Integrated Resource Planning

Technical Meeting

April 26, 2018

Meeting Logistics

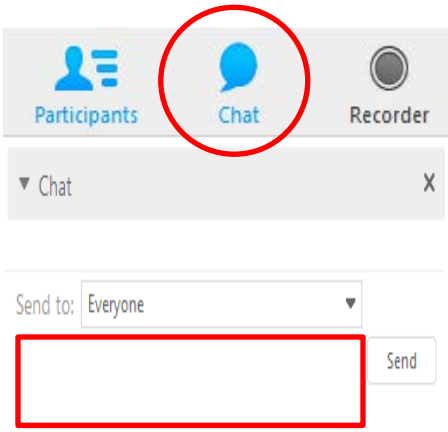
Local Participants:

- World Trade Center facility
- Wireless internet access
  - Network: 2WTC_Event
  - Password: 2WTC_Event$
- Sign-in sheets

Virtual Participants:

- Ask questions via ‘chat’ feature
- Meeting will stay open during breaks, but will be muted
- Electronic version of presentation: *portlandgeneral.com/irp*

>> Integrated Resource Planning



Today's Technical Meeting Topics

- ❑ Safety moment
- ❑ ROSE-E model discussion
- ❑ Market capacity scoping discussion

Pedestrian Safety

- **Quotes from PBOT:**
  (https://www.portlandoregon.gov/transportation/article/594867)
- In Oregon, from 2009 to 2013, 798 people on average were injured and 52 were killed after being hit by motor vehicles while walking.
- The majority of pedestrian involved motor vehicle crashes are a result of the failure of drivers to yield to people walking.
- **A quarter of people walking who are struck by vehicles are hit while they are in a crosswalk.**

- Follow all laws **AND** be alert when driving and when crossing the street.

ROSE-E Model Discussion

Elaine Hart

Agenda

- What is ROSE-E?
- Data Handling
  - Input Data and Sources
  - Output Data Reporting
- Model Formulation
- Running ROSE-E
- Demonstration

What is ROSE-E?

ROSE-E is an optimization model that designs incremental resource portfolios based on system needs, resource costs, and resource value across a range of future potential conditions.

PGE will be using ROSE-E to develop portfolios in the IRP, as a supplement to the traditional methodology of hand-designed portfolios.

Data Inputs & Outputs

ROSE-E Data Inputs & Sources

System needs (by year, future)

- Capacity shortage, MW [RECAP]
- Energy need, MWa [ALIS*]
- RPS obligation, MWa [ALIS*]

Existing and contracted resources (by year, future)

- 5-yr and infinite-life REC generation, MWa [ALIS*]

New resource cost (by resource, vintage, future)

- Real-levelized fixed cost, $/kW-yr [ROC-E**]

Resource performance (by resource, year, future) [AURORA]

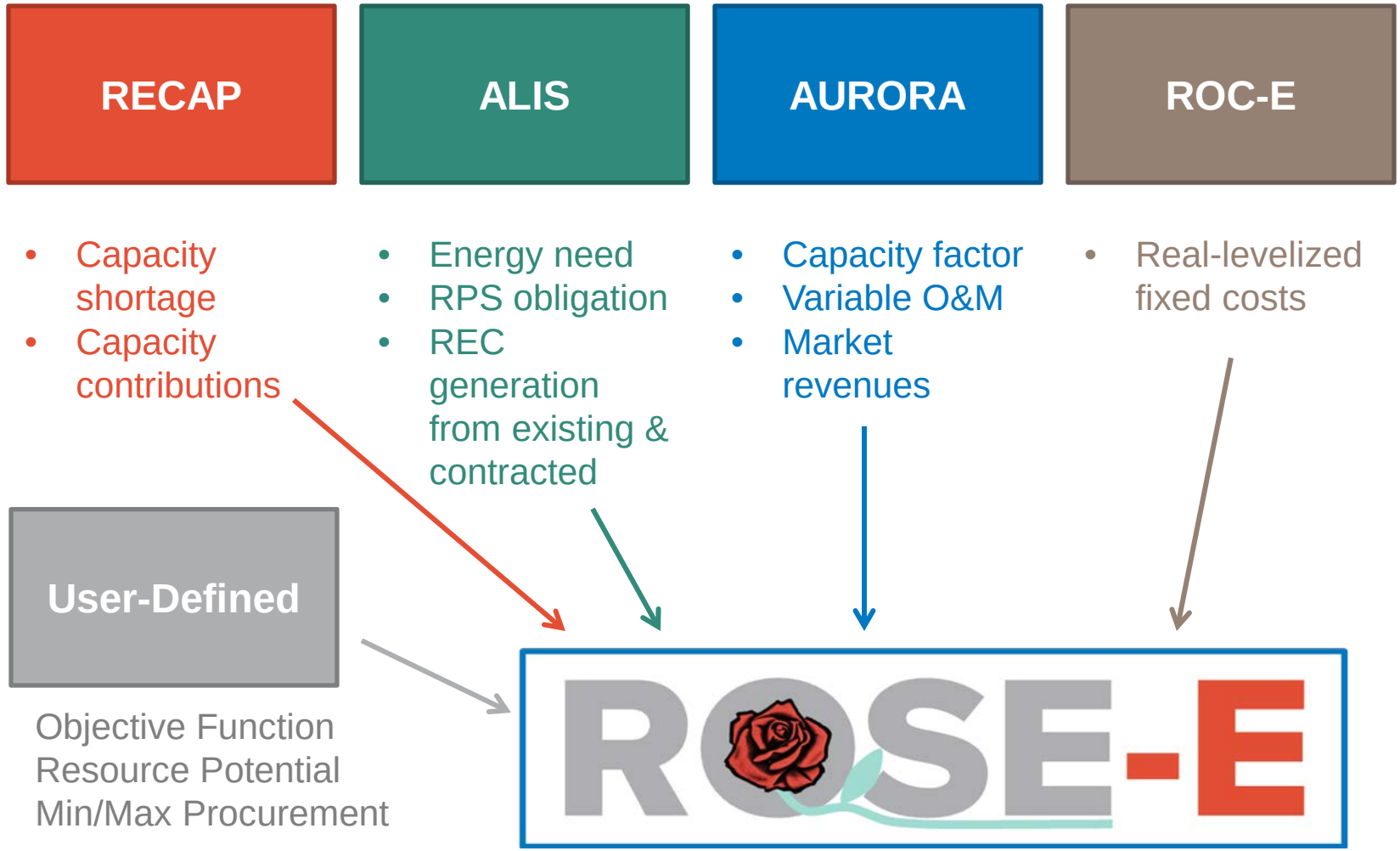
- Capacity factor, %
- Variable O&M cost, $/MWh
- Market revenues, $/MWh

Portfolio settings [user defined]

- Objective Function
- Resource Potential, MW
- Min/Max Procurement, MW
- Min Exp[NPVRR] [if applicable], M$

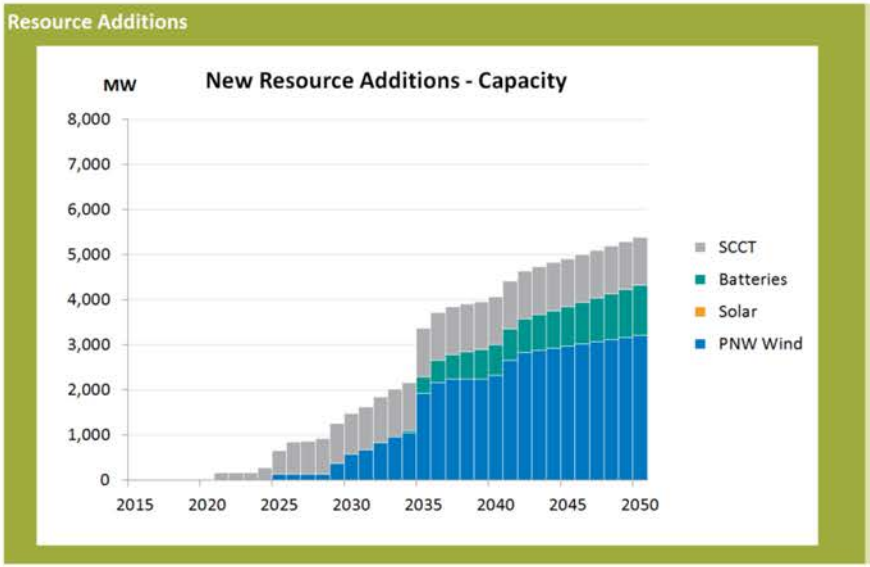
*ALIS: PGE's Load-resource balance database
**ROC-E: PGE's Revenue requirements model (formerly TCM)

