Portland General Electric Company
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January 25, 2019

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

RE: **UM 1856 – Addendum to PGE's Residential Storage Pilot**

Pursuant to Oregon Public Utility Commission (OPUC or Commission) Order No. 18-290, enclosed is Portland General Electric Company's (PGE's) addendum to its Residential Storage Pilot for OPUC Staff review. The addendum presents a revised project design with evidence demonstrating that PGE will manage risk and optimize learnings.

Per paragraph 18 of the Partial Stipulation filed in Docket No. UM 1856, PGE requests that Staff express its agreement as provided in the Stipulation.

The Commission opened Docket No. UM 1751, in September 2015, to implement House Bill 2193. This House Bill requires large Oregon electric companies (i.e. Pacific Power or PAC, and PGE) to submit proposals by January 1, 2018, to develop qualifying energy storage systems with the capacity to store at least five megawatt hours. In UM 1751, the Commission adopted specific guidelines and requirements for energy storage project proposals, in late 2016, and a framework for PAC's and PGE's Energy Storage Potential Evaluations (Potential Evaluations) in March 2017.

PGE filed its Energy Storage Proposal and Final Potential Evaluation on November 1, 2017, which were investigated in the subsequently opened UM 1856. Following multiple rounds of testimony and numerous data requests, workshops and a settlement conference, stakeholders and the company reached a Partial Stipulation and submitted Joint Testimony in support. The stipulation resolved nearly all the issues.

Attachment A provides an addendum to the Residential Storage Pilot proposal to comply with Item Nos. 18 and 19 of the Partial Stipulation. This addendum includes a revised pilot project design that:

- Aggregates and dispatches residential storage units as a single resource;
- Manages and details mitigation strategies for all program deployment[1] and life cycle risks;
- Optimizes learnings (shared control between the participant and PGE and shared benefits of the system with its participant); and
- Contains a data collection and a program evaluation plan.

PGE looks forward to working with Staff as they review this filing in accordance with Order 18-290. 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
cc: UM 1856 Service List

[1] See PGE's Application in UM 1856 at page 107.

Attachment A
UM 1856 - Addendum to PGE's Residential Storage Pilot

UM 1856 – Attachment A: Addendum to PGE's Residential Energy Storage Pilot

The following Addendum supplements PGE's original residential storage proposal to comply with the stipulation approved as part of PGE's application in UM 1856. We first discuss what other pilots informed our approach. We then discuss how we plan to study aggregation and dispatch of residential storage including the platforms we will use. Following these, we provide a discussion of the identified risks and how PGE plans to mitigate them as well as how we plan to optimize the learnings from this pilot. We conclude this Addendum with a discussion of the learning objectives, data collection plan and finally an evaluation of the pilot. PGE recommends, following Staff's review of this Addendum, that Staff make the required finding that PGE has demonstrated it will manage risk and optimize learnings of the Residential Energy Storage Pilot.

7.11 Learning Objectives & Evaluation Plan

7.1(a) Insights Inform Approach, Lessons and Risk

PGE conducted a meta-study of program proposals and offerings by other utilities for residential behind-the-meter storage. At the time of writing, residential energy storage programs were offered only by a small number of utilities, including Green Mountain Power (GMP) in Vermont, Liberty Utilities in New Hampshire (Liberty), and Consolidated Edison (Con Ed) in New York. The successes and failures of these program structures have informed PGE's approach and are discussed below.

<u>GMP</u>

GMP was an early utility entrant into the residential energy storage market. GMP, a vertically-integrated utility serving over 270,000 customers in Vermont, received approval from its regulator in 2016 to explore a residential storage offering. Many factors led the Vermont Commission to grant approval for the programs. While many of these factors are unique to Vermont, the customer value proposition and impact on grid operations are important considerations in Oregon and to PGE.

GMP serves many Vermont customers. Vermont customers have been adopting roof top solar in large part because the Vermont grid experiences more resiliency issues than other areas of the country. This is due, in part, to the rural nature of the state. Additionally, Vermont has been a difficult place to site supply-side generation. Thus, GMP is more exposed to market prices and long-term contracts than utilities in neighboring states. This has led Vermont regulators to champion customer energy solutions, such as energy efficiency and self-generation or distributed generation—also called grid edge resources.

PGE is similarly interested in understanding DER development as a valuable addition to our broader energy portfolio. This notion underlies PGE's interest in creating a residential storage program that produces a cycle of benefits for the participating customer, the grid, and all customers. Thus, the customer value proposition is nested in the grid value proposition. GMP's concept for a residential storage program is informative, and there are lessons learned from GMP's experiences that PGE hopes to leverage.

