Hawaiian Electric

Integrated Grid Planning

Solution Evaluation & Optimization Working Group Meeting

June 30, 2020

Meeting Agenda

- Welcome and Ground Rules
- Discussion of Transmission Planning Criteria and Services
- Review Stakeholder Comments on Deliverable
- Next Steps

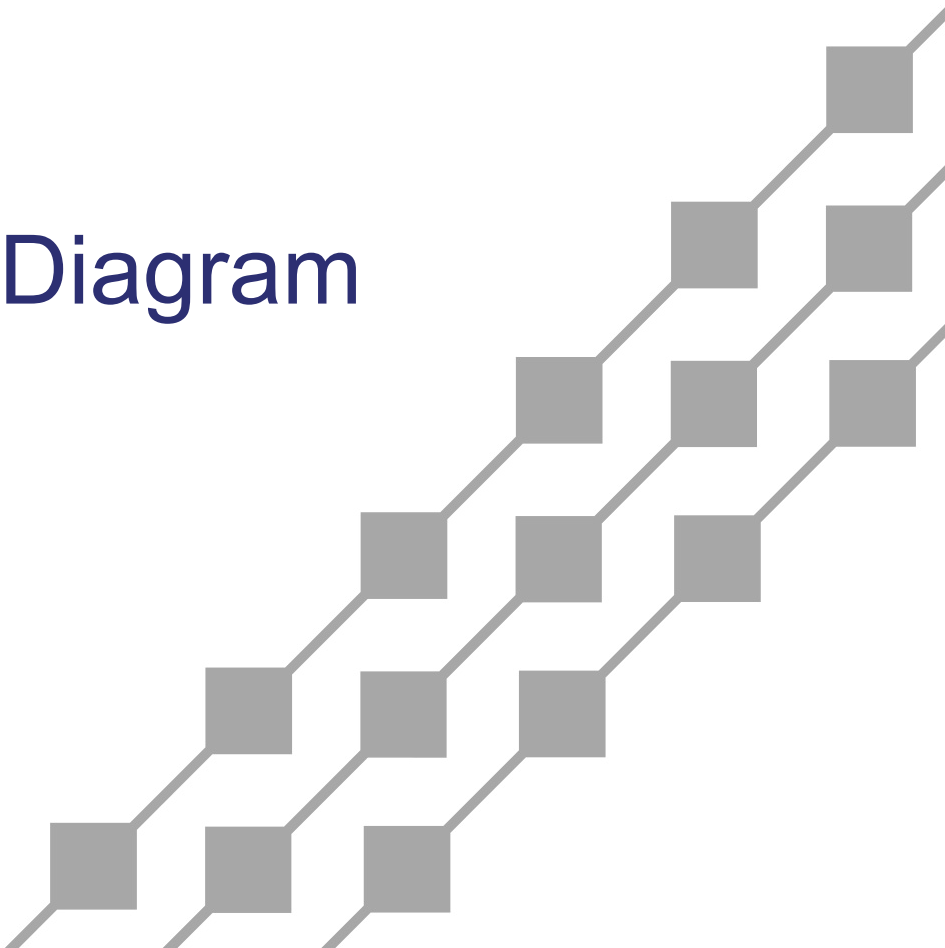
Ground Rules

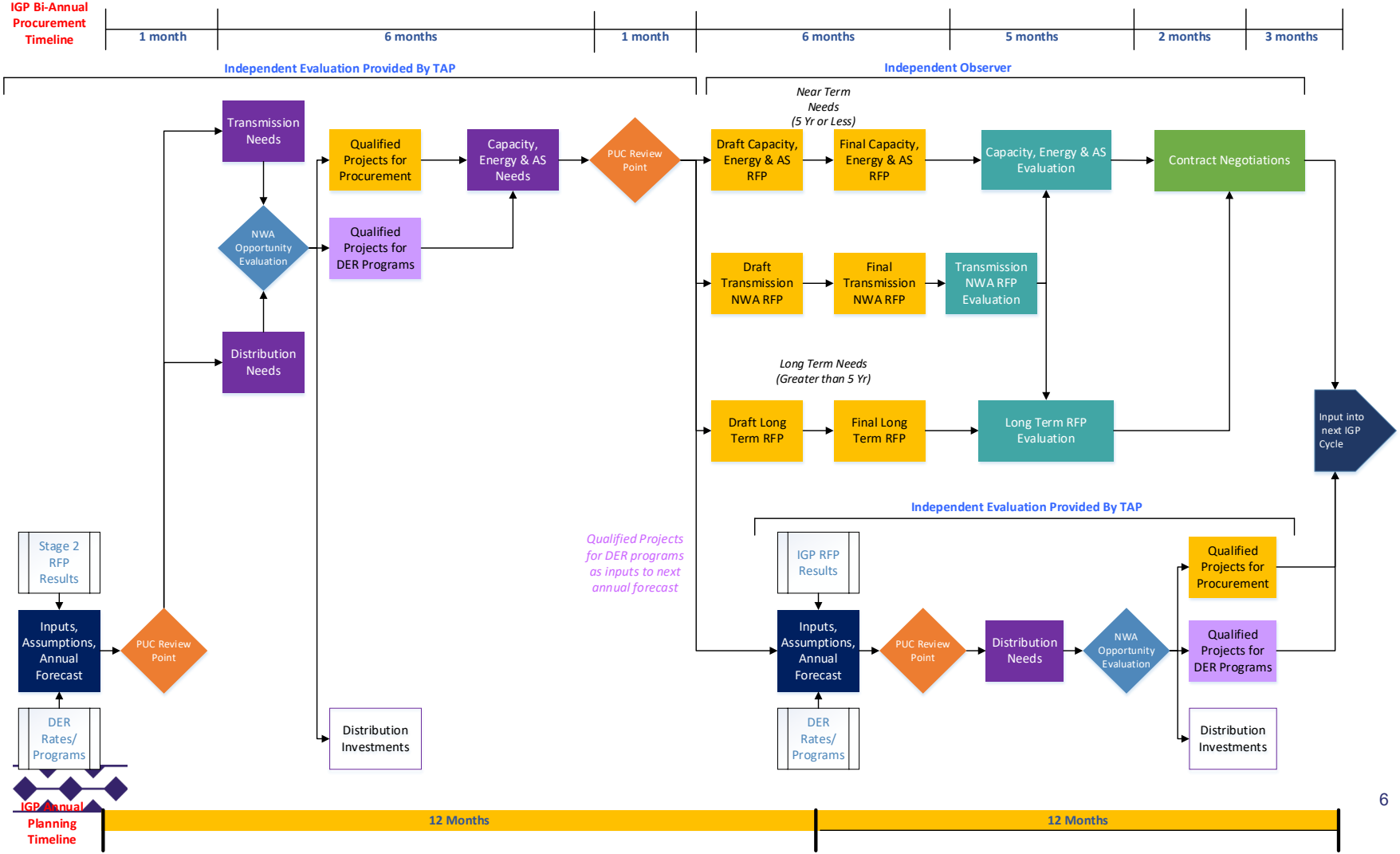
- Chatham House Rule will apply – no personal or organizational attribution will be made to any comments/feedback provided during the meeting by any participant nor in written documentation.
- Working group meetings, and other information exchanges are intended solely to provide an open forum or means 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

- Develop greater shared understanding of the Transmission Planning Criteria and Services
- Clarify comments received on the SEOWG deliverable