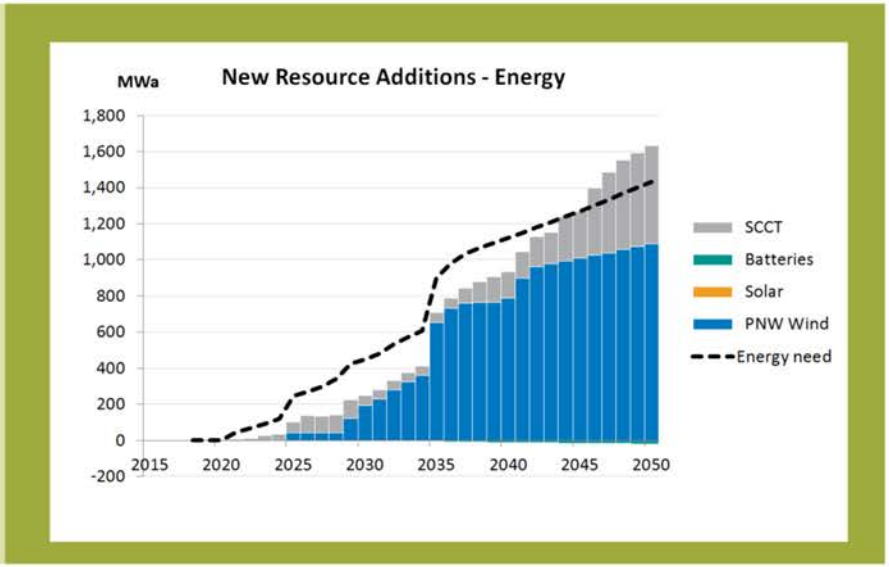
ROSE-E Data Inputs & Sources



Output Data by Future

Resource Additions – Capacity and Energy

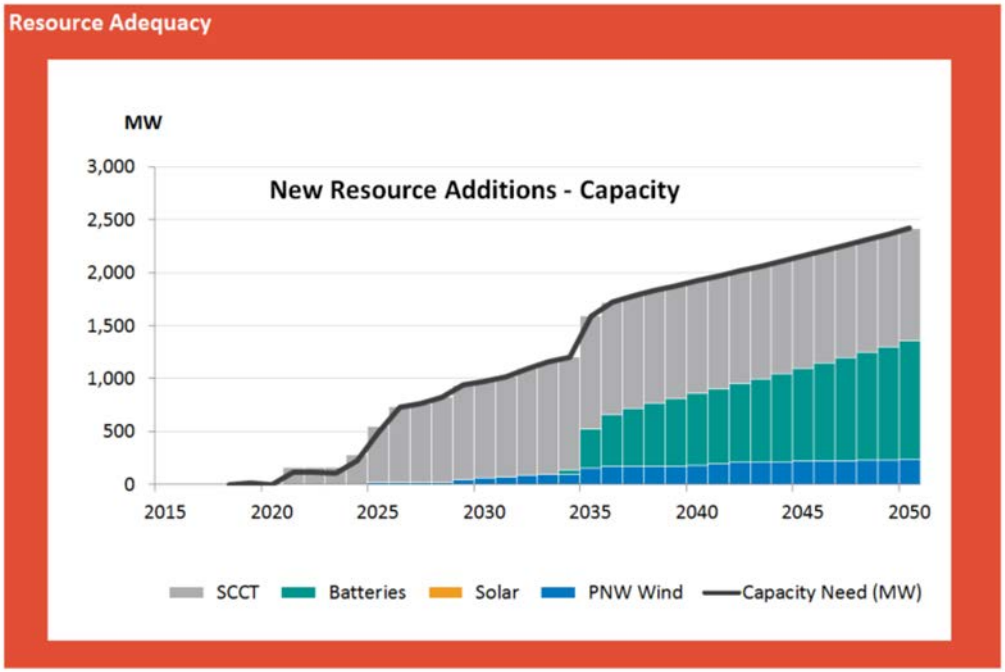




*Data is illustrative, not based on IRP inputs or modeling

Output Data by Future

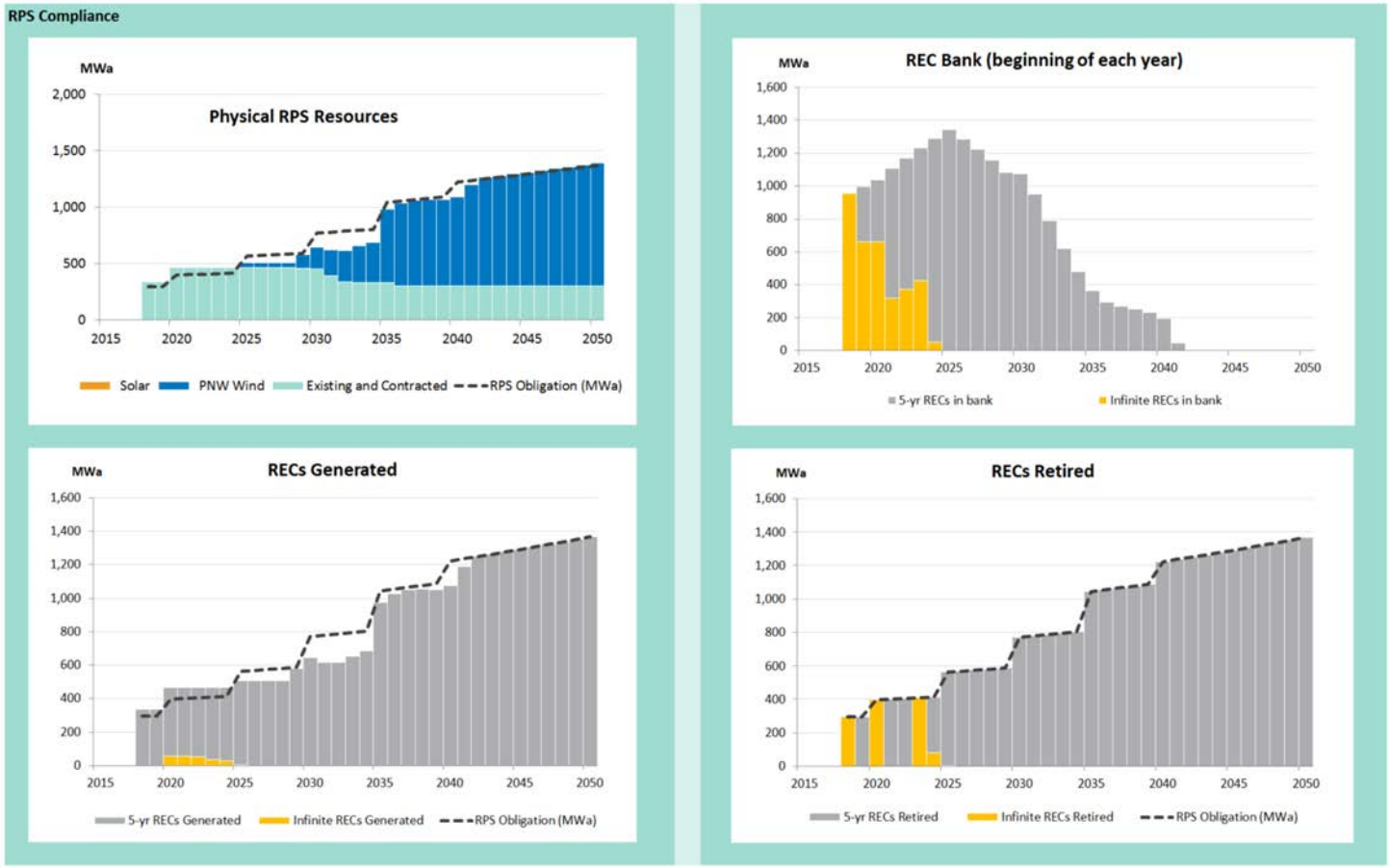
Resource Adequacy – Capacity Contribution