GMP's residential storage program offers 2,000 units of the Tesla Powerwall 2.0 at a one-time fee of $1,500 or $15 per month.[a] Tesla is responsible for marketing to customers, enrolling customers, preparing site designs, and installing the batteries.[b,c]

PGE views this approach as problematic. While Tesla understands its product better than any other entity, Tesla does not necessarily understand utility customers and how to synthesize the customer value proposition with utility grid operations. Additionally, both the Vermont residential storage market and the Oregon storage market are too small for Tesla to develop a unique service territory approach. Thus, by April of 2018, GMP only had a few hundred units in place, although Tesla is expecting nearly two thousand units by early 2019.[d]

Liberty Utilities

Liberty proposed a pilot project like PGE's Residential Storage Pilot to its regulators in 2017.[e] New Hampshire Public Utilities Commission Staff denied the pilot proposal requesting Liberty return with a revised proposal with additional detail on marketing and outreach, emphasizing the need for program design that includes adequate resources and planning for customer acquisition and program administration. On November 19, 2018, a settlement was reached where the first phase of the pilot Liberty will offer 200 Tesla Powerwalls. Participating customers would be required to install two utility-owned batteries and controller software for a one-time, upfront installed fee of $4,866 or a monthly fee of $50 per month for ten years.[f,g] The second phase, under special conditions outlined in the settlement, will allow Liberty to install up to an additional 300 batteries which will include third parties to install up to 500 batteries through a Bring Your Own Device option.

PGE finds Liberty's proposal to pilot utility and third-party owned assets to be a productive way to evaluate which ownership models best address 'customers' needs.

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[a] Trabish, Herman K. "New Hampshire settlement moves 'cutting-edge' utility BTM storage pilot forward." *Utility Dive*, 27 November 2018, https://www.utilitydive.com/news/new-hampshire-settlement-moves-cutting-edge-utility-btm-storage-pilot-for/542866/.

[b] Pre-filed testimony of Elizabeth R. Nixon on behalf of Liberty Utilities. May 2018. www.puc.state.nh.us/Regulatory/Docketbk/2017/17-189/TESTIMONY/17-189_2018-05-03_STAFF_DTESTIMONY_NIXON.PDF.

[c] Green Mountain Power recently added a program that allows customer to participate with other storage devices, including offerings from Sonnen, Sunverge, and SolarEdge ("Battery Systems." *Green Mountain Power*, accessed on 9 Oct. 2018, greenmountainpower.com/bring-your-own-device/battery-systems/.)

[d] Pre-filed Testimony of Joshua Castonguay on Behalf of Green Mount Power. April 13th, 2018. https://greenmountainpower.com/wp-content/uploads/2018/05/2018-04-13-Castonguay-Testimony.pdf

[e] Liberty Utilities. "Direct Testimony of Heather M. Tebbetts." Docket No. DE 17-189. November 20, 2017. http://puc.nh.gov/Regulatory/Docketbk/2017/17-189/INITIAL%20FILING%20-%20PETITION/17-189_2017-12-01_GSEC_DTESTIMONY_TEBBETTS.PDF

[f] Ibid, Footnote A.

[g] Liberty Utilities. "Technical Statement of Heather M. Tebbetts." Docket No. DE 17-189. November 15, 2018. http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-189/LETTERS-MEMOS-TARIFFS/17-189_2018-11-19_GSEC_TECH_STATEMENT_TEBBETTS.PDF

PGE plans to explore additional value streams beyond the local network services (LNS), regional network services (RNS), and forward capacity markets (FCM) described in Liberty's proposal by operating the proposed residential storage assets as a true virtual power plant (VPP). PGE also plans to remain the aggregator of both utility and third-party-owned residential storage assets to enable PGE to integrate the VPP into grid operations and more fully explore potential value streams by aggregating across resource types (e.g. distributed storage, demand response). Based on PGE's experience with third-party aggregators (e.g. ENERNOC), PGE also recognizes contractual risk when a third-party provider retains the contract with PGE's customers. In the case of ENERNOC, PGE had to renegotiate demand response contracts with each of its customers after the relationship with ENERNOC expired and PGE chose to not renew. By directly establishing contracts between the customer and the utility, PGE can avoid contractual risk and provide stability in connecting the entity providing grid services to the entity using the grid services.

