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October 25, 2018

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street, S.E.
P.O. Box 1088
Salem, OR 97308-1088

Re: UM 1856 PGE's Plan to Advancing its Energy Storage Modeling Capability

Pursuant to Public Utility Commission of Oregon (OPUC or Commission) Order No. 18-290 filed in OPUC Docket No. UM 1856 (PGE's Energy Storage Proposal), Portland General Electric Company (PGE or Company) hereby submits its plan, which includes incremental next steps to advancing its energy storage modeling capability to credibly estimate all benefits associated with the proposed energy storage systems as directed in Commission Order Nos. 16-504 and 17-532.

Should you have any questions or comments regarding this filing, please contact Kalia Savage at (503) 464-7432.

Please direct all formal correspondence and requests to the following email address pge.opuc.filings@pgn.com.

Sincerely,

Karla Wenzel
Manager, Pricing & Tariffs

Enclosure
KW:np

UM 1856 - PGE's Plan to Advance its Energy Storage Modeling Capability

Introduction

Portland General Electric Company ("PGE" or "Company") files this detailed explanation to comply with the Stipulation approved in Public Utility Commission of Oregon ("OPUC" or "Commission") Order No. 18-290 filed in Docket No. UM 1856, to advance storage modeling. Specifically, the Stipulation states:

> Prior to implementing any of the five projects agreed to in this Stipulation, PGE will file in this docket a detailed written explanation of its plan, including incremental next steps, to advance its energy storage modeling capability to credibly estimate all benefits associated with the proposed energy storage systems as directed in Commission Order Nos. 17-118 and 17-375. PGE's plan must set clear milestones with explanations regarding the analysis or tool development necessary to advance its methodologies to the forefront of [energy storage system] benefit modeling; then PGE must implement those methodologies for future [energy storage system] proposals made outside of the [Integrated Resource Planning] process.

One critique of PGE's Energy Storage Potential Evaluations ("Potential Evaluations") was that PGE did not quantitatively co-optimize benefits across all potential benefits of energy storage resources on its system. PGE's Resource Optimization Model ("ROM")[1] analysis included quantitative co-optimization across the following benefits: energy arbitrage, load following, regulation, spinning reserves, and non-spinning reserves. The consulting firm, Navigant, applied heuristics to approximate the interaction and co-optimization between these applications and locational and customer applications.

Background: Energy Storage Law, PGE's Proposal, and Order 18-290

The Commission opened Docket No. UM 1751 in September 2015 to implement House Bill ("HB") 2193,[2] which requires large Oregon electric companies to submit proposals to the Commission by January 1, 2018; the proposals would identify how PGE would develop qualifying energy storage systems with the capacity to store at least five megawatt hours ("MWh"). The total capacity may not exceed one percent of PGE's 2014 peak load,[3] which equates to 38.7 megawatts ("MW"). The Commission adopted specific guidelines and requirements, in Commission Order No. 16-504, for Pacific Power ("PAC") and PGE's energy storage project proposals on December 28, 2016. Then on March 21, 2017, the Commission adopted a framework in Commission Order No. 17-118 for PAC's and PGE's Potential Evaluation that includes seven elements. PGE filed its Draft Potential Evaluation on July 14, 2017. OPUC Staff ("Staff") and stakeholders reviewed this draft and made recommendations to the Commission through a Staff Report. Commission Order No. 17-375 adopted the following schedule: (1) by January 1, 2018, PGE and PAC were to file draft project proposals and updated draft potential evaluations that incorporated the improvements outlined by Staff in its Report; (2) by April 2, 2018, the utilities were to file final project proposals and final potential evaluations; and (3) no later than April 2, 2018, the Commission was to begin review of the final

[1] ROM is a multistage sub-hourly production cost model of PGE's resource portfolio.
[2] 2015 Oregon Laws Chapter 312.
[3] See HB 2193, Section 2(a).

filings. PGE's Energy Storage Proposal and Potential Evaluation resulted in a partial stipulation among most of the Parties (i.e. PGE, Staff, CUB, AWEC, NIPPC and RNW), with no party objecting to the stipulation. The stipulation was approved August 13, 2018

Co-optimization Analysis

To further improve upon the method used in the Potential Evaluation and to improve the transparency of its analysis, PGE plans to use the Electric Power Research Institute's ("EPRI's") Storage Value Estimation Tool ("StorageVET®") with PGE-specific input data to co-optimize benefits across all Bulk Energy, Ancillary Services, Transmission and Distribution Services, and Customer Energy Management Services for future analysis of small energy storage projects or programs.