*Data is illustrative, not based on IRP inputs or modeling

Output Data by Future

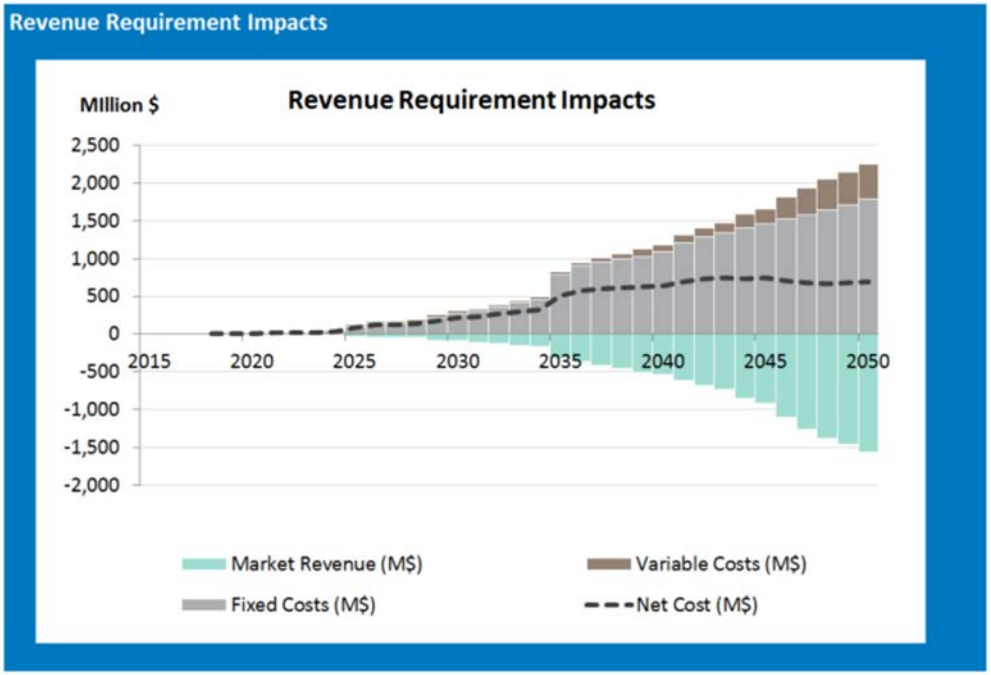
RPS Compliance & REC Banking



*Data is illustrative, not based on IRP inputs or modeling

Output Data by Future

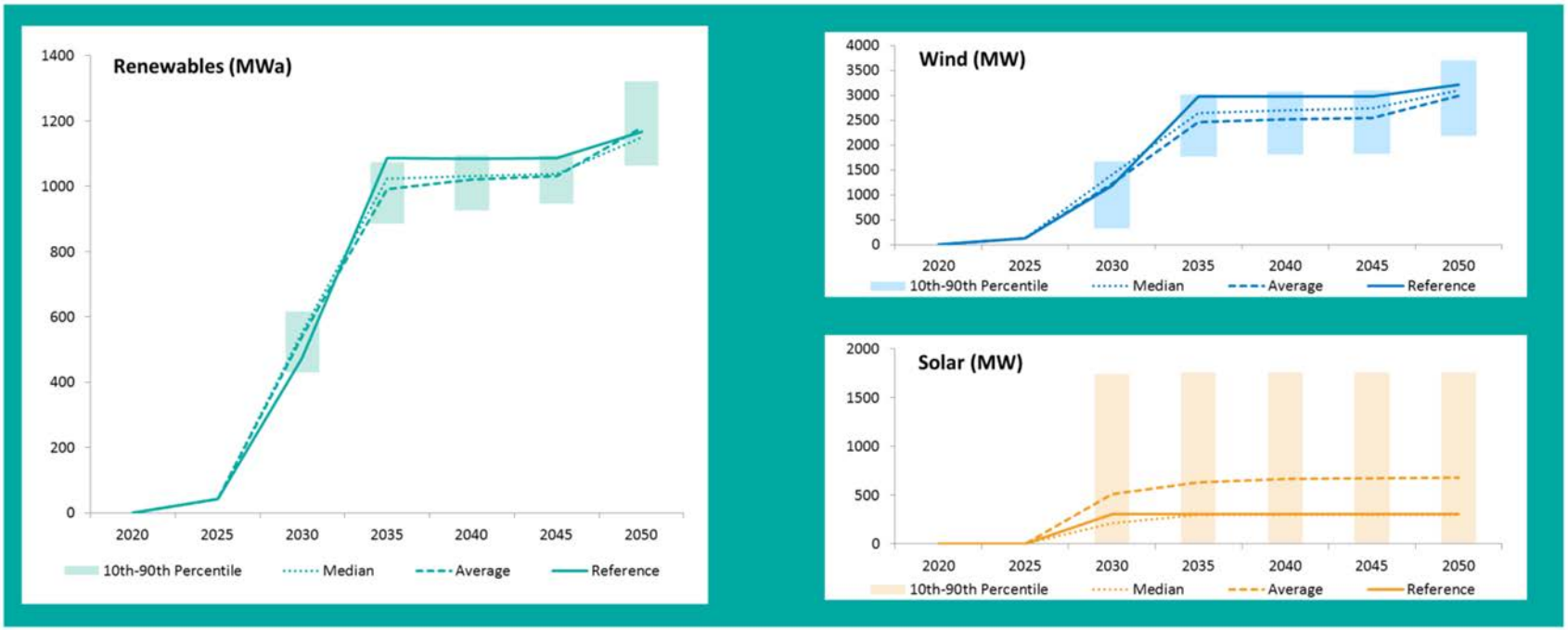
Revenue Requirement Impacts



*Data is illustrative, not based on IRP inputs or modeling

Output Data Across Futures

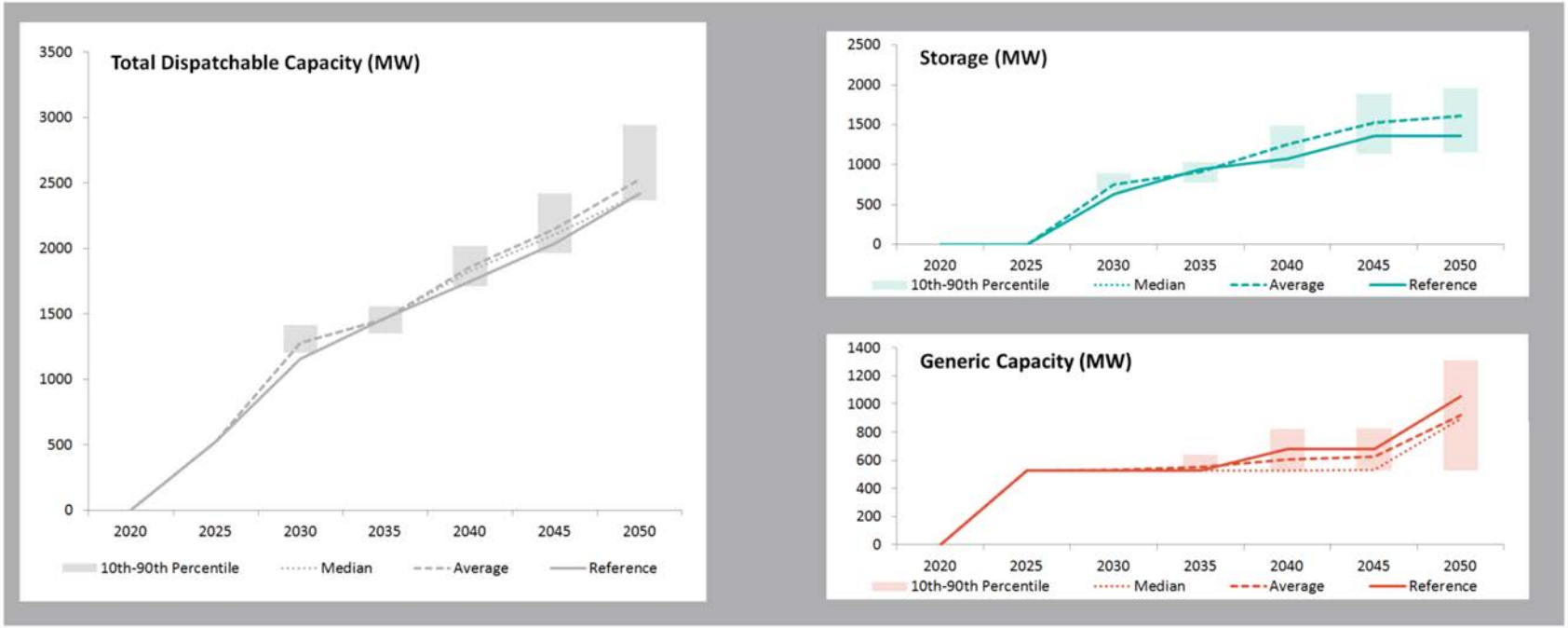
Renewable Resource Additions, working toward an RPS glide path



