IPA Integrated Resource Planning Workshop #2: Candidate Resources

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Question 1

Are there specific resource types that are not adequately captured by the proposed categories and should be reflected in the IRP framework?

Yes, long-duration storage and multi-day storage are not reasonably represented. There are four major shortcomings:

1) 10-24-hr duration storage (i.e. inter-day long-duration storage (LDES)) is not represented at all;

2)>24-hr duration storage (i.e. multi-day storage) is also not represented at all;

3) "Generic LDES" is an inappropriate, overly-simplistic way to model the distinct inter-day LDES and multi-day storage resource classes;

4) The cost assumptions for "Generic LDES" are also unreasonable, because they are not based on any actual technology. Specifically, E3 explains in the "Data Sources" table of the Cost Workbook that, for Generic LDES with a 100-hour duration: "Technology costs [are] taken as the average between thermal energy storage (PNNL ESGC) and iron-air battery (Form) technologies. 2023 and 2030 values taken directly from literature, with linear interpolation and exponential extrapolation through 2050."

This is an inappropriate way to model long-duration storage in general, and multi-day storage specifically, because:

a) It does not accurately represent either thermal energy storage or iron-air energy storage attributes;

b) It does not capture a reasonable diversity of technologies within the LDES resource class;

c) It does not recognize that three energy storage classes should be modeled (short duration, long-duration, and multi-day storage);

d) It does not allow for technology-neutral model results, which is especially important in resource categories like inter-day LDES and multi-day storage where many emerging technologies are in competition

As further explained in response to Question #2 below, the best-practice IRP approach is to model distinct “resource classes,” within which many different technologies should be represented. This will allow the model itself to accurately consider many technologies, while model outcomes should be represented in a technology-neutral manner by aggregating individual technology results by “resource class.” For example, model outputs should show a need for “X GW of inter-day LDES,” or “Y GW of multi-day storage,” based on the total capacity of individual technologies within this resource class that may have been selected by the model (e.g. various battery chemistries, compressed air or CO_2 energy storage, thermal storage, advanced pumped hydro, etc.), rather than specifying needs for any one storage technology.

Question 2

Are there any resource categories that should be added, removed, or redefined to better reflect meaningful differences in cost, performance, or system value?

We strongly encourage the ICC to include four new technology-neutral “resource classes,” within which many individual technologies should be modeled.

These resource classes should be:

1) Short-duration energy storage (<10-hours)

2) Inter-day long-duration energy storage (10-24 hours)

3) Multi-day long-duration storage (>24-hours)

4) Clean firm

The “short-duration (<10-hr),” “inter-day LDES (10-24-hr), and “multi-day LDES (>24-hr) resource classes should substitute for the existing “Generic LDES” category, which should be removed. Additionally, the “clean firm” category should substitute for the existing two nuclear technologies.

The ICC should include many technologies within each of these resource classes. For example, within the three short-duration, long-duration and multi-day energy storage classes, this technology list should include at least the following, using actual technologies:

1) <10-hour storage (short-duration): li-ion batteries; flow-batteries; compressed gas energy storage (inclusive of air and CO_2); thermal energy storage; pumped hydro

2) 10-24-hour storage (long-duration): li-ion batteries; flow-batteries; thermal energy storage; compressed gas energy storage (inclusive of air and CO_2);

3) >24-hr storage (multi-day): iron-air batteries; thermal energy storage; compressed gas energy storage (inclusive of air and CO2);

For "clean firm" resources, the ICC should include at least the following technologies: nuclear, enhanced geothermal, renewables + storage (using many combinations of renewable energy and energy storage pairs to capture a realistic range of hybrid resource types).

This approach will allow the ICC to achieve several important outcomes:

–Understand resource needs by technology-neutral "resource class"

–Accurately model many competing technologies within similar resource classes

–Account for cost uncertainty within resource classes that have many different emerging technologies

–Better design procurement in a manner that allows for competition and that seeks resource classes, not individual technologies.

The best-practice manner to account for high uncertainty in emerging technology costs is to model many different individual technologies as inputs, while grouping technologies by resource class when representing model outputs. This ensures that individual technology types will be modeled accurately, while displaying model outcomes in a technology-neutral manner. The purpose of this approach is to identify needs for a specific resource class (e.g. multi-day storage, or clean firm capacity) without specifying technology preferences.

For example, if the model selects X GW of Form Energy's 100-hour duration iron-air battery, but no other multi-day storage technologies, the model should show this result as "X GW of multi-day storage." This conveys a need for multi-day storage as part of a least-cost portfolio, while recognizing that actual technology winners will only be identified via competitive procurement over time.

Question 3

What feedback do you have on the proposed base case cost assumptions for mature technologies (including solar, wind, lithium-ion storage, and gas)?

Please indicate which specific assumption you are commenting on, describe the reason for your feedback, and provide any alternative data source or supporting materials that you would like us to consider to support your recommendation. Please provide a link or share via email.

No comment at this time

Question 4

What feedback do you have on the proposed base case cost assumptions for emerging technologies (including nuclear and long duration storage)?

Please indicate which specific assumption you are commenting on, describe the reason for your feedback, and provide any alternative data source or supporting materials that you would like us to consider to support your recommendation. Please provide a link or share via email.

