Troutman Sanders LLP
100 SW Main St., Suite 1000
Portland, Oregon 97204

troutman.com

Chris D. Zentz
chris.zentz@troutman.com

January 17, 2018

VIA ELECTRONIC FILING

Washington Utilities and Transportation Commission
Attention: Records Center
P.O. Box 47250
1300 S. Evergreen Park Drive S.W.
Olympia, Washington 98504-7250

Re: Comments of National Grid USA In the Matter of Puget Sound Energy 2017 Integrated Resource Plans for Electricity and Natural Gas in Dockets UE-160918 and UG-160919

Dear Records Center:

Enclosed for filing are comments of National Grid USA on Puget Sound Energy's 2017 Integrated Resource Plan, which was filed in the above-referenced dockets on November 14, 2017.

Thank you for your attention to this matter. Please contact me with any questions or concerns.

Sincerely,

/s/ Chris D. Zentz
Chris D. Zentz

BEFORE THE WASHINGTON STATE UTILITIES AND TRANSPORTATION COMMISSION

In the Matter of Puget Sound Energy 2017 Integrated Resource Plans for Electricity and Natural Gas	DOCKETS UE-160918 AND UG-160919 NATIONAL GRID'S COMMENTS ON PUGET SOUND ENERGY'S 2017 INTEGRATED RESOURCE PLAN

A. Introduction.

National Grid USA ("National Grid") is proud to be involved with the development of the two most promising pumped storage projects in the Pacific Northwest, the Swan Lake North Project in southern Oregon ("Swan Lake"), and the Goldendale Energy Storage Project in southern Washington ("Goldendale"). National Grid is jointly developing these projects with Rye Development, LLC.[1] Both projects will utilize environmentally-friendly "closed-loop" technology, are located near high voltage transmission corridors, and will each be able to provide unmatched flexibility as a resource, serving multiple roles, and providing stacked energy, capacity, and other reliability and economic benefits on a utility and/or regional basis.

National Grid submits these comments ("Comments") on Puget Sound Energy's ("PSE") 2017 Integrated Resource Plan ("IRP"), in response to the State of Washington Utilities and Transportation Commission's ("Commission") "Notice of Opportunity to File Written Comments," which the Commission issued on November 21, 2017 in the above-referenced dockets.

In these Comments, National Grid emphasizes that, as part of this IRP, PSE should evaluate, and consider how to procure, regional, closed-loop pumped storage projects. In doing so, PSE should update the assumptions and figures for closed-loop pumped storage projects used in its IRP. The figures currently presented in the IRP are general assumptions and grossly overstate the costs of closed-loop pumped storage. National Grid is concurrently providing pricing information for Swan Lake with these Comments,[2] which is an example of a regional, closed-loop pumped storage project for which relatively advanced design and engineering has been performed. As a result, the figures reflected in the attached pricing information are a better representation of the costs of building a large, pumped storage project like Swan Lake or

[1] Rye Development, LLC shares National Grid's concerns and fully supports these Comments.

[2] National Grid's preliminary pricing information for the Goldendale project also suggests that PSE's cost assumptions in the IRP are overstated.

Goldendale. National Grid would be willing to meet with PSE or Commission Staff to further discuss these figures, including the data and assumptions used to develop them.

B. Benefits of Closed-Loop Pumped Storage.

Closed-loop pumped storage resources are capable of providing unparalleled energy, capacity, flexibility, and ancillary services to the electric grid. For example, in addition to providing carbon-free energy and capacity, closed-loop pumped storage can provide services such as energy shifting and arbitrage, ancillary services, avoided renewable curtailment, system peaking value, locational value, and distribution and transmission system upgrade deferral.

Closed-loop pumped storage can be defined as including projects that are not continuously connected to a naturally flowing water feature, meaning these projects, once initially filled, are able to continuously operate without a constant influx of significant amounts of additional water. As a result, these projects are more environmentally friendly than open-loop pumped storage projects, which require a continuous source of naturally flowing water. Consequently, closed-loop pumped storage projects have the least environmental impacts, given that the water used to power the generation turbines is constantly recycled and reused.