*Data is illustrative, not based on IRP inputs or modeling

Output Data Across Futures

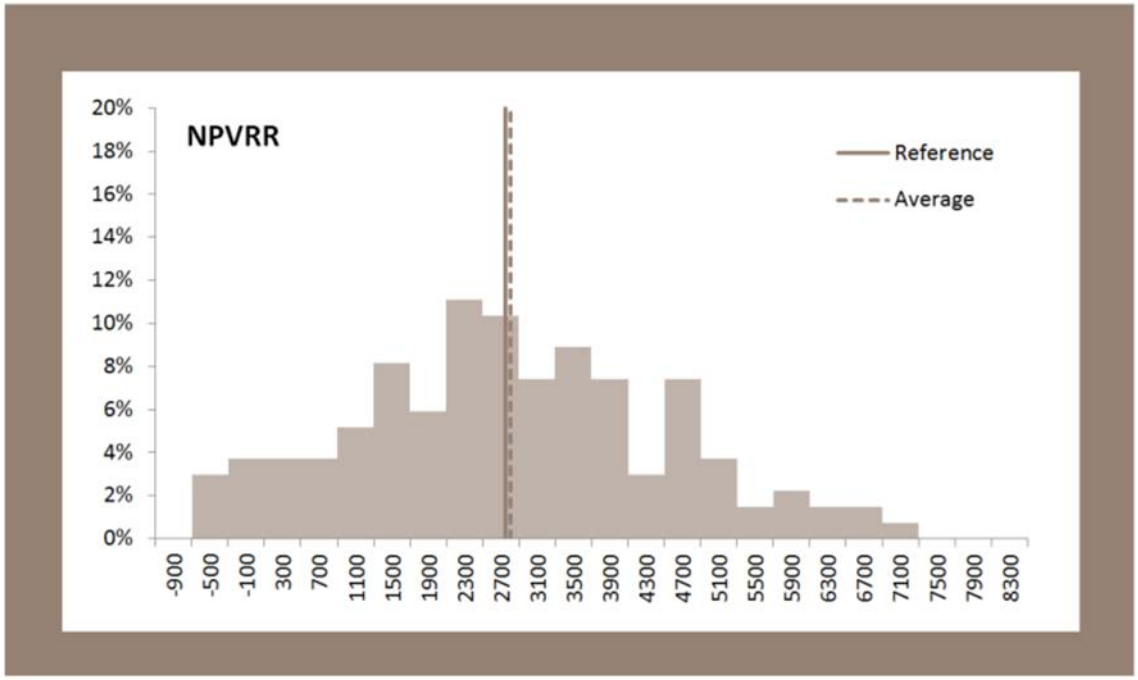
Dispatchable Capacity Additions



*Data is illustrative, not based on IRP inputs or modeling

Output Data Across Futures

Net present value revenue requirement impacts



*Data is illustrative, not based on IRP inputs or modeling

Model Formulation

Objective Functions

- ROSE-E identifies portfolios that minimize an objective function subject to specified constraints

Objective function options:

1. Minimize Expected NPVRR across all (or subset of) futures
2. Minimize Variance of NPVRR across all (or subset of) futures

Objective Function #1

Minimize Expected NPVRR across all (or subset of) futures

Sum across all futures

Total fixed costs associated with resource additions in future, k [Capital & fixed O&M]

Total market revenues associated with resource additions in future, k

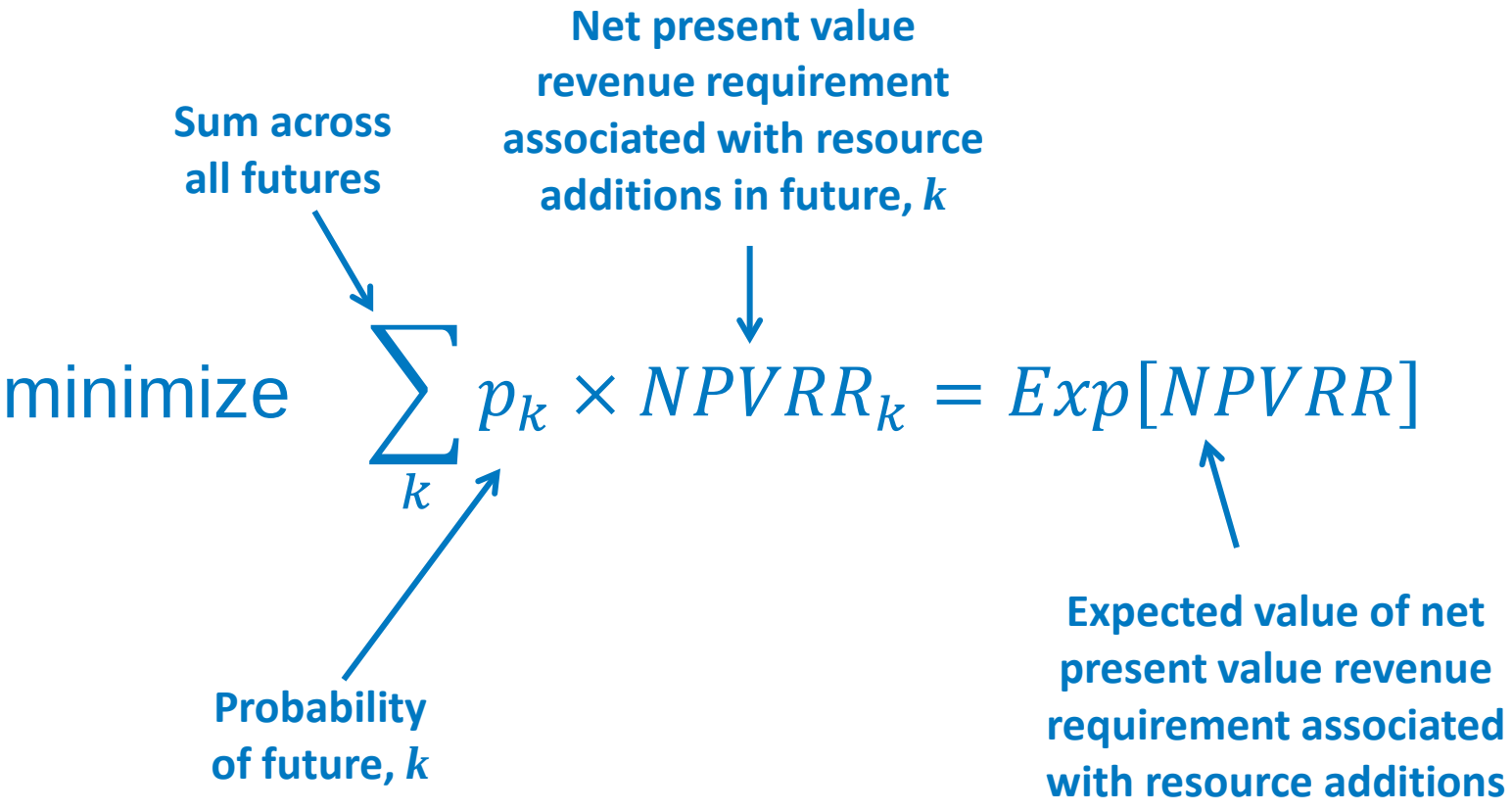
$$\text{minimize} \sum_{k} p_k \times NPV\left(c_k^{fixed} + c_k^{var} - v_k^{market}\right)$$

