Form Energy Comments on Long-Duration Energy Storage Study Stakeholder Session #2 Presentation

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Dear Dr. Ferguson

Form Energy appreciates the opportunity to comment on the "Charging Forward" study that the Massachusetts Department of Energy Resources (DOER) and the Massachusetts Clean Energy Center (MassCEC) are conducting about mid- and long-duration energy storage in compliance with Section 80 of Chapter 179 of the Acts of 2022, *An Act Driving Climate Policy Forward*. These comments focus on Stakeholder Session #2 results presented on August 16, 2023 (Stakeholder Session #2 Presentation)[1] and offer recommendations about how the Commonwealth should interpret and act on these results.

Summary Recommendations

The primary purpose of this study is to inform the design of energy storage procurement programs to help mid and long-duration energy storage overcome barriers to their deployment and to advance the Commonwealth's progress to achieving a reliable, zero carbon grid. The draft results presented at Stakeholder Session #2 provide strong evidence about the value of mid- and long-duration storage and point to the following key conclusions:

- Gigawatts of mid- and long-duration storage resources are needed to support regional grid reliability by 2030, and that need increases over time to more than 20GW by 2050

[1] Charging Forward: Energy Storage Toward a Net Zero Commonwealth: Stakeholder Session #2: Study Update and Draft Results, August 16, 2023.

- There are distinct classes of energy storage resources, and they have differing costs, performance attributes, and reliability benefits that warrant separate treatment
- It is necessary to distinguish multi-day storage from intra-day long-duration storage
- New state procurement or incentive programs are needed to close the gap between the costs of emerging mid- and long-duration energy storage and the revenues they can receive from state programs and wholesale market services.
- ELCC values are highly variable and sensitive to assumptions about the future resource portfolio. Their use as an input to long-term planning studies and in resource valuation should be limited.
- Reliability risks that emerge at high levels of renewables and low levels of existing thermal resources warrant specific study to identify optimal solutions to these risks
- From a reliability standpoint, it is a no-regrets investment to cultivate multi-GW-scale markets of mid-, long, and multi-day storage resources by 2030 to advance progress to achieving a reliable zero carbon grid in the long-term
- Future study updates should recommend reasonable procurement targets for mid-, long- and multi-day storage classes by 2030

<u>About Form Energy</u>
Form Energy is a Somerville, MA based company that is commercializing and manufacturing a new class of multi-day energy storage systems to enable a fully renewable electric grid that is reliable and cost-effective year-round, even in the face of multi-day weather events. Our first commercial product is a rechargeable iron-air battery capable of continuously discharging electricity for 100 hours at a system cost less than 1/10th the total installed cost, per unit energy, of lithium-ion battery technology. Form Energy has over 3 GWh of projects under contract and development, with our first project expected to come online in 2024 with utility Great River Energy in Minnesota. With over 500 employees, Form Energy also has offices in the San Francisco Bay Area and the Greater Pittsburgh Area. Our first commercial manufacturing facility is under construction in Weirton, West Virginia, and will employ more than 750 people and have an annual production capacity of 500 megawatts when operating at full capacity.

Recommended Study Findings

Based on the Stakeholder Session #2 draft results, there is sufficient evidence to support the following study conclusions. We encourage DOER and MassCEC to include these findings in the final report and recommendations due to the Legislature.

1. **GW of mid- and long-duration storage resources are needed to support grid reliability by 2030, and that need increases over time to more than 20 GW by 2050**

The study's reliability modeling adds new evidence that at least 10 GW of multi-day storage (modeled as 100-hr storage) by 2030 will have stable, high reliability value through 2050. It also found that at least 5 GW of mid-duration storage and 5 GW of short duration storage deployed by 2030 will have a stable, high reliability value through 2050. By 2050, at least 20 GW of multi-day storage may be needed to meet grid needs for firm zero carbon capacity.

The ELCC curves show that these resources are no regrets investments from a reliability standpoint and that multi-day storage has a more stable reliability value than shorter duration storage resources as the grid decarbonizes. Although ELCC curves do not provide information about what resource mix is least-cost, they show that these resources can contribute significantly to grid reliability needs by 2030. The ELCC results also align with the Clean Energy and Climate Plan's (CECP) findings that at least 20 GW of diverse energy storage is part of the least-cost 2050 resource mix.