With the assistance of EPRI, PGE will prepare an energy storage valuation method, incorporating applicable learnings from other participant utilities[4] investing in energy storage. PGE will achieve this outcome through participation in the EPRI supplemental program, "Energy Storage Analysis: Finding, Designing, and Operating Projects."

To advance PGE's energy storage modeling capability and credibly estimate potential benefits associated with proposed energy storage systems, as directed in Commission Orders 17-118 and 17-375, PGE, with EPRI, will conduct a deep analysis of storage operation using time-series analysis and dispatch models to address stacked benefits. In addition, PGE and EPRI will fully model and understand how storage systems are likely to influence grid operation under various conditions across the lifetime of the project. The outcome will report effective and efficient methods to perform the necessary economic dispatch optimization of small storage and other distributed energy resources ("DER"), as well as the required time-series analyses to assess integration with the grid. PGE will use these learnings to validate and refine the locational system benefits and impacts of energy storage systems to integrate future storage resources and other DER into distribution capacity planning.

While the EPRI StorageVET® supports analyses, which co-optimize the economic dispatch of all stacked benefits based on user inputs, some potential benefits have "pre-dispatch" carve-outs (e.g. T&D deferral) which prioritize reliability over economic benefits. These pre-dispatch constraints and dispatch priorities are customizable for each case, depending on the intended application of the energy storage system.

For each of PGE's proposed energy storage projects specified in Order 18-290, PGE will identify and assign the primary service and/or issue that the energy storage application is intending to address at the customer, distribution, or transmission level, along with any associated learnings the projects are intended to achieve for the various scenarios proposed. By deploying storage in a manner which considers a variety of applications, PGE will gain a broader set of learnings to be used when considering future deployments. The StorageVET® time-series analyses will co-optimize and stack all potential benefits/value streams compatible with the intended application to quantify the total value represented by the project. This approach is consistent with the method that EPRI uses in its StorageVET® model when evaluating co-optimized benefits for energy storage at other partner utilities.

Data Needs

PGE will provide a list of applicable value streams and a corresponding value for the StorageVET® to perform the co-optimization analysis in consultation with EPRI. For this

[4] Includes each of the utilities which elected to subscribe to EPRI's supplemental project on Energy Storage, "Energy Storage Analysis Finding, Designing, and Operating Projects."

evaluation, the applicable value streams include Bulk Energy, Ancillary Services, Transmission Services, Distribution Services, and Customer Energy Management Services.[5]

Generation Capacity Value

To determine generation capacity value to incorporate into StorageVET®, PGE will use the Renewable Energy Capacity Planning ("RECAP") model. Consistent with Commission Order No. 16-326, PGE has used RECAP in PGE's Integrated Resource Plan ("IRP") to determine the effective load carrying capability ("ELCC") of renewable resources to quantify capacity contributions and capacity values. Capacity contributions from RECAP have also been applied to Qualifying Facilities and were included in PGE's Resource Value of Solar in OPUC Docket No. UM 1912. In the 2016 IRP, PGE presented a preliminary analysis of the ELCC of energy storage resources in RECAP and the Company plans to advance this work in future IRPs to inform both resource portfolio planning and future analysis specific to energy storage projects and programs.

