PSE IRP Consultation Update
Webinar 1: Generic Resources Assumptions
May 28, 2020

6/18/2020

The following consultion update is the result of stakeholder suggestions gathered through an online feedback form, collected between May 13 through June 4, 2020 and summarized in the June 11 feedback report. The report themes have been summarized and along with a response to the suggestions that have been implemented. If a suggestion was not implemented, the reason is provided.

Pumped Storage Hydro

PSE received feedback from Nate Sandvig, National Grid Ventures, Bill Pascoe, Pascoe Energy representing Absoroka Energy & Orion Renewables, Katie Ware and Max Greene, Renewable Northwest; Fred Huette and Joni Bosh, Northest Energy Coalition (NWEC); Kathi Scanlan, WUTC staff; and Vlad Gutman-Britten, Climate Solutions, on the cost and operating assumptions of pumped storage hydro. This feeback included:

1. Overnight capital cost (cost that does not include interest/cost of capital)

   PSE has further reviewed other data sources for the capital cost of pumped storage hydro and has included the estimates from the Pacific Northwest National Laboratory (PNNL) report on energy storage. This estimate was already included as DOE Hydrowires 2019. Further, PSE has reviewed the assumptions for PacifiCorp's cost estimate (PacifiCorp, 2019 IRP) and concluded that it is very similar to the Swan Lake project and removed the PacifiCorp estimate so it is not double counted. The capital cost has been updated in the revised summary workbook Excel file for the generic resources assumptions available on PSE's IRP website under materials for Webinar 1 on pse.com/irp.

   Katie Ware, Renewable Northwest, notes that the PacifiCorp's draft IRP Pumped Storage Hydropower (PSH) generic resource looks to be based on Swan Lake. PSE read through PacifiCorp's generic resource assumptions and agrees, that their generic PSH resource appears to be the same as Swan Lake. PacifiCorp's draft IRP cost estimate was removed so that there isn't any double counting. Renewable Northwest also recommended additional review of the 2019 NWE Draft IRP (High) value. PSE reviewed NWE's costs and as a result will average NWE high and low cost estimates and then use the "mid" for the PSH capital cost average.

2. Operating characteristics

   PSE has reviewed the feedback received and contacted certain stakeholders (for example, Nathan Sandvig, National Grid Ventures; Bill Pascoe, Absaroka Energy & Orion Renewables, Fred Huette, Northwest Energy Coalition (NWEC)) to further discuss operating characteristics of pumped storage hydro.

   a. Nameplate capacity. The nameplate capacity will be reduced to 50 MW to assume a joint ownership and the ability to size to need.
   b. Operating range. The operating range will be updated to use 0% to 100% as supplied by Bill Pascoe and recommended by NWEC.
   c. Ramp rate. Newer technology allow the units to ramp at 20 MW/seconds. This is an input into the Plexos flexilibty model.
   d. Discharge rate. The input into the Aurora is the total energy of storage and the model will optimize the hours and energy used.

Battery Energy Storage System

PSE received feedback from Kathi Scanlan, WUTC staff, on using the Pacific Northwest National Labs (PNNL) report on energy storage. PSE reviewed the document and has included the cost estimates in the revised summary workbook Excel file for the generic resources assumptions available on PSE's IRP website under materials for Webinar 1 on pse.com/irp. PSE has also added the 2-hr Lithium Ion battery, and the 4-hr and 6-hr flow battery as resources options for the 2021 IRP.

Katie Ware, Renewable Northwest, and Vlad Gutman-Britten, Climate Solutions, provided feedback on using the Lazard levelized cost estimates. The discussion is provided below under captital costs, vintage year.

Vlad Gutman-Britten, Climate Solutions, provided feedback on on the PacifiCorp high battery storage capital cost. The high capital cost refers to a smaller 1 MW battery, so the cost was removed from the average and PSE will only use the cost estimate for the larger 15 MW battery.

PSE received feedback from Bill Pasco, Absoroka Energy & Orion Renewables, on battery degredation. The battery systems are assumed to have 0% degradation with an increased fixed O&M costs. This higher fixed costs are for maintenance over time to prevent the degredation.

Hybrid Resources

PSE received feedback from Fred Huette and Joni Bosh, NWEC; Kathi Scanlan, WUTC staff; Vlad Gutmen-Britten, Climate Solutions; Katie Ware and Max Greene, Renewable Northwest, on modeling hybrid or co-located resources such as solar + battery and wind + battery. In the 2019 IRP process, a 100 MW solar PV plus a 25 MW 2hr Lithium Ion battery was modeled with a 10% benefit to costs for co-locating the resource. The benefit represents that the battery can use the same substation and interconnection as the solar project. Also the battery received the benefit of the solar Investiment Tax Credit (ITC) since it was connected to the solar project. This same resource will be modeled in the 2021 IRP and a wind + battery resource will be added as well. PSE will model a 100 MW wind project located in Washington with a 25 MW 2hr Lithium Ion battery. The costs will be modeled with a 10% reduction for the benefit of co-location. The revised summary excel file has been updated to include these resources.