In addition to the above-referenced benefits, closed-loop pumped storage is indifferent to natural gas prices and, due to its flexibility, provides added reliability through portfolio diversity. For example, unlike many of the existing hydroelectric generating resources in the Pacific Northwest, which are subject to constraints associated with fish passage and protection, flow and flood control requirements, and preference power obligations, National Grid's Swan Lake and Goldendale projects would not be subject to similar operational constraints and, therefore, would provide greater flexibility to the electric grid. Thus, pumped storage projects like Swan Lake and Goldendale can provide an unmatched level of flexibility to meet changing energy and capacity needs, including the increasing demands associated with integrating renewable energy resources.

Two of the most significant benefits pumped storage can provide—benefits which no other resources can offer on the same basis—are the ability to integrate large amounts of renewable generation and optimize the output from PSE's existing generation fleet. For example, no viable resource, other than closed-loop pumped storage, can provide PSE with such a significant amount of upward *and downward* regulation capacity on a nearly instantaneous basis, every single day of the year. Operationally, fossil-fuel generators are constrained to minimum generation levels if they are to be available to provide upward regulation capacity. However, when those generation resources are already backed down to minimum run levels or are completely idle (often, in the spring runoff season), those resources are incapable of providing any further downward regulation capacity, resulting in the conditions we frequently experience in the Northwest—significant renewable generation curtailments due to low load and over-generation caused by simultaneous water runoff and high winds. In contrast, closed-loop pumped storage systems can absorb this over-generation on a year-round basis, thereby reducing the need to curtail renewable generation and minimizing PSE's Renewable Portfolio Standard ("RPS") costs, which in turn, maximizes the benefits of PSE's existing renewable resources and provides its customers with the greatest benefit from PSE's existing resources.

Additionally, closed-loop pumped storage facilities are uniquely capable of providing PSE with a "portfolio effect" to maximize the output and value of its existing generation fleet. By absorbing excess generation during periods of over-generation, and later discharging that energy during periods where PSE needs additional energy, closed-loop pumped storage optimizes each of PSE's existing assets, renewable or otherwise, thereby increasing the overall value that PSE's existing resources provide to its customers and improving the economics of its existing generation fleet.

Closed-loop pumped storage projects like Swan Lake and Goldendale are also well-suited to accommodate the future demands of the regional electric grid, while maintaining continued reliability. For example, closed-loop pumped storage will also help the region meet its climate policy goals—such as RPS compliance and any potential, future carbon policies established at either the state or national level. Projects like Swan Lake and Goldendale would significantly aid in RPS compliance by, at minimum, facilitating the integration of additional renewable generation and providing additional, carbon-free energy and capacity to the electric grid. Further, since both are carbon-free, environmentally-friendly "closed loop" projects, both of these projects would be well-suited to comply with any changes to the nation's or the state's carbon policies.

C. Relying on Natural Gas-Fired Resources to Meet Future Needs May Not be Realistic.

National Grid applauds PSE for considering scenarios that would involve no new thermal resources, or no thermal resources at all.[3] However, National Grid believes PSE's base scenario wrongly includes the addition of significant, additional thermal resources to meet its future energy and capacity needs.

Recent developments suggest that relying on the construction of large-scale natural gas resources may not be realistic. For example, in Portland General Electric's ("PGE") most recent IRP process,[4] PGE initially proposed constructing a second gas-fired generating facility at its Carty Generating Station.[5] Stakeholders in PGE's IRP strongly rejected this proposal.[6] In the face of weak support and strong opposition to PGE's proposal, PGE ended up pursuing other options to fulfill its capacity needs, including acquiring renewable generation resources and medium-term capacity from the market.[7]

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3 *E.g.,* PSE IRP at Ch. 6, p. 6-53, *et seq.*

4 *See* Oregon Public Utility Commission ("OPUC") Docket LC 66.

5 *See* PGE 2016 IRP, OPUC Docket LC 66 at § 13.4.1.1 (filed Nov. 15, 2016) (indicating PGE was performing due diligence for the potential acquisition of a second, natural gas-fired unit to be located at PGE's existing Carty Generating Station site).