2. **There are distinct classes of energy storage resources, and they have differing costs, performance attributes, and reliability benefits that warrant separate treatment**

Stakeholder Session #2 slide 20 shows that different energy storage classes by duration have significantly different costs. This slide also shows that within the long-duration energy storage (LDES) resource class, 12-hr storage and 100-hr storage have distinct costs in terms of both capex ($/kW) and duration ($/kWh). Additionally, the study's reliability analysis indicates that short, mid-, and long-duration energy storage classes provide different and complementary reliability functions. These two factors indicate that these resources are in functionally distinct classes.

The study's findings indicate that short, mid- and long-duration energy storage resources warrant separate policy treatment given their different cost and duration attributes, and the different reliability functions they specialize in providing. There is a benefit in cultivating a portfolio with each of these resource classes by creating procurement programs that recognize these differences, and there is a risk that this portfolio diversity will not emerge if all resources are forced to compete on a single arbitrary metric (e.g. $/kW) in supportive policy programs.

3. **It is necessary to distinguish multi-day storage from intra-day long-duration storage**

One outcome of this study should be a recommendation that the Commonwealth further refine the long-duration energy storage resource class in procurement programs and statute by creating a multi-day energy storage class (>24-hr duration) as distinct from 10- to 24-hr intra-day long-duration storage. The study indicates that 10-hr storage and 100-hr storage have significant differences in cost and reliability value, yet the study treats both 10-hr and 100-hr resources interchangeably as stand-ins for the LDES resource class.

The study results would be more helpful to DOER and MassCEC if they recommended how the Commonwealth should draw reasonable distinctions between resource durations in procurement programs. Form Energy recommends 24-hr duration as a logical separator between multi-day storage and intra-day long-duration storage.[2] This distinction will allow DOER to design technology neutral procurement programs that seek different kinds of services and resource performance and that makes it possible to build a diverse portfolio of mid-, long-, and multi-day storage. These distinctions are particularly important when designing policies to help different resource classes overcome initial market barriers, when it is important for similar resources to compete against each other and for dissimilar resources to be treated separately. Without making such distinctions, DOER runs the risk of failing to cultivate the resource diversity that is needed to address different grid needs at least system cost.

4. **New state procurement or incentive programs are needed to close the gap between the costs of emerging mid- and long-duration energy storage and the revenues they can receive from state programs and wholesale market services.**

The study accurately concludes in slide 17 that current revenue streams are not enough to support the deployment of mid-duration batteries today or in 2030. The study did not consider potential revenues for long-duration and multi-day energy storage classes. However, it should come to similar conclusions for these resources, noting that the revenue gap between these resource classes and short and mid-duration storage is even higher.

The study also correctly notes that the Clean Peak program does not scale with duration (dispatch windows are only 4 hours long), thus it is not designed to reward the incremental reliability value that long-duration and mult-day storage provide relative to short duration storage. The study should conclude that new competitive state programs are needed to close the gap between the costs of long and multi-day storage costs and the revenues needed to support the deployment of these resources by 2030. These programs should be designed to support energy storage resources that can deliver firm capacity. The key benefit of supporting these resources in the near-term is their potential to significantly lower the long-term system costs of achieving a reliable, zero carbon grid.

5. **ELCC values are highly variable and sensitive to assumptions about the future resource portfolio. Their use as an input to long-term planning studies and in resource valuation should be limited.**

The study comes to important conclusions that the ELCC of energy storage is a "function of the rest of the portfolio, particularly offshore wind,"[3] increases in energy storage duration lead to

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[2] This recommendation is largely consistent with how the U.S. Department of Energy (DOE) distinguishes the LDES resource class in its Pathways to Commercial Liftoff study of long-duration storage, available at https://liftoff.energy.gov/long-duration-energy-storage/. DOE picks 36-hrs as minimum threshold for multi-day storage, which could also be acceptable, although 24-hours is a more logical threshold based strictly on whether a resource has the capability to discharge continuously at rated capacity for longer than a day.