Capital Costs

Many stakeholders gave feedback on the data sources used for the capital cost average.

1. **Dated information.** PSE received feedback from Fred Huette and Joni Bosh, NWEC, and Vlad Gutman-Britten, Climate Solutions, about using dated sources. PSE has made sure that only the most current information is used for the cost averaging. The updated data is included in the revised summary Excel file. Older data from 2016/2017 is included in the file for comparison purposes, but is not used in the cost average cacluation.
2. **Other utilitiy cost estimates.** Vlad Gutman-Britten, Climate Solutions, suggested that averaging data for capital costs should not be based on so many utility IRP projections. We feel this in an important data point since utilities usually hire a consulting firm to develop this information, as it gives an important perspective from the utility point of view. PSE will keep the other utility cost estimates in the cost average including PSE's 2019 IRP process estimates from HDR (Generic Resource Costs of Integrated Planning, October 2018).
3. **ATB low cost estimate.** Fred Huette and Joni Bosh, NWEC, suggested to use both the low and mid National Renewable Energy Laboratory (NREL) ATB cost estimate. Per the NREL website, the mid case is the most likely scenario, so PSE will only include the mid cost estimate in the cost average and not add the low.

    Three future scenarios (Constant, Mid, and Low technology cost) through 2050 to reflect a range of perspectives based on published literature:

    a. **Constant Technology Cost Scenario:** Base Year (or near-term estimates of projects under construction) equivalent through 2050 maintains current relative technology cost differences and assumes no further advancement in R&D.
    b. **Mid Technology Cost Scenario:** Technology advances through continued industry growth, public and private R&D investments, and market conditions relative to current levels that may be characterized as "likely" or "not surprising."
    c. **Low Technology Cost Scenario:** Technology advances that may occur with breakthroughs, increased public and private R&D investments, and/or other market conditions that lead to cost and performance levels that may be characterized as the "limit of surprise" but not necessarily the absolute low bound."

4. **Cost curves.** At the suggestion of Fred Huette and Joni Bosh, NWEC, and Vlad Gutman-Britten, Climate Soluations, PSE has compared the Annual Energy Outlook (AEO) cost curves and the NREL ATB (NREL, 2019 Annual Technology Baseline) cost curves. PSE will use the NREL cost curves for future capital costs. This update has been reflected in the revised summary Excel file.
5. **Owner's costs.** Vlad Gutman-Britten, Climate Solutions, requested additional information of the costs that go into owner's costs. Owner's costs are included in overnight costs and are different than Allowance for Funds Used During Construction (AFUDC). The capital costs shared with the IRP stakeholders on May 28 represent "Overnight Capital Costs" which estimate the cost of building the project "overnight" and therefore do not include extra costs incurred during construction. Capital costs are inclusive of the Engineering, Procurement and Construction (EPC) plus the Owner's costs (financing costs), but generally do not include interconnection costs.
6. **Allowance for Funds Used During Construction (AFUDC).** PSE will assume a generic assumption of 10% to the overnight cost to reflect AFUDC from the 2019 IRP process. The revised summary Excel file has been updated to include the total all-in costs that include AFUDC.
7. **Interconnection costs.** The the assumption from the 2019 IRP process will be used for the 2021 IRP. This includes to cost of a substation, 5 miles of transnsmission lines, and 5 miles of gas pipline for the natural gas (NG) . A full discussion of the assumption is included in the HDR report (Generic Resource Costs of Integrated Planning, October 2018) on the PSE's IRP website. The revised summary Excel file has been updated to include the total all-in costs that include interconnection costs.
8. **Vintage year for average**. Many of the data sources used provide costs for different vintage years. PSE used the year with the most data and averaged across data sources that provided costs for that particulat vintage year.This meant that certain data sources were left out because costs were provided for a different year. For example, the battery storage resource was averaged for the year 2020 since that had the most data points. But this meant that the costs for the Lazard report (2019 Levelized Cost of Energy) were left out since those were for a 2018 vintage plant. The different data sources did not provide any information on inflation to change the costs into a different vintage and PSE did not make any assumptions to change the vintage year. For the 2021 IRP, PSE will remain with this assumption, but is open to suggestions for how to handle it in future IRPs.

Economic Life

PSE received feedback from Kathi Sclanlan, WUTC staff, on the assumed economic life of resources stating the solar photovoltaics (PV) economic life has substatiantially increased. PSE has researched this and found that the current manufactors of solar PV will warranty the panels for up to 25 years. Given this information, PSE will update the economic life of solar from 20 to 25 years.

Bill Pascoe, Absaroka Energy & Orion Renewables, asked what is the assumed operating life for pumped stoage hydro (PSH) and battery storage. PSH is assumed to have a 30 year-life and batteries are assumed to have a 20-year life.