Solution Sourcing Diagram

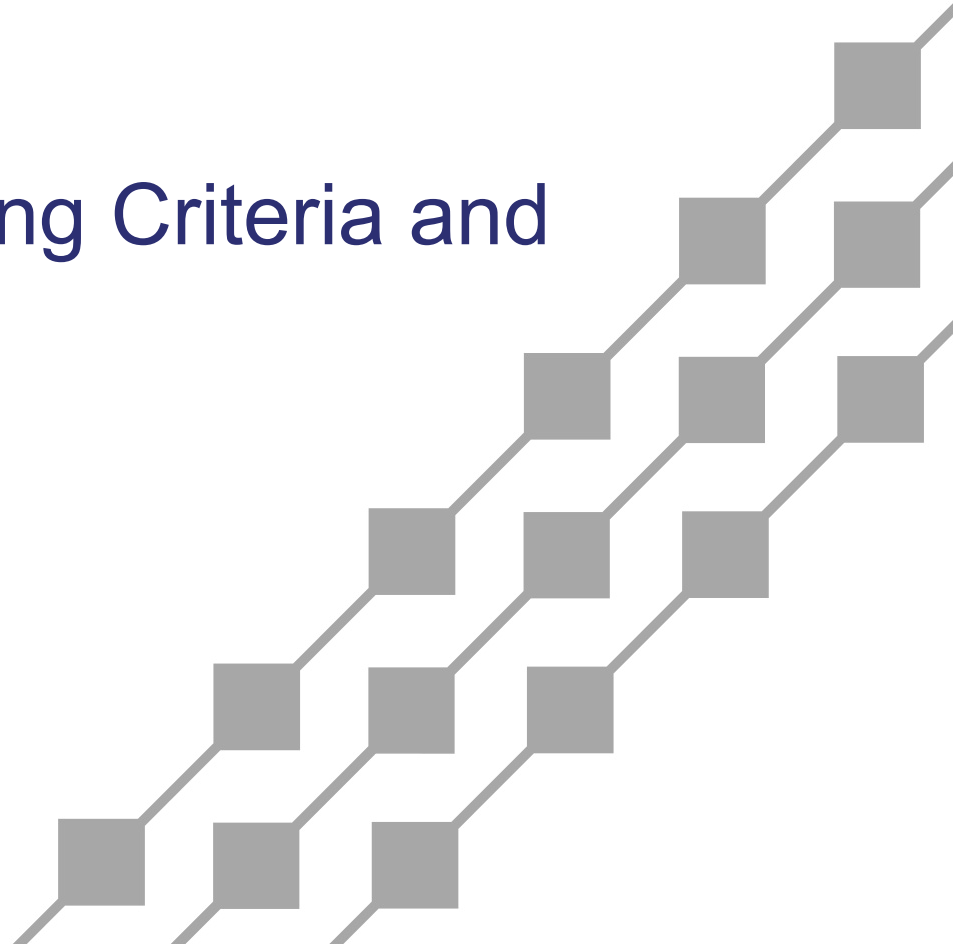



IGP Bi-Annual Procurement Timeline
1 month
6 months
1 month
6 months
5 months
2 months
3 months
Independent Evaluation Provided By TAP
Independent Observer
Transmission Needs
Distribution Needs
NWA Opportunity Evaluation
Qualified Projects for Procurement
Qualified Projects for DER Programs
Capacity, Energy & AS Needs
PUC Review Point
Near Term Needs (5 Yr or Less)
Draft Capacity, Energy & AS RFP
Final Capacity, Energy & AS RFP
Capacity, Energy & AS Evaluation
Contract Negotiations
Draft Transmission NWA RFP
Final Transmission NWA RFP
Transmission NWA RFP Evaluation
Long Term Needs (Greater than 5 Yr)
Draft Long Term RFP
Final Long Term RFP
Long Term RFP Evaluation
Input into next IGP Cycle
Stage 2 RFP Results
Inputs, Assumptions, Annual Forecast
PUC Review Point
DER Rates/ Programs
Distribution Investments
Qualified Projects for DER programs as inputs to next annual forecast
Independent Evaluation Provided By TAP
IGP RFP Results
Inputs, Assumptions, Annual Forecast
PUC Review Point
Distribution Needs
NWA Opportunity Evaluation
DER Rates/ Programs
Qualified Projects for Procurement
Qualified Projects for DER Programs
Distribution Investments
IGP Annual Planning Timeline
12 Months
12 Months

Role of Stakeholders

- SEOWG to close after the WG deliverable is final
- TAP will have oversight of the Grid Needs Assessment in the first year and Distribution Needs in the second year of the IGP cycle
  - TAP to periodically report out to the Stakeholder Council
  - Review Point material will be previewed before the Stakeholder Council prior to filing
- IO will have oversight of the RFP and contract negotiations

Transmission Planning Criteria and Transmission Needs



Overview of the Transmission Planning Criteria

- Primary objectives is to maintain reliable Transmission System operation (i.e., continuity of service) including the following:
  - Ensure public safety.
  - Maintain system stability under a wide range of operating conditions
  - Maintain equipment operating limits under a wide range of operating conditions
  - Minimize losses where cost effective.
  - Preserve the reliability of the existing transmission infrastructure.
  - Maintain an acceptable level of impact to customers for defined contingencies and events
  - Prevent cascading outages or system failure following credible contingencies and events.