Probability of future, k

Total variable costs associated with resource additions in future, k [Fuel, carbon, & variable O&M]

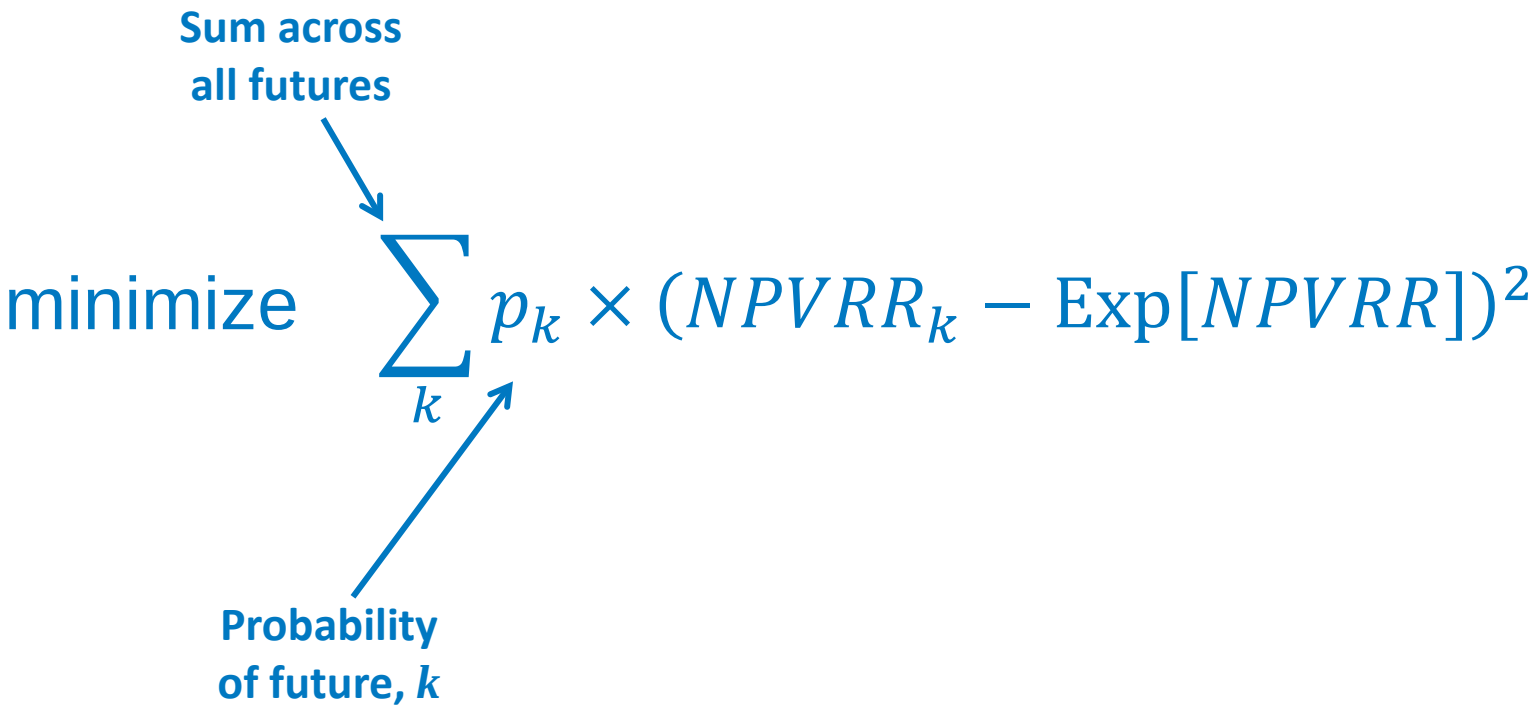
Objective Function #1

Minimize Expected NPVRR across all (or subset of) futures



Objective Function #2

Minimize Variance of NPVRR across all (or subset of) futures



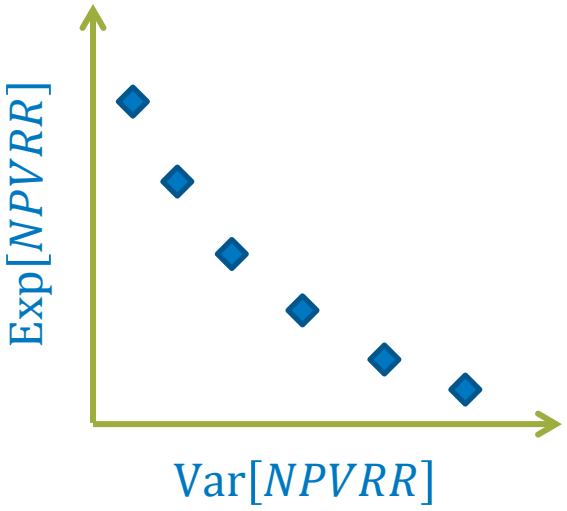
Trading off cost and risk

Combine Objective #2 with constraint on $\mathrm{Exp}[NPVRR]$

minimize $\sum_k p_k \times (NPVRR_k - \mathrm{Exp}[NPVRR])^2$

subject to $\mathrm{Exp}[NPVRR] \leq X$

Vary X to create several portfolios that achieve different balances of cost and risk



Constraints

- RPS & REC constraints
- Capacity constraints
- Energy constraints
- Resource constraints
- Optionality constraints

RPS & REC Constraints

REC bank tracking – 5yr RECs

$$b^{5yr}_{k,y+1,v} = b^{5yr}_{k,y,v} + g^{5yr}_{k,y=v,v} - r^{5yr}_{k,y,v}$$

Volume of 5-yr RECs that were generated in year, *v*, and remain in the bank in year, *y+1*, in future, k

Volume of 5-yr RECs that were generated in year, *v*, in future, k

Volume of 5-yr RECs that were generated in year, *v*, and retired in year, *y*, in future, k

5-yr REC life enforced by requiring $b^{5yr}_{k,y,v}$ to be 0 when $y > v + 5$

RPS & REC Constraints

REC bank tracking – Infinite-life RECs

$$b_{k,y+1}^{inf} = b_{k,y}^{inf} + g_{k,y}^{inf} - r_{k,y}^{inf}$$

Volume of infinite-life RECs that remain in the bank in year, *y+1*, in future, *k*

Volume of infinite-life RECs that were generated in year, *y*, in future, *k*

Volume of infinite-life RECs that were retired in year, *y*, in future, *k*

Infinite-life RECs not tracked by REC vintage, *v*, to reduce complexity without loss of accuracy

RPS & REC Constraints

RPS Compliance

$$\sum_{v} r_{k,y,v}^{5yr} + r_{k,y}^{inf} \geq R_{k,y}$$

Volume of 5-yr RECs that were retired in year, *y*, in future, *k*

Volume of infinite-life RECs that were retired in year, *y*, in future, *k*

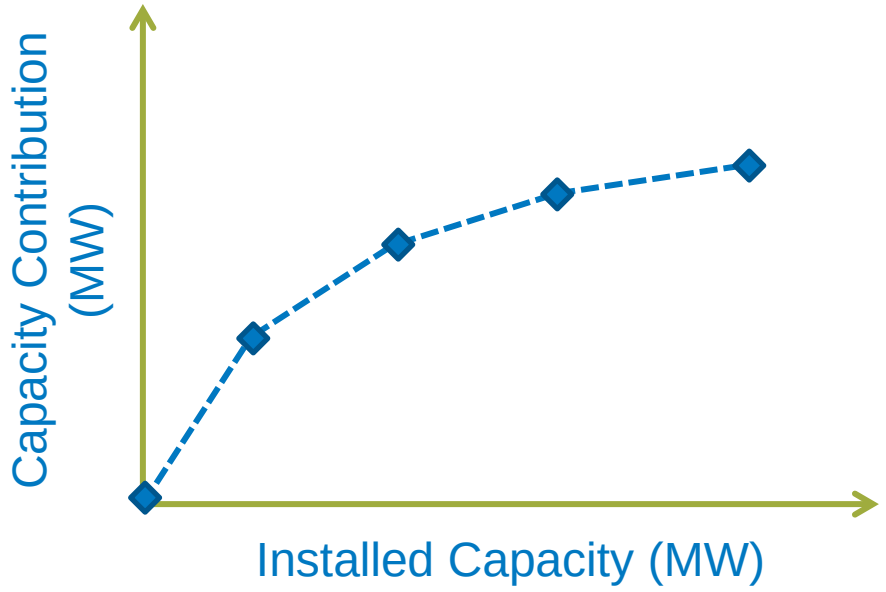
RPS obligation in year, *y*, in future, *k*