<u>Con Ed</u>

Con Ed, serving New York City, proposed the Clean Virtual Power Plant Pilot which was designed to address distribution congestion by achieving 1.8 MW (or 4 MWh) of residential storage. In addition, Con Ed offered to install solar plus storage, with the customer paying a monthly lease payment to a third-party for the solar system and a monthly payment to Con Ed for resiliency services.[h] Con Ed sought to explore three pricing frameworks: (1) resiliency payment as a percentage of expected solar savings; (2) resiliency payment as a percentage of their current utility bill; and (3) resiliency payment as a dollar value. Unfortunately, Con Ed's program was not deployed due to barriers presented by outdated building code standards which necessitated difficult and expensive upgrades to the residential circuit panels to incorporate energy storage devices.[i] PGE has identified this issue and has been working with new home builders on a storage-ready building specification. By modeling this code in new buildings, like market transformation strategies employed by the Northwest Energy Efficiency Alliance (NEEA), PGE is seeking to demonstrate and address how best to incorporate on-site residential energy storage.

7.1(b) Aggregated Dispatch

In PGE's Proposal and in the Stipulation, approved in Commission Order No. 18-290, PGE committed to aggregate and dispatch residential energy storage will as a fleet. For this pilot, PGE will explore two approaches to storage market adoption which include a BYOD and PGE owned model. Three platforms for aggregating and dispatching units, including the Enbala DER management platform, GenOnSys, and energy storage system vendor-specific DER management platforms (for PGE owned models) will be under consideration.

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[h] ConEdison. "REV Demonstration Project Outline – Clean Virtual Power Plant". July 1st, 2015. http://origin-states.politico.com.s3-website-us-east-1.amazonaws.com/files/CONEDDEMO3.pdf

[i] ConEdison. "REV Demonstration Project – Clean Virtual Power Plant 2017 1Q Quarterly Progress Report – Notice of Temporary Suspension of the Clean Virtual Power Plant Project." April 28th, 2017. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B6512D405-FA94-4BA6-B89D-732E53206358%7D

PGE uses the Enbala DER management platform to control business and government DR resources individually or as a fleet. While currently used for DR resources, PGE can have the Enbala platform incorporate energy storage into their platform in the coming year at low cost. To test this functionality and proof of concept, PGE will integrate a pilot energy storage system at City of Portland's Fire Station One by the end of 2019 through the Energy Partner program. Incorporating lessons learned on the commercial implementation will aide in our approach incorporating residential units into a "virtual power plant" platform as means to dispatch resources. PGE will be able to not only dispatch the energy storage system but aggregate them with existing DR resources. Dispatching energy storage and DR resources together can enhance the value of aggregated resources by increasing the total aggregate resource size.

As an industry leader in control of distributed resources, PGE operates a custom-built management platform built on generic control software, provided by Schneider Electric, to dispatch and control a fleet of customer-owned dispatchable standby generators.[j,k] The platform, GenOnSys, is currently dispatching over 115 MW of distributed, customer-sited back-up generators (i.e. DER) as a fleet. In a PGE internal pilot study, PGE used GenOnSys to dispatch customer-sited residential energy storage devices. The study revealed that the GenOnSys is currently capable of supporting additional DERs aside from back-up generation.

PGE may also use a DER management platform provided by the energy storage system vendor. PGE has already piloted this with the Sunverge platform since the summer of 2017 with a single customer-sited residential energy storage device. PGE has successfully dispatched the energy storage device during summer demand response events and has also dispatched the energy storage for peak shaving and has seen other successful implementations from leading providers such as Tesla.[l] Even if this is not the primary dispatch platform, it is likely that one of the above-mentioned management systems would need to integrate with the manufacturer provided dispatch platform.

Any one of these aggregation platforms (or some combination of them) would allow PGE to send commands to a fleet of residential energy storage devices. The logic that determines which command is sent, and when, to obtain the value of each use case will be common to the control logic for all energy storage. PGE plans to determine the best aggregation platform from these three options after selecting the vendor for the residential energy storage devices. With this approach, PGE will be positioned to evaluate a vendor-specific platform and will proceed with the best platform available for aggregating the specific residential energy storage devices.