Transmission Planning – Analyses Overview

Steady State Performance

Thermal equipment loading and voltage concerns

- Power flow analysis to ensure equipment thermal limits are honored
- Voltage analysis to identify reactive power requirements
  - Retirement of conventional generating resources removes system voltage support which needs to be replenished
  - Location is important for voltage support as reactive power doesn't travel for long distances

Stability Performance

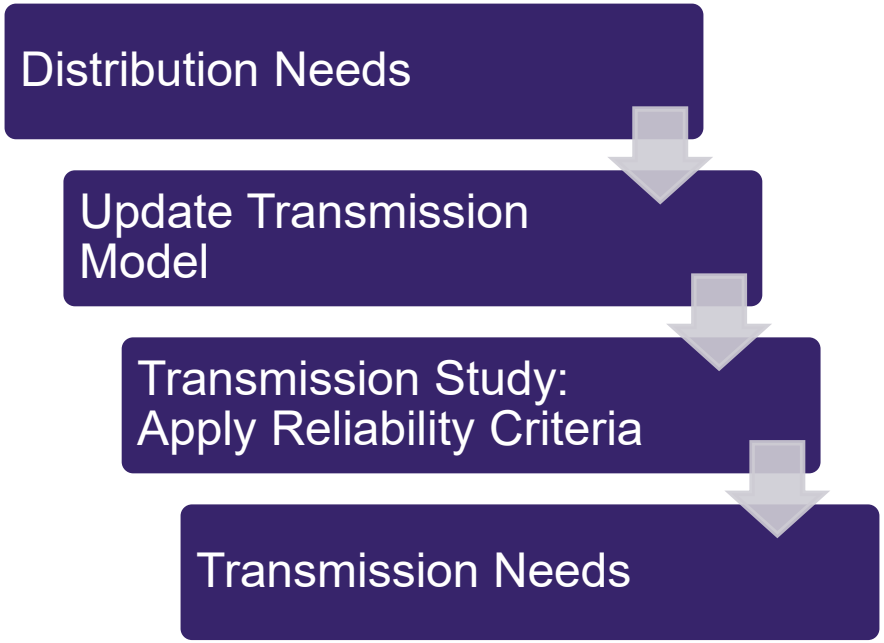
Stability, weak grid and fault clearing time concerns

- Analysis of system to recover and remain stable under faults
- Fault clearing times affect system stability.
  - Longest fault clearing time for stable performance = Critical Clearing Time (CCT)
  - Reduction in clearing time to bring it under CCT could require protection system upgrades and sometimes may need additional measures
- Lower inertia and short circuit current leads to reduction in system strength and causes "weak grid" issues
- Weak grid could cause inverter control instability and oscillatory response

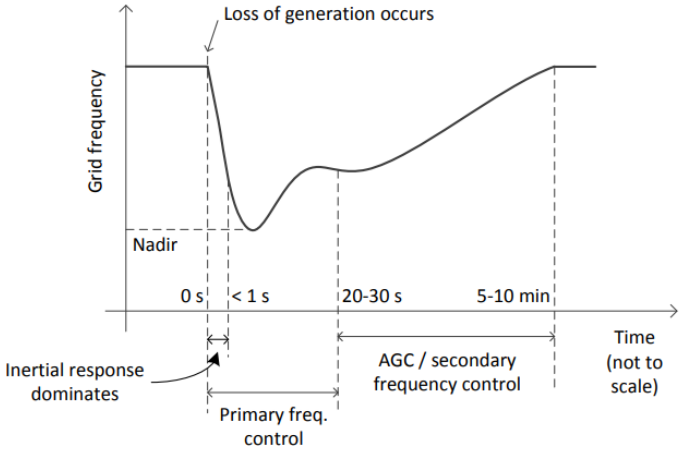
Performance is evaluated for planning events described in the Company planning criteria. Includes single and multiple contingencies as well as maintenance outage conditions

Transmission Needs Evaluation

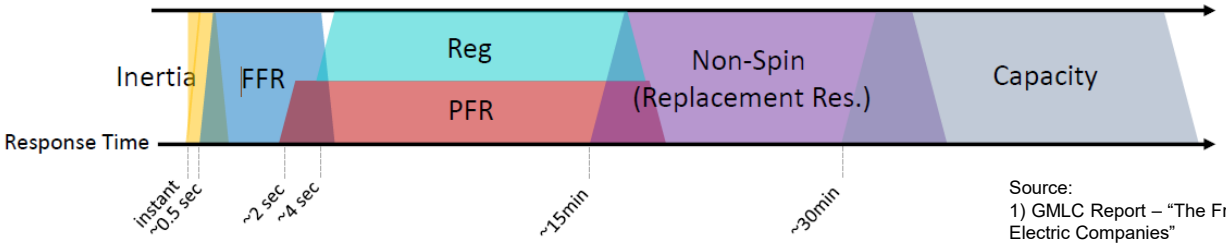
- Distribution Needs are incorporated into transmission models (e.g. load, DG)
- Forward looking transmission studies identify if system can operate in a reliable manner in future (i.e. no criteria violations)
- Any criteria violations lead to system enhancements characterized as “Transmission Needs” in the IGP process