The specific assumptions for “Generic LDES” are unreasonable, as explained above. The Cost Workbook “Output Tables” show a significantly inaccurate $6,163/kW capex cost for “Generic LDES” in 2030, modeled as 100-hour energy storage.

As noted above, the ICC should represent many actual technologies, rather than a single "Generic LDES" resource that does not represent an actual technology.

Form Energy limits its specific recommendations about cost assumptions only to Form Energy's 100-hour iron air battery assumptions.

The following are several third-party references to 100-hour iron-air batteries:

–Xcel Energy 2024 Just Transition Solicitation Plan: $2,400/kW capex, 2030 COD; p. 198 (source: https://xcelnew.my.salesforce.com/sfc/p/#1U0000011ttV/a/8b000003N3eQ/QodCDDNR0HUF75Rb_nOkwu_MzfeKzPduYws13FjugGs)

–PacifiCorp 2025 IRP: $2,730/kW capex, 2027 COD, (source: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2025-irp/2025-irp-support-studies/Public_SSR_Database_Summary_Tab_2025.xlsx)

–Idaho Power 2025 IRP: $3,000/kW capex, 2030 COD, p. 22 (source: https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/2025IRP/2025%20IRP%20Appendix%20C.pdf)

–CPUC 2024-2026 IRP Inputs and Assumptions, $2,904/kW, 2030 COD, p 108 (source: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2024-2026-irp-cycle-events-and-materials/2025_inputs_and_assumptions_report_20260210.pdf)

–DOE LDES Commercial Liftoff Report: $1,900-$2,500/kW, ~2030 COD, p. 12 (source: https://www.sandia.gov/app/uploads/sites/256/2023/09/Pathways-to-Commercial-Liftoff-LDES-May-5_UPDATED.pdf)

Question 5

What feedback do you have on the proposed commercial availability timelines shown on Slide 18? Please identify any technology timelines you believe should be revised, why you think it should be revised, and any supporting data or materials you have to support your recommendation.

The ICC base case should assume that long-duration energy storage, inclusive of multi-day energy storage, is commercially available in 2030. It is unreasonable to assume that these resources are only available starting in 2037 in the base case.

As noted above in response to Question 4, several recent utility IRPs and state IRPs have rightly assumed that long-duration storage is available earlier by 2030 in the base case.

Form Energy alone has announced 75 GWh of projects under agreement, including the largest battery system by energy capacity announced globally to date: a 300 MW / 30,000 MWh iron-air battery project with Xcel Energy in Minnesota to help power a new Google data center. Form Energy has additionally announced projects with Great River Energy, Georgia Power, Dominion Energy, the California Energy Commission, the New York State Energy Research and Development Authority, a supply agreement with Crusoe Energy, and a project in Maine with support from the U.S. Department of Energy for the second-largest energy storage project announced globally.

Question 6

Please refer to the approach to modeling VPPs in this IRP on slide 29. Are there any targeted refinements you would recommend to improve the robustness of this approach and the results?

No comment at this time

Question 7

As shown on Slide 29, this IRP will model one representative VPP made up of multiple DER building blocks. Please rank which VPP building blocks you believe are most important to include in a representative VPP. (BTM solar, BTM storage, Managed EV charging, Residential smart thermostats, Water heater controls, Commercial building controls, Others).

BTM storage; BTM solar; Managed EV charging; Residential smart thermostats; Water heater controls; Commercial building controls; Others

Question 8

Slide 30 identifies key VPP parameters that will inform the representative VPP to be modeled in the IRP. Please use the parameter categories shown when responding to the following questions. Please provide specific assumptions where possible with supporting data sources and/or program examples, where available.

- *Based on the building block rankings you provided in your response to the previous question, please specify the percentage of total VPP nameplate capacity you recommend assigning to each building block.*
- *Of those building blocks, how would you distinguish between existing and new resources in your proposal?*
- *What available capacity should be assumed for this VPP? How should it be assumed to vary over the year?*
- *How long may this VPP sustain the response? How frequently?*
- *What may this VPP cost?*

No comment at this time

Question 9

Do you have any feedback to provide on the Assumptions workbook separately posted? Please note the specific assumption, your recommendation, and any data or supporting materials to support your recommendation.

Yes. Form Energy has significant concerns about how long-duration storage and multi-day storage are represented, as well as how Form Energy's 100-hour iron-air batteries are represented. Please see responses to Questions #1, #2, and #3.

Question 10

If CCS is considered as an added, co-paired technology with natural gas resources in a scenario:

- *What is a likely timeframe for when this technology could be reasonably expected to be commercially operational and accessed?*
- *What is reasonable costing for this technology to be included in modeling and analysis? Include data and reports to support your answer.*

If CCS is added as a technology, it should be modeled within the "clean firm" resource class discussed in response to Question #2. Gas + CCS competes with nuclear, geothermal, and renewables + storage hybrid resources. Needs for these resources should all be evaluated in a technology neutral manner.

Question 11

While current policy expects that CCS would fully sequester all carbon emissions to comply with CEJA (i.e. 100% carbon sequestration), a lower percentage of carbon sequestration may be more likely (e.g. 80% or 90% of sequestered carbon, i.e. 10-20% carbon emissions). Please provide a recommendation for a different percentage if 100% carbon sequestration is deemed to not be operationally likely during the term being modeled (2027-2047). If a different percentage is proposed, please support your recommendation.

No comment at this time