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[j] Portland General Electric. "Dispatchable Standby Generation." Accessed on October 9th, 2018. https://www.portlandgeneral.com/business/get-paid-to-help-meet-demand/dispatchable-standby-generation

[k] AVEVA. "Portland General Electric – Dispatchable Standby Generation (DSG) Links 32 Generators at 21 Customer Sites Ensuring Grid Reliability at Peak Power Demands." Access October 9th, 2018. https://sw.aveva.com/success-stories/portland-general-electric

[l] Green Mountain Power. "GMP Launches New Comprehensive Energy Home Solution from Tesla to Lower Costs for Customers." May 12th, 2017. https://greenmountainpower.com/press/gmp-launches-new-comprehensive-energy-home-solution-tesla-lower-costs-customers/

The intent of dispatching the residential energy storage devices as a fleet is to address the potential use cases[m] in order of value. PGE recognizes the primary value of residential energy storage is Bulk Energy[n], followed by Ancillary Services. Localized T&D grid services are of incremental value. These values can be co-optimized to enhance the total potential value represented by a residential energy storage device, but only to the degree that the resource is of sufficient size to participate in delivering Bulk Energy and Ancillary Services (i.e. minimum of 1 MW).

PGE power operations dispatches in 1 MW increments. Using a Tesla Powerwall 2 as a benchmark resource would take approximately 300 operational units to meet this minimum requirement for a 4-hour period (the defined minimum to defer generation capacity).[o] Understanding that customers may prefer to reserve a portion of the energy storage capacity exclusively for backup purposes, the actual number of residential deployments may need to be larger than 300 units if PGE is to secure access to a minimum aggregate of 1 MW capacity to be made available for utility grid services. Charging of the batteries will be managed by the battery inverter system in coordination with signals from PGE's control system. To manage risk and maximize learnings, we recommend procuring sufficient capacity to provide PGE power operations with a usable resource while also retaining incremental capacity to support and test use cases associated with localized T&D grid services as defined in Order 17-375. For all these reasons, PGE is recommending integrating approximately 525 units.

In aggregate, fleet operation will be significant enough for grid operations to see the effects of the resource as it moves from the grid edge into distribution operations and up into the bulk system. Once PGE understands how best to design a controls hierarchy which co-optimizes the aggregate resource while retaining appropriate localized value for individual units, we will be better positioned to incorporate residential programs into the planning efforts in support of attaining localized T&D benefits. This represents a major learning for PGE which can also inform PGE's efforts to valuate and effectively integrate other DERs into T&D grid planning and operations. In the meantime, PGE will ensure customers receive the back-up power services they expect form their energy storage resources by reserving a portion of the energy storage capacity.

7.1(c) Risk Mitigation and Learnings Optimization

In Sections 7.5 and 7.6, PGE identifies program deployment and life cycle risks and mitigation strategies. Risks and mitigation strategies are further explored below.

Risk of Personal Injury and Property Damage

Safety of customers, employees and members of the public is our number one priority. New technologies, especially those that store large amounts of energy in our customer's homes, must be piloted in a way that minimizes the risk of personal injury and property damage.

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[m] The energy storage potential use cases available to PGE are defined in Order 17-375 in Docket UM 1756.

[n] The "Bulk Energy" value stream includes Generation Capacity/Resource Adequacy value and Energy Arbitrage.

[o] The Powerwall 2 has an effective energy capacity of 13.5 kWh. Dividing by 4 hours gives and average production of 3.375 kW per unit, resulting in need for 297 units to operate at 1 MW for 4 hours.

Minimizing these risks will be achieved by implementing mitigation strategies during energy storage system procurement, installation, and operation, and end-of-life. During procurement, PGE plans to only evaluate bids from vendors that have received: 1) all applicable Underwriters Laboratories, or equivalent listings; 2) have demonstrated that their devices can be installed in our service territory in accordance with all relevant codes and standards; 3) have successfully deployed energy storage systems in over 100 homes in the US; 4) are capable of detecting unsafe conditions and automatically shutting down equipment; and 5) have not had any instances of personal injury or property damage.

When installing energy storage systems, PGE will only contract with licensed installers that have been approved and trained by the energy storage system vendor. Installation will adhere to PGE indemnification policies and support customer claims. All systems will only be deemed ready for operation after receiving all applicable inspections and permits from all relevant jurisdictions and after PGE's interconnection team has inspected and performed all necessary testing. PGE will require installers to train customers in the safe operation and emergency shut-off of all equipment and disconnect devices will be accessible to PGE personnel.