6 *E.g.,* Comments of Sierra Club, Oregon Department of Energy, Industrial Customers of the Northwest Utilities, the Citizens' Utility Board of Oregon.

7 *E.g.,* PGE's Response to OPUC Staff's Report, Docket LC 66 at 5-6 (filed Aug. 4, 2017) ("During the IRP review process, the Commissioners, Staff, and other stakeholders encouraged PGE to explore short- and medium-term opportunities to acquire capacity in the marketplace from existing regional resources, such as hydro generation,

The barriers to development of new thermal resources are significant and include formidable stakeholder opposition, substantial permitting and construction risk and uncertainty, and the limited ability of these resources to meet future climate policies and de-carbonization goals. Consequently, relying on thermal resources to meet PSE's energy and capacity needs is an increasingly risky approach that is not well suited to future developments. As PSE acknowledges, absent the addition of large scale thermal resources, pumped storage is the only viable, grid-scale option to fulfill PSE's future energy and capacity needs.[8] As noted in Section B above, closed-loop pumped storage projects like Swan Lake and Goldendale could provide significant additional benefits to PSE, in addition to allowing PSE to retire its currently operating gas and coal plants and eventually transition its generation fleet away from carbon-emitting resources.

Although pumped storage is an attractive replacement for large, baseload power plants like gas and coal, PSE's use of generic cost assumptions in its IRP for pumped storage resulted in the costs of pumped storage being overstated. Based on National Grid's analysis for its pumped storage projects, the actual costs of pumped storage are much lower, which raises questions about the assumptions in the IRP that dual fuel frame peakers are cost effective, as compared to pumped storage.[9]

D. Actual Costs of Closed-Loop Pumped Storage are Much Lower Than the Generic Cost Assumptions Used by PSE in its IRP.

PSE's analysis of pumped storage as a potential resource relied on incomplete information, which resulted in pumped storage being characterized as more expensive than the base scenario selected by PSE in its IRP. PSE's pumped storage pricing analysis appears to be based on generic models and forecasts for hypothetical pumped storage projects.[10] However, actual data from closed-loop pumped storage projects currently under development in this region—such as Swan Lake and Goldendale—suggests that the costs to construct these facilities are much lower.

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instead of pursuing the resources included in the preferred portfolio. In light of this guidance and collaborative discussions with stakeholders. . . PGE contacted owners of existing capacity resources in the Pacific Northwest to determine whether there was available capacity starting in 2021. This market outreach confirmed that there is available medium-term capacity in the region that could be offered to meet the capacity need identified in PGE's Action Plan.") (emphasis added).

[8] PSE IRP at Ch. 6, p. 6-54 ("With no new thermal resources available, the only resource large enough to meet the capacity need is pumped storage hydro.").

[9] *See* PSE IRP at Ch. 2, p. 2-11 (noting that dual fuel frame peakers are cost effective (and therefore included) in every scenario); *see also* PSE IRP at Fig. 1-1 (indicating PSE needs over 2,400 MW of capacity by 2037 under the base scenario).

[10] *See* PSE IRP at Ch. 4, p. 4-31 ("Figure 4-1 summarizes generic resource assumptions.") (emphasis added); *accord* PSE IRP at Appendix D, p. D-37 ("Figure D-19 summaries the generic costs and assumptions used in the analysis for energy storage resources.") (emphasis added).

For example, in Table 4-18 of the IRP, PSE suggests that the overnight capital costs for a pumped storage hydro resource are approximately $2,400/kw-yr.[11] Based on National Grid's extensive engineering and modeling for its Swan Lake project, and with analytical support from Energy Environmental Economics ("E3"), National Grid conservatively estimates that Swan Lake would cost between $1,750 and $1,950/kw-yr to construct. This information, in addition to other pricing information for Swan Lake, which was prepared by E3, is presented in the table attached hereto as Attachment A. Attachment A also provides a comparison of the costs of constructing and operating Swan Lake against battery storage resources or a natural gas combined cycle facility. The project-specific figures and assumptions provided in Attachment A demonstrate that a closed-loop pumped storage resource like Swan Lake is cost competitive with these other types of resources. Furthermore, although National Grid's cost estimates for Goldendale are preliminary and subject to change, these initial estimates suggest that Goldendale's costs will be lower than those assumed in the IRP.