Bulk Energy and Ancillary Services Value

Bulk energy and ancillary service values include energy arbitrage, load following reserves, regulation reserves, spinning reserves, non-spinning reserves, voltage support, and black start. To co-optimize across applications, StorageVET®, and other price-taker energy storage evaluation tools, require time series information about the value of providing each of these services to the system. For an energy storage system that operates within an organized energy and ancillary services market, the value of the resource is typically estimated by calculating the maximum revenue that could be collected in the market given hourly historical, or forecasted, energy and ancillary service price streams. Because PGE does not operate within an organized energy and ancillary services market, PGE has estimated the value of providing energy and ancillary services with energy storage resources as the reduction in variable costs[6] that can be achieved with the resource, as simulated in ROM. This approach more accurately reflects the value of an energy storage operating within PGE's resource fleet than alternative methods.[7]

To provide additional insight regarding the co-optimized bulk energy and ancillary service value of energy storage resources, PGE will conduct additional analysis to estimate the time-varying marginal value of providing bulk energy and ancillary services within its system. For a system that does not operate within an organized market, the hourly value of providing a given service can be estimated by the shadow price of the constraint associated with that service. For example, in each hour the system is required to hold a specified amount of regulation reserves. The shadow price of the regulation reserve constraint is equal to the marginal cost of providing the last increment of regulation reserves to meet that constraint. This regulation reserve shadow price provides an analog to the price that a resource may be paid if it were selected to provide regulation reserves in an organized market. The hourly shadow prices for each bulk energy and ancillary service constraint can therefore serve as a proxy for the hourly market prices in a price-taker model like StorageVET®. Production cost models like ROM[8] can be configured to export shadow prices when they solve for the commitment and dispatch of a resource portfolio. PGE plans to use ROM to provide shadow prices for energy and ancillary services for use in StorageVET® to enable co-optimization across these and other services. Because PGE has not undertaken this type of exercise in the past, this analysis may require multiple iterations to ensure accuracy and consistency with PGE's system needs and true marginal costs.

[5] See Commission Order No. 17-375 and Commission Order 18-290 Appendix A at 5-6.
[6] Variable costs include fuel, start-up costs, and variable operation and maintenance costs across PGE's resource fleets as well as net costs associated with market purchases and sales and potential future carbon costs.
[7] Providing this accuracy requires more modeling complexity, which could be viewed as reducing transparency.
[8] ROM is a tool designed to investigate operational cost trade-offs over short time scales and with a high degree of rigor with respect to PGE's portfolio.

Ancillary services that are not currently modeled in ROM include frequency response, voltage support, and black start service. PGE will work with EPRI to identify best practices for quantifying these value streams in a way that is transparent and allows for co-optimization.

This plan does not include efforts to substantively modify ROM to incorporate non-bulk energy and ancillary service value streams. Due to the complexity of power system operations and planning, all models of power systems are designed to best serve their specific purpose with practical and computational trade-offs in mind. In the case of ROM, PGE has prioritized temporal resolution over geographical resolution. This allows ROM to resolve value streams related to operations in very short timescales and those associated with time-varying operating constraints on PGE's resource portfolio that are challenging to model (like generator unit constraints). In contrast, distribution planning tools, like the Integrated Planning Tool, prioritize geographical resolution over temporal resolution because locational value is primarily dependent on geographic placement of the resource and its connectivity to the local T&D infrastructure. While an ideal model might attempt to resolve energy storage value streams at high resolution with respect to both temporal factors and geographical factors at the same time, current computational limitations in both industry and research prevent such a model from being practical at scale (i.e. for more than a small number of locations). This proposal allows PGE to use its existing models to focus on what they do well, and for StorageVET® to leverage the resulting simplified output information (like shadow prices from ROM) to consider problems that are complex across both time and geography.