Energy storage has well-developed and autonomous control systems that monitor for abnormal electric currents and temperatures. PGE is not aware of any case where a Li-Ion type battery fire occurred in a stationary application.[p] Even electric vehicle battery fires are rare and typically only occurred in a crash where a violent mechanical event occurred to the battery. The average residential battery has about one-half therm of stored energy, or about the amount in a half-gallon of propane. The safety measures implemented in energy storage systems and in all likely failure modes protect and mitigate against damage to the home. PGE plans to require the manufacturers to assume liability for damages caused by the failure of their product design and its implementation.

The program O&M budget includes an annual 30-minute electrician post-installation visit per unit to ensure the system has not been physically damaged and is performing as expected. The electrician will conduct a visual inspection of all equipment, check energy storage system performance parameters via a software diagnostic tool and test all emergency safety systems for proper functionality. In addition, during system operation, PGE will require the energy storage system vendor to monitor all systems remotely and notify PGE immediately if any safety-critical errors are received. Customers will also have access to energy storage system performance data via web-based and/or mobile applications.

The most common failure modes are detected by control login in the operating system on site. When an abnormal condition is discovered, a fault message is dispatched to the vendor and, if possible, PGE at the same time. Upon receipt of a safety message and/or abnormal telemetry data, the vendor will remotely shut down the equipment if shutdown has not already occurred. PGE or the vendor will dispatch a local crew to determine the root cause and take appropriate action to address the issue.

[p] There are of course, non-battery related fire risks associated with potentially faulty wiring. Per the code, residential installations must adhere to NESC and NFP 855 code requirements.

At energy storage system end-of-life, PGE will only use licensed and approved technicians to remove equipment. PGE will dispose of all equipment in accordance with local regulations and seek to recycle equipment where possible.

Associated Learnings

To ensure that PGE captures all relevant findings, we will document issues that arise in the installation, maintenance, and decommissioning of the units as well as the resolution strategy implemented. These will be documented both in internal project tracking as well as through stakeholder interviews from the evaluator.

Risk of Power Quality or Reliability Impacts

Installation of power electronics behind-the-meter could potentially result in power quality issues if the control systems are not properly configured and managed. Additionally, failure of the energy storage system could potentially have reliability impacts on the host customer.

PGE will actively monitor power quality and reliability on the host sites through its energy storage management platform and will ensure that alarms are in place to alert the operators to any issues that arise as soon as possible (we have piloted this monitoring through R&D installations at employee homes). Our budget allows for the deployment of electricians to host sites if issues require immediate on-site assistance, though most should be able to be resolved remotely through the management platform.

Associated Learnings

The data historian for the management system will allow PGE to track all issues as they arise. These data will be available for our program evaluator to capture the incidence and trajectory of issues through the pilot. These will help inform PGE on what to expect from systems in the field and will allow us to better understand what level of support may be needed to assure power quality is appropriately maintained.

Integration Risk

There are many issues that can arise in the integration of any DER into utility system operations. These include infrastructural barriers as well as software integration issues.

On the power systems side, limited hosting capacity can hamper DER deployment. While we do not anticipate hosting capacity to be an issue for this pilot, particularly given the small size of the individual energy storage systems, PGE will continue to develop expertise in performing hosting capacity assessments as-needed to support program deployment.

Communications infrastructure can also present an issue where systems rely on utility networks. While work is still being done to expand our field area network communications, we anticipate these systems initially being connected through a customer broadband internet connection or cellular modem. Maintaining this connection will be a requirement of participation and PGE will monitor communications uptime through its management platform.

Another issue is maintaining integration between software systems. Regardless of the management system utilized, there will likely be an integration maintained between the energy storage management system at the customer site and a central control system. PGE has included budget for controls that includes maintenance of these integrations whether it be by ensuring over-the-air updates take place for any firmware upgrades or updated integrations between platform application programming interfaces.

<u>Associated Learnings</u>

As part of the reporting and evaluation work, PGE will identify and record learnings. Learnings on working around hosting capacity issues will be captured in project documentation and through stakeholder interviews. PGE will also gain applicable learnings around smart inverter settings for customer-connected devices and will explore how different settings can affect hosting capacity. Communications downtime will be monitored through PGE's management platform and recorded in the data historian. Software integration issues will be documented as necessary.

Risk of Inopportune Timing

There is some risk that our deployment timeline may be misaligned with customer needs and/or system needs. This may be due either to some external project that may look to leverage rebates for residential energy storage (e.g. community energy initiative) or some development taking place that could potentially look to install many units in a single instance (e.g. a resilience-minded planned housing development). PGE will monitor these opportunities as they arise and assess the impacts to the pilot of participating, including impacts on cost, timeline, and project risks. PGE will keep communication open with OPUC Staff throughout the pilot and will consult with them on these issues as necessary.

