Integrated Grid Planning

Joint Competitive Procurement and Solution Evaluation & Optimization Working Group Meeting

December 9, 2019
Agenda

♦ Welcome & Introductions
  ♦ WG Ground Rules
    ♦ Objectives for today’s meeting
♦ Review latest draft of the proposed IGP Solution Sourcing process
♦ Discuss decomposition of Capacity, Energy & AS Needs process step
♦ Review of RESOLVE and PLEXOS
♦ Discuss CEAS needs sensitivities
♦ Provide updates on CPWG & SEOWG process description outlines
♦ Next Steps
Ground Rules

♦ Chatham House Rule will apply – no personal or organizational attribution will be made to any comments/feedback provided during the meeting by any participant nor in written documentation.

♦ Working group meetings, and other information exchanges are intended solely to provide an open forum or means for the expression of various points of view in compliance with antitrust laws.

♦ Under no circumstances shall engagement activities be used as a means for competing companies to reach any understanding, expressed or implied, which tends to restrict competition, or in any way, to impair the ability of participating organizations to exercise independent business judgment regarding matters affecting competition or regulatory positions.

♦ Proprietary information shall not be disclosed by any participant during any industry engagement meeting or information exchange. In addition, no information of a secret or proprietary nature shall be made available to industry engagement participants.

♦ All proprietary information which may nonetheless be publicly disclosed by any participant during any industry engagement meeting or information exchange shall be deemed to have been disclosed on a non-confidential basis, without any restrictions on use by anyone, except that no valid copyright or patent right shall be deemed to have been waived by such disclosure.
Objectives for Today’s Meeting

♦ Clarify and agree on next steps regarding feedback received from stakeholders on:
  ♦ CEAS needs analysis
  ♦ Forecast scenarios v. RESOLVE sensitivity tests
  ♦ Linkages to & potential dependencies on developments in other dockets (i.e. ARDS, DER)

♦ Clarify and receive feedback on updated IGP Solution Process

♦ Develop deeper understanding of proposed CEAS needs methodology and use of modeling tools

♦ Clarify SEOWG & CPWG Deliverables, schedule and dependencies within IGP
Thank you for the feedback

We will talk about the specific suggestions later today

- Some clarifications
- Group discussion and shared understanding of proposed use cases

We are working with FAWG & DPWG to consider and develop an approach which will:

- Develop a small set of appropriate scenarios (e.g. DER adoption, electrification, etc.)
- Identify best step in the process (e.g. forecasting, needs assessment) to run scenarios
- Use of scenarios and sensitivities (forecasting and RESOLVE/PLEXOS)

Proposed scenario and analysis approach will be the main topic for January SEOWG meeting
Capacity, Energy & AS Needs Process

1. Assess Tx needs for REZ

Inputs, Assumptions, Annual Forecast

Sales, Resource Cost, and Fuel Forecast

Capacity, Energy & AS Needs

- Resource Optimization
  - Energy
  - Load Reduction
  - Load Build
  - Fast Frequency Response
  - Regulating Reserve (1-min & 20-min)
  - T&D Deferral
  - RPS

Portfolio Verification

Yes

RESOLVE Modeling

PLEXOS Modeling

Portfolio Shortfalls?

No

System Security

1. Assess Distribution System (Normal and Contingency Analysis) for Load Growth and DER (PV/ESS, EV, EE)

RESOLVE Sensitivity

***

RESOLVE Sensitivity

***

RESOLVE Sensitivity

Completed RESOLVE runs to any portfolio

Draft Capacity, Energy & AS RFP
Inputs for Solution Evaluation Process

1. Major & minor transmission upgrades
   ♦ Identify the locational value of siting different resources on each island (i.e., reliably harnessing high renewable energy areas)

2. Timing of CEAS Needs aligned with long-term planning targets
   ♦ As discussed in previous SEOWG meeting, CEAS Needs are developed based on planning criteria subject to load forecasts, unit operating characteristics, and resource potentials
   ♦ HECO will use RESOLVE & PLEXOS to (1) identify CEAS Needs timing and (2) perform subsequent solution evaluation
RESOLVE/PLEXOS Model Comparison

Overview
Review of RESOLVE & PLEXOS

RESOLVE
Proactive Capacity Expansion Model

+ What resources can we select that result in a least-cost portfolio to meet long-term planning goals?