Refresher –Frequency Response (FR)



Inertia, PFR and FFR work together (at different times on the time scale) in an under-frequency event to support system frequency



Source:
1) GMLC Report – "The Frequency-Watt Function Simulation and Testing for the Hawaiian Electric Companies"
2) Telos Energy February 7, 2020 presentation to SEOWG

FR Requirement –Key Considerations

- Minimum Inertia: Buying time for FFR to activate
  - Criteria requires planning for a 3Hz/s change of frequency event
  - Allow 0.5 sec for FFR to activate
  - Plan for largest generation loss contingency
  - Consideration for legacy DG PV trip settings
- FFR and PFR: Both are required to survive largest generation loss contingency with acceptable load loss per the planning criteria
  - Requirement is determined by utilizing production simulation unit dispatches to calculate the available FR and shortfall based on largest generation loss contingency for every hour
  - BESS can provide frequency droop response depending on state of charge and MW headroom (rated MW output less pre-disturbance MW output)

Voltage Support

Key Drivers

- Replacement of conventional generation
- Changes in resource locations
- Long distance power transfer
- System losses

Evaluation

- Contingency analysis
- Voltage stability analysis
- Adherence to the planning criteria

Potential Solutions

- Capacitors
- Dynamic reactive support devices (e.g. SVC, Statcom)
- Synchronous condensers
- Inverter Based Resources with reactive support capabilities

Short Circuit Current

- Two perspectives
  - Measure of grid strength. High SC current indicates stronger grid which is more resilient
  - Adequate short circuit current is required for system protection to operate safely
- Short Circuit Current sources
  - Synchronous generators
  - Synchronous condensers
- Replacing synchronous generators with IBRs causes reduction in fault current
- Issues include longer fault clearing times, degradation in stability performance, reduction in system strengths and other “weak grid” issues

Weak Grid – What is it?

- Qualitative Description:
  - How “stiff” the grid is in response to small perturbations (e.g. change in load demand, switching equipment etc.)
- Quantitative Description:
  - No universally accepted definition exists
  - Typically system specific and requires studies to determine
  - Short Circuit Ratio (SCR) based metrics are used in the industry
    - Provide only an “indication” of grid strength
    - Generally an SCR of 3 or less considered “weak grid”

Weak Grid Issues

- Classical stability limits
  - Large voltage deviations relative to changes in power
- Control instability problems in IBRs
- Interactions between different equipment controls and grid
- Tripping of resources
- Disturbance Ride through failure
- Inverter Phase Lock Loop (PLL) stability issues

Transmission Expansion

- The updated resource potential maps from NREL will assist in developing Renewable Energy Zones (REZ)
- The maps will take into account land availability, protected areas, and other factors
- Concept of REZs will be used as a proxy for potential renewable generation sites
- Company experience with Stage 1 RFP studies and Stage 2 RFP review has shown that the available transmission capacity is depleting fast
- REZ concept will help evaluating transmission expansion needs on in a proactive manner

REZ Evaluation

- Evaluation of REZs will identify transmission expansion needs
  - Potential trunk lines to utilize high potential zones and bring energy from REZs to existing transmission back bone
  - Other major upgrades to the existing infrastructure required to support renewable interconnection
  - Evaluation needs to be performed in accordance with the Company planning criteria
- At this time, REZ evaluation is an exploratory concept to assess and accordingly determine the next step in the process

Grid Needs Assessment and Solution Evaluation

Modeling Objectives

- Quantitative requirements that can be solved for in the modeling analyses
  - RPS, Resource Adequacy, Least Cost
- Factors that can be considered in the non-price evaluation of the RFP
  - GHG Impact, Resilience, Community Impact

- Should other quantitative objectives be considered?
- Is there a means to convert the non-quantitative factors into quantitative requirements?