<u>Associated Learnings</u>

Unexpected events can present great opportunities for new learnings. PGE will monitor these events as they come up and be sure to document them in the process evaluation. Where they present cases for program adjustments, we will analyze the impacts of these adjustments and consult with OPUC Staff on the prudency of moving forward with them.

Risk of Low Enrollment

Achieving the desired learnings from this pilot requires a large and diverse pool of participants (e.g. load profile). PGE will design participant selection to ensure a representative sample of PGE customers to the extent possible. Whatever the final total enrollment, control of the group will be analyzed to determine what minimum levels in a future program are required to extract value for any use case.

GMP successfully demonstrated strong customer interest in a program where the cost of the energy storage system is shared, so we expect a future program will reach the critical mass needed for any use case. Their first residential energy storage program, in which Tesla Powerwall 1 energy storage systems were leased to customers for $37.50 per month, quickly reached the 500 units maximum program size and began to accumulate a waiting list of interested customers.[q,r] Building on this successful program, GMP released a second program where customers can lease a Tesla Powerwall 2 for $15.00 per month with a program cap of 2,000 units.[1] The Powerwall 2 program launched in August 2017.

PGE will also evaluate program growth monthly, adjusting marketing and outreach resources as necessary to achieve the desired participation levels. PGE is also exploring integrating our residential energy storage pilot with the proposed Testbed pilot.[s] The pilot can provide additional outreach and marketing resources, potentially including an energy storage program as part of a larger, bundled offering.

Associated Learnings

PGE will track and report program enrollment throughout the pilot. The process evaluation will include review of marketing materials, benchmarking of similar programs, stakeholder interviews, and customer surveys. These tools will provide critical information on customer adoption of energy storage systems, and what works/what doesn't in marketing energy storage programs to residential customers. If differentials exist in enrollment between ownership models, it will be important to track customer motivations between the two options as reported in participant surveys.

Risk of High Enrollment

Another possible issue that could arise would be high and rapid uptake of the program offerings. While this would be an important finding for the pilot, this would need to be managed to ensure that rollout does not happen so quickly that it hampers the pilot's ability to adjust to other risks that may arise (as outlined in the other parts of the section) or exceeds the budget. PGE will closely monitor uptake at the onset of the program and be sure to space out installations if it seems that the program will be subscribed too quickly.

If after the first year the program implementation is running smoothly, the evaluation findings indicate that the program has been successful, and economic analysis presents an opportunity for a cost-effective rollout, then PGE would engage with OPUC staff to discuss the possibility of expanding the program. This would be like PGE's recent expanded DR programs, such as its residential thermostat program.

Associated Learnings

PGE will track program enrollment throughout the pilot. The process evaluation will include review of marketing materials, benchmarking of similar programs, stakeholder interviews, and customer surveys. These tools will provide critical information on the barriers to customer adoption and what works/what doesn't in marketing energy storage programs to residential customers. If differentials exist in enrollment between ownership models, it will be important to track customer motivations between the two options as reported in participant surveys.

[q] Conversations with Josh Castonguay, Vice President and Chief Innovation Executive at Green Mountain Power.
[r] GMP – Tesla Powerwall Innovative Pilot Program Rider (filled with Vermont Public Service Board on December 3, 2015).
[s] See PGE Advice No. 18-14 Attachment A.

Risk of Partner Failure

Residential energy storage systems are still an emerging technology with many product offerings coming from newer businesses with unproven business models. To mitigate the risks associated with key vendors no longer being able to perform their agreed-upon duties, PGE will require vendors to submit their credit information during the procurement process and only partner with organizations that present a low level of financial risk (this is already standard practice for PGE).

PGE will also seek to procure energy storage systems that adhere to open communications protocols and have discrete and serviceable components. If a vendor can no longer support portions of the energy storage system or software platform, components can be swapped out by licensed technicians and aggregation platforms changed to ensure program continuation. The use of discrete and serviceable parts also ensures the cost-effective repair of components like inverters, communications gateways, and batteries.

PGE will mitigate the risk of a vendor not meeting program delivery timelines and goals through deliverables-based contracting and the evaluation of back-up providers that can step in quickly should a vendor fail to meet their duties.

Associated Learnings

PGE will use this pilot to assess the performance of the hardware, software, aggregation, and operations and maintenance vendors contracted. In cases where vendors fail to perform duties we will adjust as necessary and conduct a post-failure analysis to understand the cause of that failure. Accounts of failures will also be documented by the evaluator through stakeholder interviews with key program staff at PGE and with its partners to understand all perspectives on critical issues.