PLEXOS
Detailed Production Simulation Model

+ What is the least-cost operational dispatch of a resource portfolio on an hourly basis?

<table>
<thead>
<tr>
<th>Total Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>7000</td>
</tr>
</tbody>
</table>

- Storage MW
- Onshore Wind MW
- Offshore Wind MW
- Grid Solar MW
- DGPV MW
- Hydro MW
- Geothermal MW
- Biomass MW
- Biodiesel MW
- Refuse MW
- ULSD MW
- Diesel MW
- LSFO MW
- MSFO MW
- Naphtha MW
- Coal MW

Day-Ahead Schedule

Real-Time Dispatch
RESOLVE Day Sampling
Estimating Annual Operating Costs in Capacity Expansion Planning Context

♦ PLEXOS simulates every hour in its production cost simulation
♦ RESOLVE uses a statistical sampling to downscale annual data to ~40 representative days

RESOLVE representative dispatch days are downsampled and weighted based on historical data to accurately estimate operational costs under most conditions.
Using Scenario Analysis with RESOLVE
Comparing Different Policy Pathways on Cost & GHG Emissions Reductions

Reductions Needed to Meet 80% Goal

2050 Annual Cost Increase ($ millions)

0 5 10 15 20 25
Reduction in 2050 Greenhouse Gas Emissions (million metric tons)

Reference Case
Regional 30% RPS
Regional 40% RPS
Regional 50% RPS
No New Gas
40% Reduction
60% Reduction
80% Reduction
Gov Tax
Leg Tax

E3 Pacific Northwest Low Carbon Scenario Analysis
Modeling Inputs

Overview
## PLEXOS Generator Inputs

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum and Maximum Power Output</td>
<td>Minimum operating capacity of a resource. Maximum rated capacity of a resource unit.</td>
<td>MW</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>Fuel efficiency</td>
<td>MMBtu/MWh</td>
</tr>
<tr>
<td>Rating Factor</td>
<td>Percentage of a unit’s rated output, ranges 0 – 100%</td>
<td>%</td>
</tr>
<tr>
<td>Ramp Rate</td>
<td>Flexibility of a resource to increase or decrease its power output over time</td>
<td>MW/minute</td>
</tr>
<tr>
<td>Minimum Up/Downtime</td>
<td>Required on/off time for a unit</td>
<td>Hours</td>
</tr>
<tr>
<td>Start Cost</td>
<td>Cost to start a unit</td>
<td>$</td>
</tr>
<tr>
<td>Start Cost Time</td>
<td>Used in combination with Start Cost to define cooling states of a unit</td>
<td>Hours</td>
</tr>
</tbody>
</table>
### PLEXOS Generator Inputs Continued

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Outage Rate (MOR)</td>
<td>Scheduled outage for unit maintenance</td>
<td>%</td>
</tr>
<tr>
<td>Forced Outage Rate (FOR)</td>
<td>Unexpected or unplanned outages, resulting in partial or complete loss of generating capacity for a period of time</td>
<td>%</td>
</tr>
<tr>
<td>Operational Costs (Variable/Fixed/Running)</td>
<td>Costs associated with operating the generator units</td>
<td>$</td>
</tr>
<tr>
<td>Regulation Up/Down</td>
<td>How much up/down spin needs to be provided by generator spare capacity</td>
<td>MW</td>
</tr>
</tbody>
</table>
# RESOLVE Generator Inputs

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Build</td>
<td>Maximum capacity of existing generators and capacity targets for new, renewable generators</td>
<td>MW</td>
</tr>
<tr>
<td>Resource Cost</td>
<td>Cost of existing resources and the current market value of new renewable resources</td>
<td>$/kW-year</td>
</tr>
<tr>
<td>Physical Zone</td>
<td>Where the Resource is located (e.g. island, etc.)</td>
<td>N/A</td>
</tr>
<tr>
<td>RPS Eligible</td>
<td>Does the unit contribute to RPS?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Unit Retirement</td>
<td>Can the unit be retired?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Reserves</td>
<td>Does the unit contribute to spinning, regulation or load following reserves?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>Ability to provide Total or Partial Frequency Response</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>
### PLEXOS Generator Operating Constraints

