to lower contracts, smaller profit margins
    • Caused surplus supply, leading to several major manufacturers to strategic corrective measures like temporary/permanent closures of factories
• Manufacturers chasing greater performance, efficiency, and importantly to the region/WECC, greater flexibility

Proposed 2021 Plan Reference Plants
Gas Peaker(s), CCCT, recip
## 2021 Plan Reference Plants: Natural Gas

<table>
<thead>
<tr>
<th>Configuration &amp; Technology</th>
<th>Gas Frame Combustion Turbine</th>
<th>Gas Combined Cycle Combustion Turbine</th>
<th>Gas Reciprocating Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) General Electric 7HA.02 Frame</td>
<td>1x1 General Electric 7HA.02 Frame, Dry-cooling, Single Fuel</td>
<td>12x 18V50SG Wartsila gensets</td>
<td></td>
</tr>
<tr>
<td>Capacity (MW)</td>
<td>380 MW (ISO)</td>
<td>573 MW (ISO)</td>
<td>220 MW (ISO)</td>
</tr>
<tr>
<td>Heat Rate HHV (Btu/kWh)</td>
<td>8890 (ISO)</td>
<td>5973 (ISO)</td>
<td>8176 (ISO)</td>
</tr>
<tr>
<td>Location</td>
<td>East side</td>
<td>East-side</td>
<td>East side</td>
</tr>
<tr>
<td>Financial Sponsor</td>
<td>IOU</td>
<td>IOU</td>
<td>IOU</td>
</tr>
<tr>
<td>Economic Life (years)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Overnight Capital Cost ($/kW)</td>
<td>$550</td>
<td>$1,150</td>
<td>$1250</td>
</tr>
<tr>
<td>Fixed O&amp;M Cost ($/kW-yr)</td>
<td>$5.50</td>
<td>$10</td>
<td>$5</td>
</tr>
<tr>
<td>Variable O&amp;M Cost ($/MWh)</td>
<td>$6.50</td>
<td>$3</td>
<td>$5</td>
</tr>
<tr>
<td>Development Time (yrs)</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Construction Time (yrs)</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Earliest Commercial Online Date</td>
<td>2020</td>
<td>2021</td>
<td>2020</td>
</tr>
</tbody>
</table>

### Remaining Considerations

- Determine which gas peaker reference plant(s) to include in the model
  - Qualitative analysis and cost estimates on all technology types will still be completed and included in the technical work of the power plan
- Maximum build-out potential
  - Informed by gas pipeline capacity
  - GRAC meeting on February 27
Developing a Reference Plant

- Categorization of New Resource Options
  - Primary
  - Secondary
  - Long-term

- Develop Reference Plant

- Resource Option(s)

- Environmental Methodology

- Financial Assumptions

- Microfin

- Fuel Price Forecast

- Model Analysis RPM AURORA

Background Slides
Resource Categories

Prioritization based on a resource’s commercial availability, constructability, cost-effectiveness, and quantity of developable resource in the region

Primary; Significant: Resources that look to play a major role in the future PNW power system.
Assessment: In-depth, quantitative characterization to support system integration and risk analysis modeling. Will be modeled in RPM.

Secondary; Commercial w/ Limited Availability: Resources that are fully commercial but that have limited developmental potential in the PNW.
Assessment: Mix of qualitative and some quantitative analysis sufficient for potential modeling in the RPM.

Emerging/Long-term: Resources that have long-term potential in the PNW but that are not commercially available yet.
Assessment: Qualitative discussion of status & regional potential, quantify key numbers as available. Will not be modeled in RPM.

Proposed Generating Resources Categorization for 2021 Plan

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
<th>Emerging/Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>Conv. Geothermal</td>
<td>Enhanced Geothermal Systems</td>
</tr>
<tr>
<td>Onshore Wind</td>
<td>Offshore Wind</td>
<td>Small Modular Reactors</td>
</tr>
<tr>
<td>Gas CCCT</td>
<td>Distributed Generation*</td>
<td>Carbon Capture &amp; Sequestration</td>
</tr>
<tr>
<td>Gas SCCT - Frame</td>
<td>Biomass</td>
<td></td>
</tr>
<tr>
<td>Battery storage (Li-ion)</td>
<td>Hydro Upgrades</td>
<td>Hydrogen Gas Turbine</td>
</tr>
<tr>
<td>Solar + Storage</td>
<td>Biogas</td>
<td>Allam Cycle Gas</td>
</tr>
<tr>
<td>Pumped Storage</td>
<td>Power-to-Gas</td>
<td>Wave, Tidal</td>
</tr>
<tr>
<td>Reciprocating Engine</td>
<td>Small Hydro</td>
<td></td>
</tr>
<tr>
<td>Gas SCCT - Aeroderivative</td>
<td>Combined Heat and Power</td>
<td></td>
</tr>
</tbody>
</table>

* DG will also be included in the load forecast
Omitted: Advanced nuclear, coal, large hydro, CAES
Focus on “H/J” class...

Overnight Cost of Natural Gas Frame CT - “H/J” Class - 2016$/kW

Overnight Cost of Natural Gas CCCT “H/J” Class - 2016$/kW