Risk of Supply Chain Failure

As the energy storage market is still growing at a rapid pace, supply chain deals such as committing production to a single subscriber are not uncommon. These may be on the manufacturer side or be upstream on the battery cells or even raw materials. These delays could hamper our ability to rollout the pilot on the intended timeline. PGE will seek to mitigate this by engaging with vendors early to plan deployment, securing production and delivery guarantees, and managing customer expectations. If supply chain problems exist, PGE will pursue alternate vendors as appropriate.

Associated Learnings

Reasons for delays, where observed, will be recorded and mitigated where possible. Through stakeholder interviews, the evaluator will capture issues observed and recommend mitigation strategies for wider program deployments. Supply times observed in the pilot will be used to update program planning assumptions for future offerings.

Risk to Technological Obsolescence

Energy storage systems are still an emerging technology and product offerings that are state of the art today may become outdated within the program lifetime. To mitigate the risk of our offering no longer appealing to our customers, we will require vendors to provide product roadmaps during the procurement process, helping ensure that vendors will be able to provide updated product offerings.

PGE will also require vendors to guarantee support for all products for the duration of the pilot so that all assets remain usable. PGE may also select products with discrete components that are capable of being upgraded to maintain viability as technology progresses.

Associated Learnings

Where PGE observes rapid changes in product capabilities, these will be captured in the process evaluation. If major changes are observed in the pilot period, we will incorporate obsolesces assumptions into future models for program planning and cost-effectiveness.

Risk of dispersal

PGE understands that a few hundred units offered across the service territory are not likely to concentrate in one area of the distribution system at levels high enough for PGE to collect enough operational data and experience to directly learn about the T&D locational benefits of multiple batteries installed on one feeder or substation. PGE is preparing a strategy whereby a residential energy storage device could be first offered first to Test Bed participants with the hope of identifying and creating a cluster of residential batteries within the Test Bed to accelerate our learnings from the Residential Energy Storage pilot. Therefore, the Test Bed application maps of each substation in the Test Bed identifying the location of self-generation and roof-top PV. If this strategy yields too few enrollments, we will then expand to a wider population.

Associated Learnings

If successful targeted deployment is achieved, PGE will be able to demonstrate localized use cases directly at the Test Bed substations. These will be reported specifically for the residential batteries in the evaluation of this pilot as well as in aggregate with DR resources in the Test Bed evaluation report.

7.1(d) Learning Objectives

PGE aims to use this pilot program to gain experience in residential energy storage program design, procurement, customer acquisition, deployment, operation, maintenance, and end-of-life.

In broad strokes, this pilot would require evaluation of the following topics:

Table 36: Evaluation Topics (Residential Pilot)

Project	Quantitative Topics					Qualitative Topics				
	Bulk Energy	Ancillary Services	Transmission Services	Distribution Services	Customer Energy Management Services	Resiliency	Procurement	Infrastructural Readiness	Organizational Readiness	Customer Engagement
Microgrid	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Substation	✓	✓	✓	✓			✓	✓	✓	
Mid-Feeder	✓	✓	✓	✓			✓	✓	✓	
Residential	**✓**	**✓**	**✓**	**✓**	**✓**		**✓**	**✓**	**✓**	**✓**
Generation	✓	✓					✓	✓	✓	

The pilot will inform future program design elements, including but not limited to:

- BIS design, power output, and energy storage specifications;
- Effective capacity available for behind-the-meter systems;
- Customer acquisition and enrollment strategies;
- Differences in enrollment and operations between customer and utility owned systems;
- Procurement, installation, and commissioning best practices;
- Operational strategies;
- Fleet command software design; and
- BIS maintenance and end-of-life.

PGE also seeks to answer the following research questions:

- How can PGE most effectively leverage distributed energy storage to optimize benefits for generation, transmission, and distribution operations while also providing a compelling customer value proposition?
- What program improvements can be made to support successful dispatch of the aggregated BIS fleet to provide capacity, energy and ancillary services, and transmission deferral services?
- What additional services can the aggregate BIS fleet provide, and how can these benefits be best included in future program designs?
- What are PGE customers willing to pay for enhanced and power reliability?

- In what proportion should storage capacity be shared between PGE and customers to maximize total benefits?
- What business model is most compelling for the customer between utility and customer owned?
- What operations and maintenance issues arise from BIS operation, and how will that affect program maintenance costs?
- How will distributed energy storage contribute to PGE's broader set of distributed flexibility resources (such as DR and DSG)?