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Hours</td>
<td>Time when a unit can/cannot operate</td>
<td>Hours</td>
</tr>
<tr>
<td>Must-run</td>
<td>Indicator for when a unit must operate</td>
<td>N/A</td>
</tr>
<tr>
<td>Curtailment Order</td>
<td>Priority order for unit curtailment</td>
<td>N/A</td>
</tr>
<tr>
<td>Capacity/Energy Factor Limit</td>
<td>Maximum capacity and energy a unit may be dispatched up to</td>
<td>MW and MWh, respectively</td>
</tr>
</tbody>
</table>

### RESOLVE Generator Operating Constraints

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtailment</td>
<td>Is the resource curtailable?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Hourly Pmax</td>
<td>Limits the operational capacity of a unit that may be on a maintenance outage, or may operate at a percentage of max capacity</td>
<td>%/hour</td>
</tr>
</tbody>
</table>
# PLEXOS Energy Storage Inputs

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Power</td>
<td>Rated maximum power of a unit</td>
<td>MW</td>
</tr>
<tr>
<td>Max Capacity</td>
<td>Rated maximum energy output (duration)</td>
<td>MWh</td>
</tr>
<tr>
<td>Charge/Discharge Efficiency</td>
<td>Start and end charges of a battery for one cycle (roundtrip efficiency)</td>
<td>%</td>
</tr>
<tr>
<td>Capacity/Energy Factor Limit</td>
<td>Maximum capacity and energy a unit may be dispatched up to</td>
<td>MW and MWh, respectively</td>
</tr>
<tr>
<td>O&amp;M Cost</td>
<td>Battery operational and maintenance costs</td>
<td>$</td>
</tr>
</tbody>
</table>
# RESOLVE Energy Storage Inputs

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Build</td>
<td>Maximum capacity and energy of existing storage and capacity targets for new storage</td>
<td>MW and MWh</td>
</tr>
<tr>
<td>Resource Cost</td>
<td>Cost of existing storage units and the current market value of new energy storage</td>
<td>$/kWh-year</td>
</tr>
<tr>
<td>Paired Resource</td>
<td>Can the storage be paired to a renewable generator?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Reserves</td>
<td>Does the storage contribute to spinning, regulation or load following reserves?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>Ability to provide Total or Partial Frequency Response</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Pairing</td>
<td>Ties a battery to a generator</td>
<td>-</td>
</tr>
<tr>
<td>Max Cycles/Time</td>
<td>Limits the number of cycles over time (e.g., once a day, once a day for every day of the year, etc.)</td>
<td># of cycles/time</td>
</tr>
<tr>
<td>Operating Hours</td>
<td>How many hours the battery is allowed to run</td>
<td>hours</td>
</tr>
<tr>
<td>Degradation</td>
<td>Percentage of capacity degradation per cycle</td>
<td>%</td>
</tr>
<tr>
<td>Min/Max State of Charge</td>
<td>Define the minimum and maximum charge within a battery at any given time</td>
<td>%</td>
</tr>
</tbody>
</table>
Fuel

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Non-renewable, renewable, and blended fuel types</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>Fuel price by forecast</td>
<td>$/barrel</td>
</tr>
</tbody>
</table>

**Constraints**

Able to use various coefficients to do different things with the fuel including:

- Limiting how much MMBTU of a certain fuel a unit uses.
- Use a different fuel under designated conditions
### Sales

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Load of the Node/System</td>
<td>MW</td>
</tr>
<tr>
<td>DER</td>
<td>DER modeled as a generating unit</td>
<td>Generating Unit</td>
</tr>
</tbody>
</table>

EXAMPLE:

A 50 MW DER program would have:

- Max Capacity: 50 MW
- Rating: A profile in the form a .csv file
- Mark-up: -X $/MWh (Negative mark-up to make it taken earlier. Will not affect actual cost)
- Reserves: X MW (How much of this resource can contribute to reserves)
Model Outputs
Overview
PLEXOS Outputs

**Generators**
- Most model inputs
  - i.e. Unit Capacity (MW)
- Generation (MW or MWh)
- Units Shutdown
- Fuel Offtake (MMBTU)
- Start Fuel Offtake (MMBTU)
- Hours curtailed (h)
- Capacity Curtailed (MW)
- Curtailment Factor (%)
- Marginal Fuel Cost

**Battery**
- Energy (MWh)
- State of Charge (%)
- Generation (MW)
- Load (MW)
- Losses (MW)
- Hours Charging/Discharging/Idle (h)
- Hours Idle
- Age (cycles)
- Many more
RESOLVE Outputs

♦ Portfolio
  ♦ Resource Quantity
  ♦ Resource Timing
  ♦ Costs
  ♦ Comparison of other portfolios
Solution Evaluation Methodology

Overview
## Grid Service Definitions

<table>
<thead>
<tr>
<th>Grid Service</th>
<th>Description</th>
<th>Represented in Evaluation Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>A continuous, controllable, and predictable supply of megawatt-hours to serve system load needs in response to an AGC signal</td>
<td>✓</td>
</tr>
<tr>
<td>Load Reduction</td>
<td>Capacity that can be provided by a generator, storage or controlled load to reduce system load in the required timeframes and durations in response to an AGC signal.</td>
<td>✓</td>
</tr>
<tr>
<td>Load Build</td>
<td>Capacity that can be provided by storage or controlled load to increase system load in the required timeframes and durations in response to an AGC signal.</td>
<td>✓</td>
</tr>
<tr>
<td>Fast Frequency Response FFR1</td>
<td>An autonomous and predictable capacity to limit the frequency drop resulting from a frequency disturbance.</td>
<td>◇</td>
</tr>
<tr>
<td>Regulating Reserve</td>
<td>A reserve capacity provided by generating and load resources to allow continuous energy balance over the next 1 minute and 20 to 30 minute time interval due to the variability in renewable resources and load that can be called upon in response to an AGC signal.</td>
<td>✓</td>
</tr>
<tr>
<td>Distribution Capacity</td>
<td>A supply and/or a load modifying service that DERs provide as required via the dispatch of power output for generators and electric storage, and/or reduction in load that is capable of reliably and consistently reducing net loading on desired distribution infrastructure.</td>
<td>◇</td>
</tr>
<tr>
<td>Distribution Reliability</td>
<td>A load modifying or supply service capable of improving local distribution reliability under abnormal conditions.</td>
<td>◇</td>
</tr>
</tbody>
</table>
Grid Service Definitions

- Needs are defined as constraints in evaluation models based on planning criteria
- Constraint shadow prices estimate the value of each service based on available, least-cost resources on the system

<table>
<thead>
<tr>
<th>Grid Service</th>
<th>Needs Calculation Methodology</th>
<th>Represented in Evaluation Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPS</td>
<td>% of annual retail sales forecast</td>
<td>✓</td>
</tr>
<tr>
<td>Transmission Deferral</td>
<td>Major and minor transmission upgrade thresholds &amp; levelized costs</td>
<td>◐</td>
</tr>
</tbody>
</table>
Solution Evaluation Methodology

♦ Two options for solution evaluation:

1. Using **discounted cash-flow** allows us to estimate the value of each option individually without rerunning RESOLVE & PLEXOS
   - Assuming each resource is a price-taker in the future, we can use constraint shadow prices from CEAS Needs cases
   - Price-taker approach allows us to **quickly rank and screen options** individually

2. We can rerun evaluation models to select **optimal resource portfolios** for 5-Year Action Plan
   - Assume each option is a price-taker on CEAS Needs constraint shadow prices as an estimate of discounted value of option to overall system in the future
   - Captures the **interactive effects** of adding new resources to the system, such as on transmission constraints and curtailment
Calculating Value of Services Provided

- Constraint shadow prices are an estimate of the value of each service.
- Resources generation profiles can be provided by each specific option and multiplied against constraint shadow prices to estimate value of services provided.