Hydrogen as a Fuel

Many stakeholders, including Kevin Jones and Rob Briggs of Vashon Climate Action Group and Doug Howell of the Sierra Club, gave feedback on using hydrogen as a fuel source for the natural gas generators. PSE has consulted with industry experts and thermal plant engineers. This is an emerging fuel source and PSE will continue to monitor the progress of the technology and applications in the US and abroad, as well as continue our involvement in the development as a member of Renewable Hydrogen Alliance. Many companies are developing hydrogen ready gas turbines that can start with a blended hydrogen to NG fuel and in future years retrofit the combustor to run on 100% hydrogen. Though the technology for turbine exists today, the supply for 100% hydrogen does not. The current gas transportation pipelines can only handle a 3% - 10% hydrogen mix. To move to a higher concentration of hydrogen would require new pipelines or electrolyzer and storage on site. The cost to create the hydrogen fuel is currently unknown. PSE is researching the cost of a hydrogen ready gas turbine and the cost for future retrofits to handle 100% hydrogen along with the costs for the fuel supply. PSE will provide an update on our findings as we begin the portfolio modeling and if there is enough iformation to include it as a resource option in the 2021 IRP. Even if there is not enough information to include it as a resource option, the 2021 IRP will include a discussion of hydrogen as a fuel and the technology need for the fuel supply.

Summary of all Updates

PSE appreciates the feedback provided by stakeholders. In summary, the Excel summary workbook includes the following changes:

- Pumped Storage Hydro overnight capital costs revised to include more data sources and averaging across vintage year 2021 instead of 2020.
- Pumped Storage Hydro size assumption has been revised to 50 MW. PSE will also update operating characteristics for PSH to reflect newer techonology.
- Considering hybrid resources, certain changes have been made in the summary Excel file. Wind + battery resource as been added. PSE will model a 100 MW wind project located in Washington with a 25 MW 2 hr Lithium Ion battery.
- PSE has adopted the NREL data to generate cost curves.
- AFUDC and interconnection costs have been added in a new tab to calculate the all-in capital costs that will be used in the models.
- PSE will update the economic life of solar from 20 to 25 years.
- PSE will further develop costs concerning hydrogen as a fuel for application in the 2021 IRP analysis or if that is not feasible, the 2021 IRP book will include a robust discussion of the state of the industry concerning hydrogen.
- Lithium Ion 2-hr battery and flow 4-hr and 6-hr battery added. PSE was able to collect some other data sources from the PNNL energy storage report and some other utility IRPs besides the HDR report (Generic Resource Costs of Integrated Planning, October 2018).

Figure 1 below is a table comparing the costs from the 2019 IRP, the draft 2021 IRP as presented on May 28, and the updated capital costs after stakeholder feedback. The following table is also located in the revised Excel summary file under the tab “summary” and available for stakeholders can track the costs and calculations.

Figure 1: Overnight capital costs

(2021 Vintage, 2016 U.S. Dollars)	**Overnight Capital Cost ($/kW)**		
	2019 IRP	2021 IRP draft	2021 IRP proposed
CCCT	991	927	943
Frame Peaker	618	660	664
Recip Peaker	931	1,248	1,256
Solar Utility	1,422	1,226	1,264
Solar Residential	--	2,848	2,957
Onshore Wind	1,438	1,484	1,421
Offshore Wind	5,730	4,971	4,377
Pumped Storage	2,176	2,515	2,145
Battery (4hr, Li-Ion)	2,427	1,900	1,542
Battery (2hr, Li-Ion)	1,455	--	849
Battery (4hr, Flow)	1,625	--	2,051
Battery (6hr, Flow)	2,244	--	2,860
Solar + Battery	2,698	--	1,901
Wind + Battery	--	--	2,043
Biomass	7,744	5,119	5,246

Figure 2 below is a table showing how the AFUDC and interconnection costs are added to the overnight for the final all-in costs that PSE will be using for portfolio modeling. The following table is also located in the revised Excel summary file under the tab “summary” and available for stakeholders can track the costs and calculations. The cost curve with costs by vintage year are also included with this table.

Figure 2: All-in capital costs

(2021 Vintage, 2016 U.S. Dollars)	Overnight Capital	AFUDC	Interconnection Costs	Total All-In Capital cost
CCCT	943	94	91	1,128
Frame Peaker	664	66	134	865
Recip Peaker	1,256	126	143	1,525
Solar Utility	1,264	126	100	1,489
Solar Residential	2,957	296	--	3,252
Onshore Wind	1,421	142	47	1,610
Offshore Wind	4,377	438	65	4,878
Pumped Storage	2,145	214	47	2,406
Battery (4hr, Li-Ion)	1,542	154	367	2,063
Battery (2hr, Li-Ion)	849	85	367	1,301
Battery (4hr, Flow)	2,051	205	367	2,624
Battery (6hr, Flow)	2,860	286	367	3,513
Solar + Battery	1,901	190	420	2,511
Wind + Battery	2,043	204	373	2,620
Biomass	5,246	525	607	6,378