PGE also intends to evaluate program costs, realized system benefits, realized customer benefits and willingness to pay, and equipment ownership structure.

7.1(e) Data Collection Plan

Throughout the pilot, PGE will collect and maintain the following types of data:

- Battery state of charge, Volts, Amps, Watts at a 15-minute basis if not more frequent
- Battery reported charge/discharge rate
- Control signals sent from PGE to batteries
- Data on times when PGE system would benefit from battery charge/discharge and how much
- Alarms reported by storage management system(s)
- Customer AMI data, including kW, kWh, and service voltage at 15-minute increments.
- Customer rooftop solar production data (where relevant and available)
- Customer outage data
- Agreements between customers and PGE concerning storage device control
- Program tracking data
- Program marketing materials
- Participant survey data
- Stakeholder interviews
- Literature review of comparable programs

7.1(f) Evaluation Plan

For the residential program, PGE plans to engage a third-party evaluator to document and analyze program impacts and processes.

For the impact evaluation, there are three main areas in which problems could arise between the expected capabilities of the batteries and their actual performance for PGE system benefit:

- Do the batteries meet the expected capabilities? Is the degradation over time and with temperature changes greater or less than expected?
- When called, do the batteries' control systems respond as expected?

- How much of the theoretical maximum PGE system benefit can be gained given the need to reserve sufficient capacity to also provide specific customer benefit?
    - Do customers need to have units providing some minimum level of backup?
    - How does the balance between customer needs and system needs change seasonally, i.e., summer (low outage incidence) and winter (higher outage incidence)?
    - How do systems purely solar-fed (customer-owned systems subject to the investment tax credit) respond differently than those that are grid fed?

Area of Inquiry	**Data used**	**Analysis Method**
Do the batteries meet the expected capabilities? Is the degradation over time and with temperature changes greater or less than expected?	State of charge, battery-reported charge/discharge rate, customer AMI data.	Compare battery's nameplate charge/discharge rate with that observed by AMI. Compare observed changes in storage capacity with manufacturer guidance.
When called, do the batteries' control systems respond as expected?	PGE control signals, battery-reported charge/discharge rate, AMI.	Compare what PGE control signals call for the batteries to do versus the observed charge/discharge rate in AMI.
How much of the theoretical maximum PGE system benefit can be gained given realistic operation (e.g. imperfect foresight on charging/discharging; need to also provide customer benefit)?	Data on times when PGE system would benefit from charge/discharge and how much; control signals sent to batteries.	During periods when PGE is attempting to use the batteries in the way that it would with an at-scale battery program, compare control signals sent to batteries with data on potential PGE system benefit had the batteries been charged/discharged.

PGE's method of inquiry for the process evaluation include qualitative analysis of information gained from PGE in documentation, interviews, and analysis of other utilities' experience. The evaluator will conduct a thorough review of all program tracking data and marketing materials to ensure that they follow industry best practices. They will benchmark program outcomes and process against comparable utility programs to ensure to illuminate any ways that PGE and/or its customers deviated from what's commonly observed.

The program evaluator will implement a program logic model early in the process to document the intended causal model of the program and identify metrics to evaluate effectiveness at each step in the process. This will be critical in identifying where each data collection mechanism and associated metric will inform program design.

The process evaluation will use primary data collected from participant surveys and stakeholder interviews to answer research questions such as:

- How effective was the program at addressing customer needs and wants with respect to energy storage?
- What were the biggest barriers to implementation?
- What were the biggest factors in program success?
- How satisfied were participants with the program? Did this change over time?
- Were there any issues with the following processes:
  - Customer acquisition?
  - Installation?
  - Commissioning?
  - Calling events?
  - Ongoing operations/communications?
  - Operation in backup mode?
- What marketing messages/channels were most effective?
- Were there differences in how customers responded to different ownership models?
- How can PGE identify customer propensity to adopt, and did different types of customers adopt one model over another?
- What adjustments should be made from the pilot that would lead to a more effective program at scale?

7.1(g) Conclusion

PGE submits this addendum to its initial proposal, which includes a revised pilot project design that:

- Aggregates and dispatches residential storage units as a single resource;
- Manages and details mitigation strategies for all program deployment and life cycle risks;
- Optimizes learnings (shared control between the participant and PGE and shared benefits of the system with its participant); and
- Contains a data collection and a program evaluation plan.