Transmission Value

The following transmission values will be calculated:

- Transmission Reliability – This will be calculated based on the potential for an energy storage system to offset transmission reliability/resiliency-based investments (e.g. the value to PGE for transmission outage avoidance/mitigation). The Transmission Reliability value requires a commitment to reserve energy storage capacity to provide this service as the primary use case during all times during which the system may be exposed to a potential reliability event.
- Transmission Capacity and Loss Reduction – PGE will forecast potential changes in transmission system losses due to the presence and availability of a DER portfolio (e.g. storage) of varying penetration levels to offset system demand during a four-hour system peak. The results will be extrapolated to consider the per-unit transmission system loss reduction available and corresponding value for this mode of operation across 365 days per year.
    - Concurrent with the transmission loss reduction value, PGE will consider the same mode of operation for a DER portfolio to offset transmission system capacity needs during the four-hour system peak. PGE will calculate the forecasted transmission system capacity investment needed to support general system demand at the time of the peak, as identified per compliance with the North American Electric Reliability Committee ("NERC") TPL-001 reliability standard. In addition, PGE will assign a pro-rata transmission capacity value to the DER based on the size of the resource and its proportionate ability to influence transmission system flow in the area(s) of identified transmission capacity needs. The Transmission Capacity value and Loss Reduction value require a commitment to reserve energy storage capacity to provide these services as the primary use cases during the time of the daily system peak (compatible with the Distribution Capacity and Loss Reduction use case).

Distribution/Locational Value

The following Distribution and Locational values will be calculated:

- Distribution Voltage Management – This will be calculated based on the potential for an energy storage system to offset investments otherwise needed to support feeder voltage profile management, especially pertaining to Volt-Var Optimization ("VVO") and Conservation Voltage Reduction ("CVR") programs. For screening purposes, PGE will assign an average cost-per-feeder for the investment needed to support CVR and will calculate a pro-rata value for an energy storage system's ability to offset these investments. In future project proposals, the value considered for Distribution Voltage Management may be revised to reflect specific costs and benefits for the feeder in which the planned DER will interconnect.
- Distribution Reliability & Power Quality – This will be calculated based on the potential for an energy storage system to offset distribution reliability/resiliency-based investments. This includes the value to PGE for customer outage avoidance/mitigation minus the integration cost of necessary microgrid control. The Distribution Resiliency value requires a commitment to reserve energy storage capacity to provide this service as the primary use case during all times during which the system may be exposed to a potential reliability event.
- Distribution Capacity & Loss Reduction – PGE will forecast what change in distribution system losses may be available given the presence and availability of a DER portfolio of varying penetration levels to offset system demand during a four-hour system peak. The studies will be extrapolated to consider the per-unit distribution system loss reduction available and corresponding value for this mode of operation across 365 days per year.
    - Concurrent with the distribution loss reduction value, PGE will consider the same mode of operation for a DER portfolio to offset distribution system capacity needs during the four-hour system peak. PGE will calculate the forecasted distribution system capacity investment needed to support general system demand at the time of the peak and assign a pro-rata distribution capacity value to the DER based on the size of the resource and its proportionate ability to influence distribution system flow in the area(s) of identified distribution capacity needs. The Distribution Capacity value and Loss Reduction value require a commitment to reserve energy storage capacity to provide these services as the primary use cases during the time of the daily system peak (compatible with the Transmission Capacity and Loss Reduction use case).

Customer Value

The following customer values will be calculated for behind the meter projects:

- Time-of-Use ("TOU") Optimization – PGE will use TOU rates as potential value streams in areas where those optional rates are available for customers. For residential applications, this will use TOU rates. For nonresidential applications, PGE's Schedules 32 ("Small Non-Residential Standard Service") and 38 ("Large Non-Residential Optional TOU Service") rates will be used.
- Demand Charge Reduction – For nonresidential customers, PGE will test the ability to manage peak demand against relevant demand charges.

Interactions with Other Planning Processes

Integrated Resource Planning

Consistent with Order 18-290, PGE will use the Storage Potential method, adopted by the Commission in Order 17-375, when considering energy storage resources outside of the IRP. PGE draws this distinction for both technical and logistical reasons.