National Grid suggests that the Commission request that PSE hold a workshop to update its cost information for pumped storage and re-run its analysis using corrected figures and assumptions. In support of this effort, National Grid is willing to provide PSE or Commission Staff with the underlying data and assumptions that went into producing the figures in Attachment A.

E. PSE Should Evaluate Closed-Loop Pumped Storage in this IRP, Given that it is Considering Other Long Lead Time Projects.

PSE's IRP contains a proposed Action Plan that would include issuance of an all-source RFP sometime this year. Part of PSE's stated reasoning for the timing of this RFP is the fact that some of the resources in PSE's base scenario require long lead time investments, such a transmission system upgrades or construction of new transmission lines. For example, PSE notes, "Bringing on future additional renewable resources, whether in PSE's balancing authority or in BPA's, may require transmission system upgrades that will require long lead times to study, design, permit, and construct."[12] Therefore, given that PSE's proposed Action Plan includes consideration of resources requiring long lead time investments—such as transmission upgrades or construction—PSE should also consider regional, closed-loop pumped storage projects in this IRP.

In part due to the time and effort required to construct such a large infrastructure project, pumped storage resources require planning and support throughout their development process. As a result, a utility cannot just assume a pumped storage resource would be available in the future in order to fill any portion of its energy or capacity needs. Rather, these resources require some lead time to plan, permit, and construct, meaning PSE must

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[11] PSE IRP at Ch. 4, p. 4-32.

[12] PSE IRP at Ch. 1, p. 1-8 (emphasis added); *see also id.* (noting that issuing an RFP in 2018 for delivery in 2022 would provide potential respondents time to address long lead-time issues such as transmission).

engage with developers of these resources several years in advance of when PSE expects these resources to be available.

Additionally, although closed-loop pumped storage projects take some time to develop, the development timeline for these resources is often still shorter than transmission development. For example, PSE announced its Energize Eastside transmission upgrade project in December 2013; however, PSE did not even begin the permitting process until November 2017.[13] Thus, it took nearly four years for PSE to reach the beginning of the permitting. Following several years to complete permitting, it is likely PSE will still need several years to construct a large transmission project like the one proposed. Transmission projects that require action by BPA or other transmission providers may take even longer to reach commercial operation, if they ever do.

In comparison, National Grid conservatively estimates that Swan Lake will achieve commercial operation by 2024 and Goldendale will be operational by 2028. These timelines are largely attributable to the time and effort required to construct such large infrastructure projects. When considering only the time required to design and permit these projects, National Grid expects each of its pumped storage projects will have completed the permitting and licensing process in less than five years. Thus, in contrast to PSE's statements in the IRP,[14] closed-loop pumped storage projects like Swan Lake and Goldendale take less time to design, permit, and construct than projects involving significant transmission upgrades or construction. Moreover, the permitting timeline for pumped storage projects may be further condensed if the U.S. Senate approves a recent bill that was unanimously approved by the U.S. House of Representatives, which would shorten the FERC licensing process for these projects to two years.[15] If enacted into law, this two-year licensing process may be available for the Goldendale project, in which case it could be possible to accelerate the commercial operation date of that project.

F. PSE's Resource Forecast Currently Emphasizes Batteries, Which Are Not As Cost-Effective as Pumped Storage.

Although PSE's IRP contains some discussion of pumped storage as a potential resource, PSE's proposed Electric Portfolio Resource Additions Forecast ("Forecast") clearly focuses on batteries when discussing potential, viable storage options. For example, PSE states in its Forecast that it intends to "Install a small-scale flow battery to gain experience with the operation of this energy storage system in anticipation of greater reliance on flow batteries in the future."[16] Similarly, PSE goes on to note that, "This IRP finds energy storage,

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13 *See* Energize Eastside News, available at: https://energizeeastside.com/news.