System Security Iteration

- The system security process step is a check of the initial transmission needs that can be modeled in RESOLVE/PLEXOS as well as other grid needs that cannot be captured in these models
- Small shortfalls passed thru to RFP
  - A representative resource could be manually added to the resource plan in the Grid Needs Assessment to cover the shortfall
- Larger shortfalls may require re-optimization of RESOLVE/PLEXOS cases and iteration of System Security to update the marginal avoided costs for each service

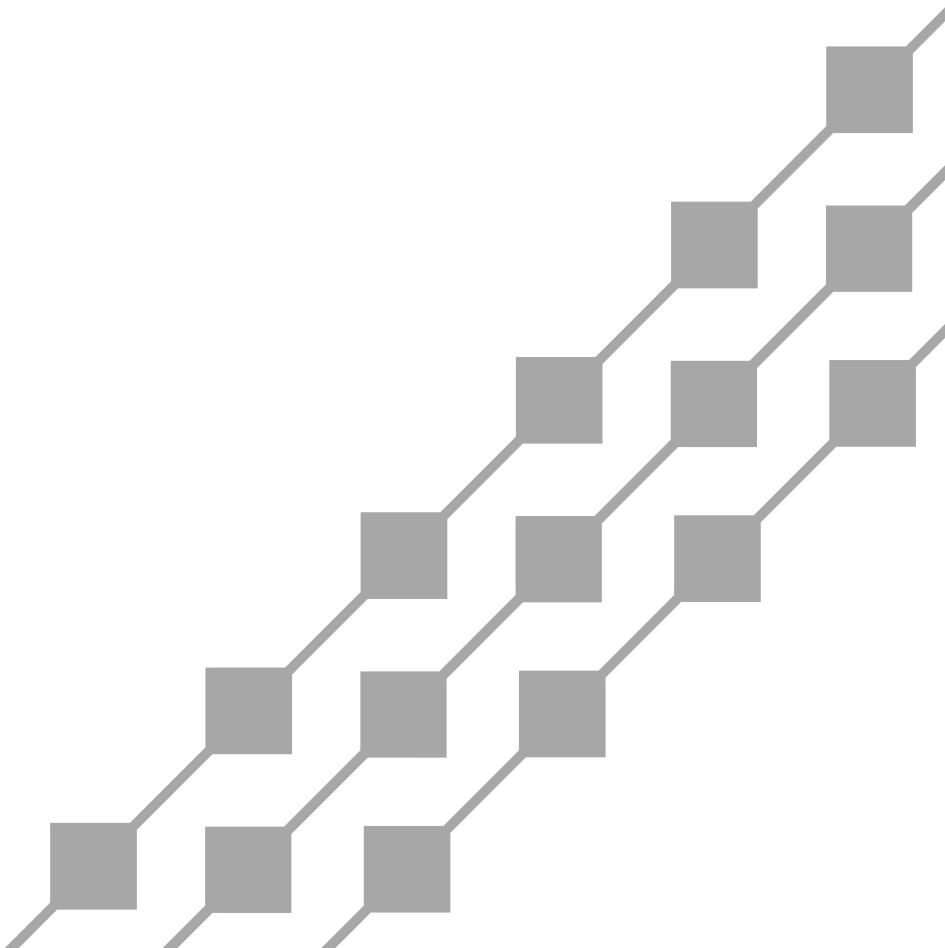
- Is there a shortfall band around the needs that is acceptable i.e. what is a small vs. large shortfall?

Solution Evaluation

- Initial Evaluation: Avoided Cost Screening
  - For each proposal, the avoided cost of each grid need would be multiplied by the expected ability of the proposal to provide that service and summed across the services to determine the total potential benefit ($)
  - The benefit would then be normalized by the annual energy (MWH) that the proposal can provide to determine a levelized benefit ($/MWH)
  - Proposals would then be ranked by their levelized benefit to inform the development of a shortlist
- Detailed Evaluation: Optimal Portfolio
  - Combinations of proposals from the shortlist will be run through the RESOLVE model used to develop the Grid Needs Assessment
  - The generic resource costs and performance characteristics for the candidate resources will be replaced by information from the proposals
  - Due to computational limitations, all proposals from the shortlist may not be evaluated simultaneously but rather in groups
  - The ranking developed as part of the initial evaluation can also be used to screen the proposals in the detailed evaluation to those that provide the highest potential benefit to the system

The IO will provide oversight of this part of the process

Next Steps



Next Steps

- Continue working with the TAP to vet the concepts proposed in the SEOWG deliverable