- Technical considerations – The third-party tools available for energy storage evaluation, including StorageVET®, are not consistent with the frameworks and methodologies used in the IRP. StorageVET® and other third-party energy storage evaluation tools are price-taker models, which assume that the behavior of the resource being modeled does not impact the prices of the services that it provides. This assumption is generally valid for smaller resources (e.g. a 10 MW energy storage system) relative to the total size of the system (e.g. the size of PGE's resource portfolio). However, as the size of the resource (or resource fleet) grows, it can fill larger shares of the system needs, reducing prices and marginal value, and eventually saturating the system. This effect is important in portfolio planning efforts, like the IRP, which consider major resource actions. These effects may be less important for small individual projects, e.g., a small distribution- or customer-sited energy storage project. For this reason, PGE will continue to pursue production cost modeling in the IRP while investigating the potential to use price-taker models such as StorageVET® in applications that are not expected to materially impact PGE's generation portfolio.

- Logistical considerations – The production cost modeling that occurs within the IRP is highly data- and time-intensive. In the effort to enable energy storage resources that are cost-effective for customers, PGE does not wish to burden each individual distribution- or customer-sited storage resource with the same level of analysis (regarding bulk energy and ancillary service value) that major resource actions, including large energy storage projects and/or programs, require in the IRP. The plan, as described here, would allow for PGE to update bulk energy and ancillary service inputs into a tool, StorageVET®, after each IRP so that the Company could conduct more nimble analysis of specific projects between IRPs.

Within the IRP, PGE will continue to advance its modeling capabilities for capturing the value of flexible and distributed resources like energy storage. While not occurring within the IRP, the analysis described in this plan will provide helpful learning that, over time, may inform future IRPs. In determining how the learnings from this analysis may inform future IRPs, PGE will use the IRP stakeholder engagement process to work toward applying new methodologies, or frameworks, in ways that ensure that resource options are compared on a consistent basis, as required by the IRP Guidelines.

Transmission and Distribution Planning

From a Transmission and Distribution ("T&D") Planning standpoint, the EPRI StorageVET® price-taker model may be used to quantify locational value of future energy storage applications until a given location reaches saturation. Saturation in the T&D Planning context will be identified through a system-wide hosting capacity analysis which identifies an "upper bound" for DERs specific to each defined location, after which the locational value for any incremental resource will be offset to some degree by a corresponding system integration cost.

Customer Program Planning

The StorageVET® output may be used to identify a mix of potential use cases from behind-the-meter storage resources. This may aid in the design of programs in understanding the balance between customer value propositions and grid value. It may also help identify where locational deployment of programs would be appropriate.

Timelines and Key Milestones

In accordance with Order 17-375, PGE established energy storage potential value streams. In addition, in PGE's Potential Evaluation, PGE calculated draft shadow prices (i.e. arbitrage, load following, regulation, and spin/non-spin reserves) as well as draft values for specific transmission, distribution, and customer benefits. Going forward, PGE will develop internal capabilities to use the EPRI StorageVET® tool to evaluate and quantify potential benefits of energy storage systems and benchmark the StorageVET® reported value for Bulk Energy, Ancillary Services, and Capacity Value against those values derived in the ROM model through PGE's IRP process.

To maintain the validity of the transmission and distribution values attributed to energy storage through participation in the EPRI Supplemental project, PGE plans to create incremental FTE positions in PGE's Distribution Planning department. These resources will periodically review and update a system-wide Hosting Capacity Assessment and will perform ongoing time-series analyses to support the accuracy of the assigned locational values.

Table 1, below, provides PGE's timeline for developing and updating the valuation methodology for energy storage systems.

Table 1: PGE's Timeline for Developing and Updating Energy Storage Valuation Methodology

Action	Completed By
1. PGE provides input values for StorageVET®	1/1/2019
2. EPRI StorageVET® output delivered	6/1/2019
3. PGE completes running StorageVET®	8/1/2019
4. Method developed to validate/refine input values to StorageVET®	10/1/2019
5. Benchmark StorageVET® output against IRP	1/1/2020
6. EPRI to compile and deliver co-optimized benefits report/recommendations	6/1/2020
7. Finalize valuation methodology	12/1/2020