Example of Value Streams for a Storage Resource

Example of Value Streams for a PV Resource
Hourly value streams can be aggregated to annual and NPV values for each resource.
Solution Evaluation: Producing Optimal Portfolios

Key differences from CEAS Needs RESOLVE runs:

- Shorter time horizon but with higher (annual) granularity
- Remove generic resources (select only real options)
- Select resources based on full size of option to meet portfolio requirements
  - Alternatively, rank options based on total value to system doing in/out cases

Long-term CEAS Needs RESOLVE cases run in 5-year increments to reach 2045 policy goals

Solution Evaluation RESOLVE cases select resources for current 5-Year Action Plan.
Out-year value estimated based on generic system values from CEAS Needs cases.
Solution Evaluation Methodology Outputs

♦ Outputs can include:

♦ Ranking of options based on long-term CEAS Needs values
♦ Estimated annual and NPV value of services (e.g., energy, AS) provided by each option
♦ Updated CEAS Needs values based on least-cost portfolio of options
♦ Potential T&D upgrades or deferred T&D upgrades
Stakeholder Feedback
Stakeholder Feedback
Pre-RESOLVE Sensitivities

♦ Legacy NEM self consumption load shift
♦ Transmission and distribution constrained
  ♦ No new substations, poles or wires except line extensions
♦ EV low load factor
  ♦ Customers primarily self supply charge with onsite batteries
♦ EV optimized high load factor
♦ High Grid Defection
♦ Grid charge load shift need for extended periods of low wind and solar
Stakeholder Feedback
RESOLVE Sensitivities

♦ Transmission constrained (land only)

♦ Load shift bring your own device
  ♦ Dispatchable and passive capacity services for excess energy, ramping, peaking time domains with consideration for distribution domain services/needs when/where applicable

♦ DGPV excess energy capacity dispatch
  ♦ Renewable curtailment order based on resource cost if not being dispatched for capacity services

♦ Frequency responsive load bank
Competitive Procurement Working Group

- Evolution of IGP CEAS procurement process has changed the needed deliverables from CPWG:
  - Adoption of Independent Observer
  - RFPs will follow more of the “traditional” process
- Competitive Bidding Framework will likely need to be modified to reflect current procurement types and environment – focus for CPWG going forward
- Plans for January CPWG Meeting
  - Provide an updated Framework for Competitive Bidding for review and comment
    - Applicability and flexibility to cover all IGP procurements
      - Generation, Grid Services, Storage, NWAs, Long Term RFPs
    - Align “PUC Review Points” in the current proposed IGP Sourcing Approach with the review process in the CBF
    - Applicability and appropriate use/need of Parallel and Contingency Plans
    - Stakeholder review and feedback
1. Description of the process methodology to be used to identify capacity, energy, ancillary service needs
   - Due 01/15/2020
2. Description of the evaluation methodology for T&D Non-wires RFP
   - Due 2/1/2020
3. Description of the evaluation methodology to be used for system resources RFP
   - Due 3/1/2020
4. Description of the optimization methodology to be used for proposed solutions that may address multiple resource/grid needs
   - Due 6/1/2020
CPWG Deliverables & Schedule

1. Review of Competitive Bidding Framework (CBF) and first draft of proposed modifications
   - January 2020

2. Incorporate stakeholder feedback on CBF and produce second draft
   - February 2020

3. Final draft of proposed modification of CBF
   - March 2020
Next Steps

SEOWG

* Walk through details of the RESOLVE and PLEXOS modeling
  * What planning criteria will be solved for?
  * What constraints will be incorporated into the models?
  * What grid service needs will be identified by the models? How are these services defined?
* What kind of information will be used from the CEAS needs to develop near term and long term RFPs? How specific should the RFPs be?
* Reach agreement on the CEAS needs process step by January 15, 2020

CPWG

* Develop first draft of proposed CBF update for distribution to stakeholders in advance of January work group meeting
Thank You