Additional constraint requires physical compliance in last year (i.e., RPS generation exceeds RPS obligation in last year of study)

Capacity Constraints

Capacity Contribution

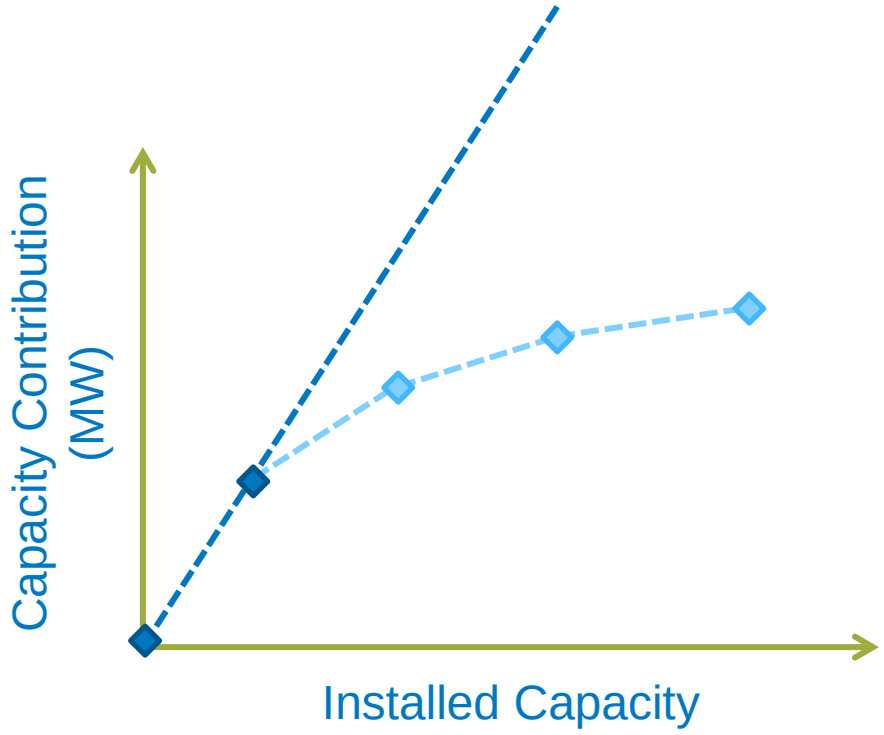
- Capacity contribution of each resource option is represented by a set of linear equations based on ELCC curves from RECAP
- Example:



Capacity Constraints

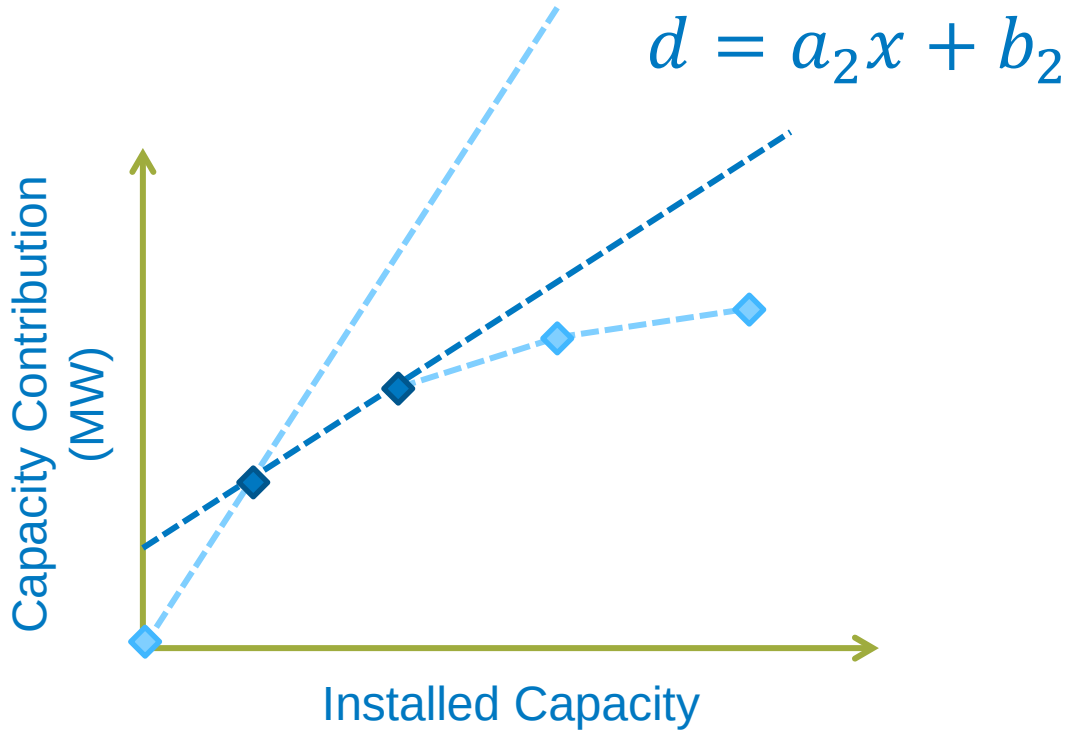
Capacity Contribution

$$d = a_1 x + b_1$$



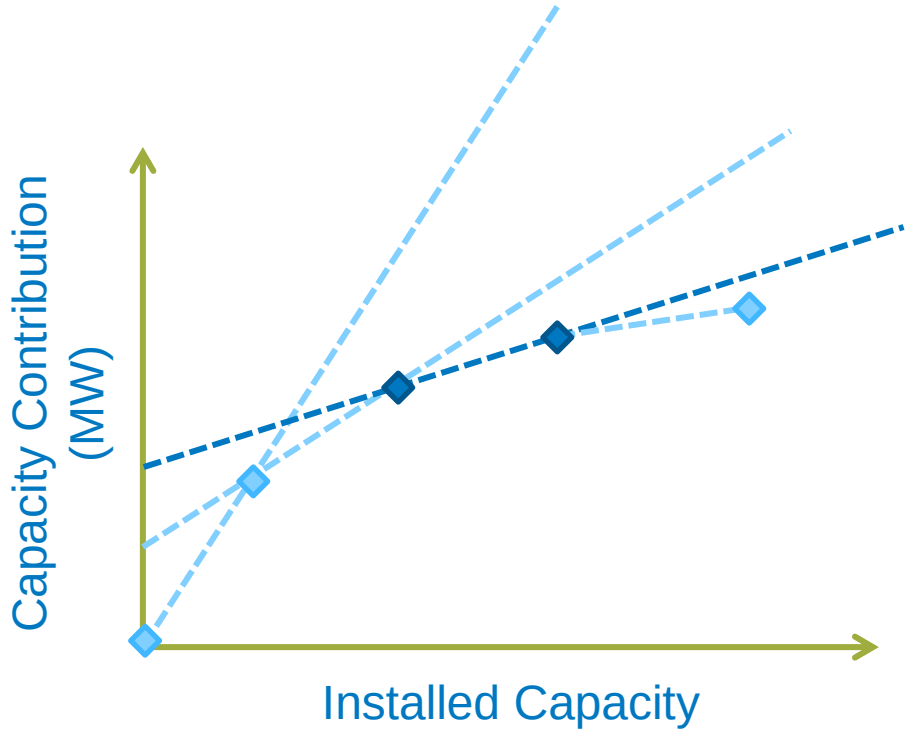
Capacity Constraints

Capacity Contribution



Capacity Constraints

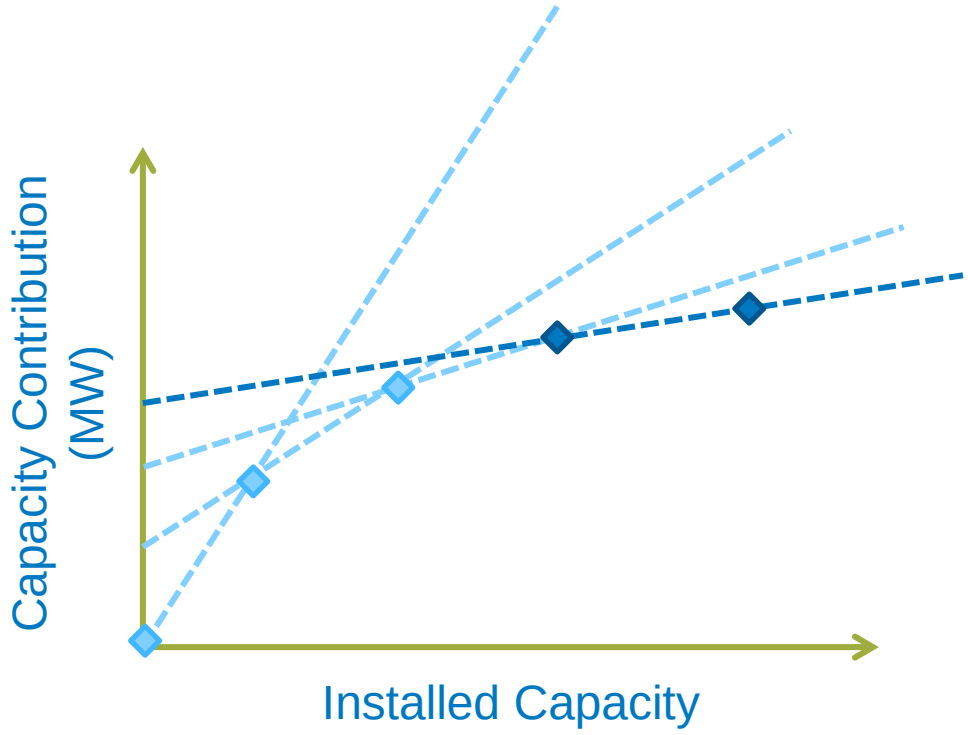
Capacity Contribution



$$d = a_3 x + b_3$$

Capacity Constraints

Capacity Contribution

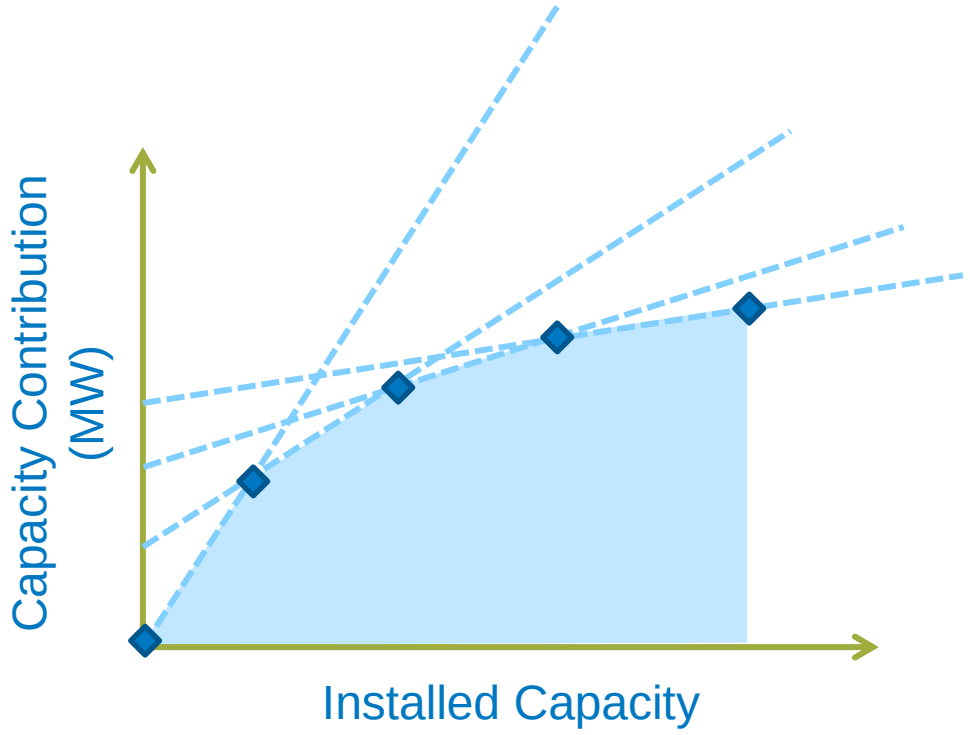


$$d = a_4 x + b_4$$

Capacity Constraints

Capacity Contribution

$$d_{i,k,y} \leq a_{i,j} x_{i,k,y} + b_{i,j} \quad \forall j$$



Capacity Constraints

Capacity Contribution

Installed capacity of resource *i* in future *k* and year *y*

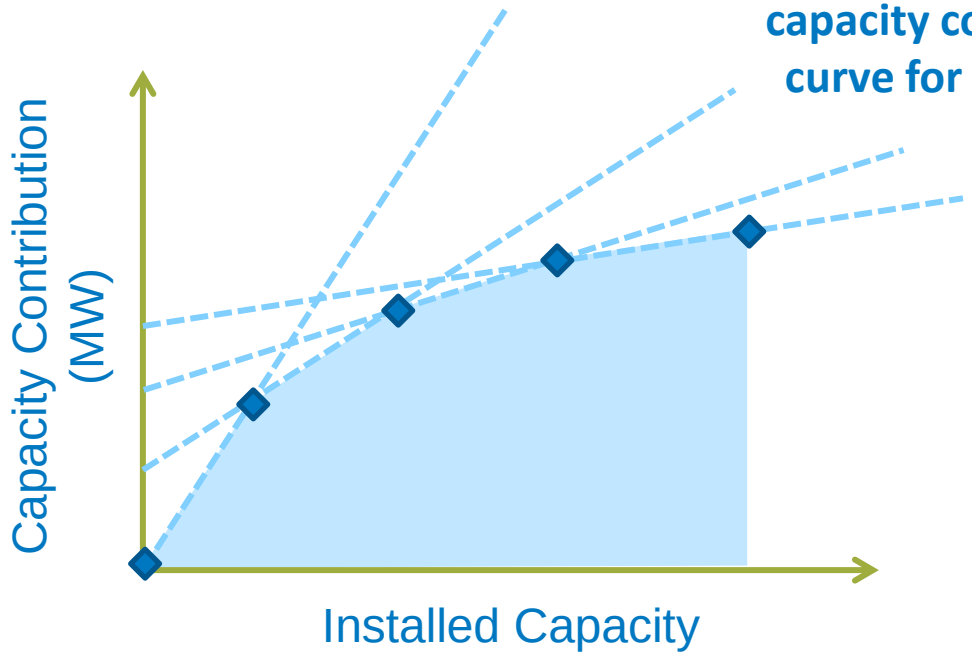
$$d_{i,k,y} \leq a_{i,j} x_{i,k,y} + b_{i,j} \quad \forall j$$

Capacity contribution of resource *i* in year *y* and future, *k*

Slope of segment *j* of capacity contribution curve for resource *i*

For all segments *j*

Intercept of segment *j* of capacity contribution curve for resource *i*



Capacity Constraints

Resource Adequacy

- Maximum capacity shortage $\sum_i d_{i,k,y} \geq D_{k,y} - \delta_y^-$

- Maximum capacity surplus $\sum_i d_{i,k,y} \leq D_{k,y} + \delta_y^+$

- To ensure resource adequacy in a given year, set maximum capacity deficit to 0 in that year

Capacity Constraints

Resource Adequacy

- Maximum capacity shortage

$$\sum_i d_{i,k,y} \geq D_{k,y} - \delta_y^-$$

Maximum capacity shortage in year *y*

Sum of capacity contributions of incremental resources in year *y* and future *k*