14 PSE IRP at Ch. 6, p. 6-59 ("Pumped hydro resources also may have more extensive permitting processes and require sites with specific topologic and/or geologic characteristics.").

15 *See* Promoting Hydropower Development at Existing Non-Powered Dams Act, H.R. 2872 (115th Congress, 1st Session) (introduced June 12, 2017).

16 *Id*.

specifically flow batteries, to be a cost-effective part of the resource plan. While batteries are more expensive than peakers on a dollars per kW basis, batteries are more scalable, so they fit well in a portfolio with a small, flat need. . . ."[17] However, as demonstrated in the updated cost figures provided in Attachment A, closed-loop pumped storage projects like Swan Lake and Goldendale are much cheaper than batteries and cost competitive with new natural gas facilities. Therefore, as noted above, National Grid requests that the Commission require PSE to re-evaluate the role of pumped storage resources in its Forecast using updated pricing information.

G. Some of PSE's Statements and Assumptions Regarding Pumped Storage are Inaccurate.

National Grid also notes that certain of PSE's assumptions in the IRP regarding pumped storage resources are inaccurate. First, National Grid's projects are "closed loop," so they would not present the types of adverse environmental impacts PSE listed in the IRP as perceived negatives of these types of projects.[18]

Second, without conducting a more robust evaluation of National Grid's specific pumped storage projects, National Grid believes it would be impossible for PSE to determine whether Swan Lake or Goldendale could also provide PSE's system with transmission and distribution benefits. PSE cites these transmission and distribution benefits as a significant driver for the perceived value of battery storage.[19] Taken together, these inaccuracies, when coupled with the inflated cost assumptions noted above, result in PSE substantially undervaluing pumped storage resources like Swan Lake and Goldendale in its IRP and, not unsurprisingly, concluding that these projects are uneconomic when compared to PSE's base scenario.[20]

Therefore, in addition to updating its cost assumptions for pumped storage, as described in Section C above, National Grid requests that the Commission require PSE to revisit its analysis of pumped storage using real world assumptions and information from either of National Grid's projects. National Grid believes that, once accurately considered in the IRP, pumped storage resources like Swan Lake or Goldendale will be the most attractive, non-carbon resources that can economically meet PSE's future energy, capacity, and system flexibility needs.

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[17] *Id*. at p. 1-19; *see also* PSE IRP at Ch. 6, p. 6-30 ("When its flexibility benefit is combined with avoided T&D costs, battery technology becomes a cost-competitive resource because it is more scalable than thermal resources.").

[18] PSE IRP at Ch. 6, p. 6-59 ("[Pumped storage facilities] may have controversial environmental impacts.").

[19] *Id*. ("A key value stream from batteries is the ability to create transmission and distribution benefits that cannot be derived from pumped hydro.").

[20] *Id*. (Noting the sensitivity scenario involving 50 MW of pumped storage increased the net present value of the Forecast by $15 million over the base scenario.).

H. Closed-Loop Pumped Storage Has a Unique Ability to Deliver Additional Benefits to PSE's Customers.

Due to some of the recent developments in the Pacific Northwest, particularly including implementation of the energy imbalance market ("EIM"), the high voltage transmission interties with California experience frequent (*i.e.*, hourly or daily) interchanges of energy and capacity between the Pacific Northwest and California, which differs from the operational paradigm in existence when these transmission lines were conceived and constructed. As a result, resources like pumped storage, which can provide significant operational flexibility to the electric grid, are best suited to meet the changing demands brought about by recent developments such as the EIM and more frequent exchanges of energy and capacity with California.

The proliferation of renewable generation as a significant component of the regional energy supply, combined with flat or declining load growth, will only further exacerbate generation oversupply conditions in the Western United States. Closed-loop pumped storage is uniquely capable of remedying this problem by absorbing excess energy, particularly renewable energy, and returning it to the grid at a later time when the energy is needed. This capability becomes increasingly valuable as states like California transition a larger share of their resource mix to renewable resources in order to comply with state renewable portfolio standards, thereby resulting in cheap (or even negative) renewable over-generation. Given their geographic location—near the Oregon-California border (Swan Lake) and near the north end of the Pacific AC and DC interties with California (Goldendale)—National Grid's closed-loop pumped storage projects are ideally suited to absorb this excess energy and maximize this potentially significant value stream to the benefit of PSE and its customers.

If you have any further questions regarding these comments, please contact Nate Sandvig at (503) 602-0998 or Erik Steimle at (617) 701-3288.

Dated this 17th day of January, 2018.

Respectfully submitted,

/s/ Stephen C. Hall

Stephen C. Hall
Christopher D. Zentz
TROUTMAN SANDERS LLP
100 SW Main Street, Suite 1000
Portland, OR 97204
Phone: 503-290-2336
Steve.Hall@troutman.com
Chris.Zentz@troutman.com

Attorneys for National Grid USA

ATTACHMENT A

E3's Cost Comparison of Swan Lake to Other Types of Resources

Energy+Environmental Economics
101 Montgomery Street | Suite 1600 | San Francisco, CA 94104 | 415.391.5100 | www.ethree.com

High-level comparison between Swan Lake pumped storage-hydroelectricity and other types of generation and storage resources

The following represents a high-level comparison of pumped storage hydroelectricity (PSH), natural gas combined cycle power plants, and battery storage along several different metrics pertinent to project developers, investors, and local stakeholders. This not an exhaustive or definitive list and represents only one potential view of the differences among these energy storage and generation technologies. For reference, we consider both generic applications and specific examples in the Pacific Northwest context, such as Carty Generating Station built by Portland General Electric[1] and the proposed Swan Lake Pumped Storage Project in Klamath County, Oregon.

	Pumped Storage (Swan Lake PSH)	Battery Storage (Generic Lithium-Ion)	Natural Gas Combined Cycle (Carty Generating Station)
Capital Expenditure	$1,750 to $1,950/kW 400 MW, 9.5-hours of storage (~3,800 MWh), <$700M to $780M cost[2]	$3,088 to $7,336/kW for an 8-hr Li-ion system[3] 100 MW, 8-hours of storage (800 MWh), $309M to $734M cost	$1,166 to $1,519/kW (based on original and final Carty Generating Station Cost).[4] 440 MW, $514M original cost with overrun of ~$150M
Annualized Capacity Cost[5]	$243 to $269/kW-year	$542 to $1,245/kW-year	$167 to $214/kW-year
Useful Life	60-year lifespan	20-year lifespan	30-year lifespan
O&M Costs (Fixed and Variable)	Fixed O&M costs of $22 to $34/kW-year are comparable to O&M costs for an NGCC plant. O&M costs for Swan Lake could be lower using low cost oversupply of daytime solar from California. Variable O&M costs are minimal.	Fixed O&M costs range from $27 to $56/kW-year for most installations. At the lower end, these costs are competitive with a NGCC plant. Variable O&M costs are minimal.	O&M costs are dependent upon plant utilization. Fixed O&M costs are approximately $6 to $11/kW-year. Variable O&M costs are approximately $3 to $5/MWh of generation. Total (fixed and variable) O&M costs for Carty, in the PNW, were ~$24/kW-year recently. Future carbon pricing or taxes could contribute additional operating costs associated with CO2 emissions.

[1] https://www.portlandgeneral.com/our-company/energy-strategy/how-we-generate-electricity/carty-generating-station
[2] National Grid and Rye Development estimates
[3] Lazard LCOS v2.0
[4] http://www.oregonlive.com/business/index.ssf/2016/03/pge_sues_insurers_for_cost_ove.html
[5] Levelized fixed cost of capacity under comparable financing costs. E3 Analysis.