Capacity need in year *y* and future *k*

- Maximum capacity surplus

$$\sum_i d_{i,k,y} \leq D_{k,y} + \delta_y^+$$

Maximum capacity surplus in year *y*

- To ensure resource adequacy in a given year, set maximum capacity deficit to 0 in that year

Energy Constraints

Average Annual Net Market Exposure

- Maximum Net Market Exposure $\sum_i e_{i,k,y} \geq E_{k,y} - \epsilon_y^-$

- Maximum Net Energy Surplus $\sum_i e_{i,k,y} \leq E_{k,y} + \epsilon_y^+$

Energy Constraints

Average Annual Net Market Exposure

- Maximum Net Market Exposure $\sum_i e_{i,k,y} \geq E_{k,y} - \epsilon_y^-$

Maximum energy shortage in year *y*

Sum of all generation from incremental resources in year *y* and future *k*

Net market exposure with no actions in year *y* and future *k*

- Maximum Net Energy Surplus $\sum_i e_{i,k,y} \leq E_{k,y} + \epsilon_y^+$

Maximum energy surplus in year *y*

Resource Constraints

- Resource Potential – constrains resource procurement across all years by a total resource potential

$$x_{i,k,y} \leq X_i^{potential}$$

- Min. Procurement – requires minimum resource procurement in each year by a specified value (used for hand-designed portfolios, 0 if inactive)

$$x_{i,k,y} \leq X_{i,y}^{max}$$

- Max. Procurement – constrains maximum resource procurement in each year by a specified value (used for hand-designed portfolios, 9999 if inactive)

$$x_{i,k,y} \geq X_{i,y}^{min}$$

Optionality Constraints

- One goal of the IRP is to identify near-term actions that result in good outcomes across a range of potential futures

- To explicitly address this goal, ROSE-E incorporates optionality constraints
  - Constraints that require near-term actions to be the same across all futures

$$x_{i,k,y} = x_{l,k,y} \quad \forall l \neq i, i \in i_{nearterm}$$

  - Constraints that ensure that near-term actions do not preclude potential futures of interest

Carbon Constraints

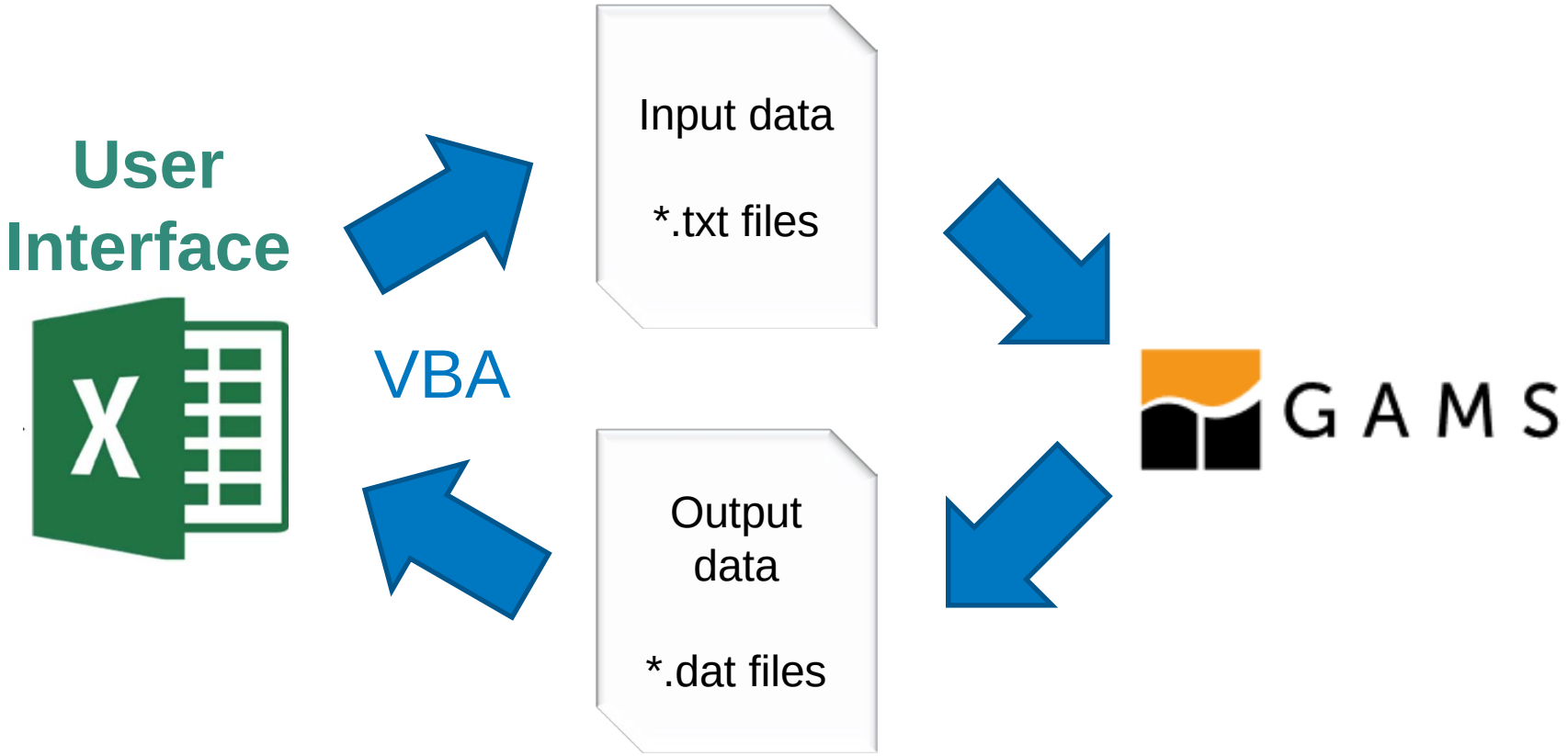
- Design of carbon constraints is currently underway
  - Potential carbon pricing impacts already accounted for within variable costs
  - Carbon constraints could be layered on in addition to carbon pricing
- Potential options
  - Design and score a carbon-constrained portfolio
  - Incorporate constraints that requires all portfolios to meet a carbon constraint in all futures
  - Incorporate constraints that requires some or all portfolios to meet a carbon constraint in one or more futures
    - Could use optionality constraints to ensure that near-term actions do not preclude meeting long-term carbon goals

Running ROSE-E

Software Requirements

- User Interface: Excel with VBA
- Optimization modeling environment: GAMS 24.7.1 (General Algebraic Modeling System)
- Optimization solver: Gurobi

Data Handling



Demonstration

(after a quick break)

Demonstration

1. Minimize Exp[NPVRR]
2. Minimize NPVRR in Reference Case
3. Hand-designed portfolio
4. Minimize Var[NPVRR] subject to constraint on Exp[NPVRR]

Market Capacity

Kate von Reis Baron

2016 IRP Summary

- Real-time: In RECAP analysis, PGE assumed the availability of 200 MW of market energy under capacity-constrained conditions in all but summer on-peak hours
- Mid-term: Final 2016 IRP Action Plan included an action item to conduct bilateral negotiations to fill a portion of the identified capacity need
- Other: Per Guideline 9, long-term opt-out load was not included in IRP planning
- Order No. 17-386 directs PGE to conduct a study of the treatment of capacity to inform the next IRP

Questions for the next IRP

- What is the regional capacity position in the Northwest (long or short) over time?
  - Impact of load growth, EE, new resources, and plant retirements
- What constraints limit PGE's access to capacity in the region?
- How should PGE's long-term planning process account for the potential availability of capacity in the region?

Proposed Scope

- Review of regional resource adequacy analysis
  - NWPCC Resource Adequacy Study
  - PNUCC
  - WECC
  - Others?
- Analysis of physical or long-term contractual constraints on PGE's access to market capacity
- Determination of a reasonable assumption in the IRP for market availability under constrained conditions
  - Seasonal, probabilistic?

Stakeholder Feedback

- What would you like to see in the scope of the study?
- If you have additional thoughts or questions, please email irp@pgn.com
- Early input is especially appreciated!