Fuel/Charging Costs **(Additional to O&M Costs)**	Pumping (“charging”) is the primary variable cost of operation. If able to charge at zero or negative prices in future, these costs may be negligible or may even provide revenue.	Operating costs mostly consist of the cost of charging the batteries. If able to charge at zero or negative prices in future, these costs may be negligible or may even provide revenue.	Fuel cost is dependent on gas prices and supply, which can be volatile. Average U.S. gas price for power plants over past 12 months was $3.50/MMBtu, but annual average has ranged from $2.83 to $9.27 in past 10 years.
Carbon Pricing	Not Applicable	Not Applicable	Applicable
History	Flexible, fast response variable speed pumped storage hydropower is an established, proven technology. Utility-scale solution to flexibility and overgeneration issues. Twenty-four existing pumped storage projects in operation in the US, ranging from 50 to 1800 MW in size.	Emerging technology, yet to be proven on a large 100+ MW scale. Is modular and can be built in small increments. There are a range of forecasts with a great deal of uncertainty around future costs. Cost of disposal and future remediation is uncertain.	Established technology with long track record of performance, but increasingly hard to permit due to tighter regulations and local opposition.
Climate/Environmental	Zero-carbon source of peak power (if charging from renewable sources). Increases deliverability of zero-carbon renewables and allows for more renewable integration. Closed-loop technology utilizes ground water only. No surface water or fish impacts. No threatened or endangered species issues. Oregon Water Resources Department Endorsement.	Zero-carbon source of peak power (if charging from renewable sources). Increases deliverability of zero-carbon renewables and allows for more renewable integration. Disposal and future remediation is uncertain. Lithium relies on mining and processing rare earth commodities.	Local air pollution, carbon emissions, air quality standards, and water impacts if not air cooled. Fast ramping and flexible technology like modern CCGTs can allow for more renewable integration compared to older thermal units although under highly renewable systems CCGTs would not be expected to be highly utilized.
Reliability/Capacity Value: Bulk vs. Local	Can only provide bulk system reliability/capacity value unless available transmission makes power deliverable to a constrained load pocket for local reliability/capacity value.	Can provide local distribution deferral value in addition to bulk system reliability/capacity value (if applicable) depending on location and size.	Can only provide bulk system reliability/capacity value unless available transmission makes power deliverable to a constrained load pocket for local reliability/capacity value.
Timescale/Applications	Short and Long duration storage, up to multiple days. Can integrate both diurnal solar generation, as well as wind generation which can have lulls/peaks that last days. Provides physical inertia to the system.	Typically, short duration, as the cost per additional hour of storage is currently relatively high. Does not provide physical inertia to the system.	Typically run continuously, following load (lower output off-peak). Expected to cycle and ramp up/down more frequently as penetration of intermittent renewables increases, driving up costs. Provides physical inertia to the system.

EIM Participation and Cost Savings to Ratepayers	PSH can participate extensively in the EIM by flexibly buying and selling power at sub-hourly intervals. E3's Swan Lake modeling illustrates participation in the EIM could deliver $35 to $231/kW-yr ($14 to $90 million/yr) in incremental value in 2030 by absorbing costly market volatility due to energy imbalances.	Battery storage can participate extensively in the EIM by both buying and selling power at sub-hourly intervals. The rapid response time of battery storage makes it ideally suited to a balancing role at short time intervals, such as the 5-minute market within the EIM.	NGCCs can participate in the EIM by changing generation at sub-hourly intervals, but NGCC capacity is less flexible and more expensive to ramp up and down than energy storage. Advanced NGCCs with greater operational flexibility exist, but are also more expensive to build and operate.
Economic Impacts	Create 3,360 full year equivalent jobs during development. Once in operation, Swan Lake: 35 full time jobs annually; plus, a new source of tax revenue in Klamath County ECONorthwest's Analysis indicates that the construction of the Swan Lake Project will have cumulative, direct, indirect, and induced economic impacts in Oregon of $523 million in output and 167 million in labor income.	Not assessed, but likely less localized due to concentrated and overseas manufacturing (e.g. Tesla's Gigafactory in Nevada, Samsung, Panasonic, etc.)	For Carty Generation Station 1 (440 MW): "100s of jobs during peak construction" and about 20 full-time workers during normal operation.[6] Early retirement (after 10 years) could cost PGE ratepayers average of 0.25c/kWh for another 10 years.

[6] http://www.power-eng.com/articles/2016/06/construction-winding-down-at-pge-carty-natural-gas-plant.html