[3] Stakeholder Session #2, Slide 32.

marginal improvements in ELCCs, and LDES delivers improved reliability relative to short duration storage. These findings support a conclusion that multi-day storage contributes substantially more to firm capacity needs than shorter-duration storage. The study results also indicate that ELCCs have important limitations.

In Form Energy's comments on Stakeholder Session #1, we noted that renewables and energy storage must be optimized together, as they have interactive effects. This fact is still not widely appreciated in the industry. The study could help elevate awareness of this dynamic and its implications for resource planning by comparing resources side by side and showing how substantially individual resource ELCCs vary based on the assumed portfolio of other resources.

For example, the draft study results identify that under two scenarios of future renewable energy portfolios, the ELCC value of 100-hour storage could remain constant at 90% through 20 GW of installed capacity in 2050, or it could be as low as 34% based on the availability of excess renewable energy supply. This variability calls into question the reasonableness of using ELCCs in capacity accreditation exercises in wholesale markets *unless* ELCCs are the result of a least-cost resource optimization. This variability creates risk that grids may not be as reliable as they appear based on the summation of ELCC values alone, and that capacity markets may not be sending long-term investment signals that align with the long-term, least-cost portfolio.

Consequently, Form Energy recommends that ELCC values should always be an outcome of a least-cost portfolio analysis. Despite how widely ELCCs are used in capacity accreditation, we are not aware of any wholesale market that generates ELCCs as an *output* of long-term least-cost resource planning. This study could help move the industry in that direction by highlighting the sensitivity of ELCCs to portfolio assumptions and producing information about the distribution of ELCCs based on different portfolios.

6. **Reliability risks that emerge at high levels of renewables and low levels of existing thermal resources warrant specific study to identify optimal solutions to these risks**

The study results in slides 35 and 36 show that it is important to directly model tail-end reliability risks so that procurement and wholesale market services can be designed to ensure reliability during the specific conditions that cause these risks. We agree with the findings of slide 36 that more than 20 GW of LDES can directly substitute for perfect firm capacity in New England by 2050. However, at even higher levels of storage deployment with very low levels of existing thermal resources, the study identifies that the reliability value of individual resources may sharply decline when these resources are considered in isolation. This potential divergence highlights a shortcoming of ELCC studies, which is that they do not provide useful information about how combinations of resources (e.g. renewables paired with storage) can deliver the performance needed to meet a defined long-term, low-probability reliability risk.

To plan for a reliable zero carbon grid and to accurately value firm resources, it is necessary to directly model the kinds of conditions that cause reliability risks: renewable energy lulls, periods of extreme heat and cold, periods of fuel shortages, major grid asset outages, and times when one or more of these events occur simultaneously. ISO New England's probabilistic Operational Impacts of Extreme Weather Events[4] is an example of the kind of analysis that can directly translate into a procurement program or market service to address a defined reliability risk. We encourage DOER's final study to place the results of slide 35 and 36 in context so that the tail end scenarios are appropriately qualified and the value of LDES is not understated.

7. **From a reliability standpoint, it is a no-regrets investment to cultivate multi-GW-scale markets of mid-, long-, and multi-day storage resources by 2030 to advance progress to achieving a reliable zero carbon grid in the long-term**

Taken together with the CECP least-cost portfolio analysis, the Stakeholder Study #2 results provide strong evidence that near-term investments to build a market for mid-, long- and multi-day storage by 2030 are no regrets from a reliability perspective and a long-term system cost perspective. At least 5 GW of these resources by 2030 will have durable reliability value through 2050, and at least 20 GW of these resources are part of a least-cost, reliable New England portfolio by 2050. These findings support a study recommendation that Massachusetts should pursue procurement programs to develop a market for diverse energy storage resources, with a particular focus on long-duration storage resources, which have high long-term value and lack existing state programs and wholesale market services that value firm zero carbon capacity.

Recommended Study Updates

1. **Future study updates should recommend reasonable procurement targets for mid-, long- and multi-day storage classes by 2030**

We hope that final versions of this study will recommend minimum procurement targets for mid, long- and multi-day storage resources by 2030, and a finding that such procurement is beneficial to the Commonwealth, both of which are supported by draft study results and CECP results. Such a recommendation is one of the key requirements of Section 80, which initiated this study.

2. **Additional ELCC sensitivities and surfaces can help clarify how the value of long-duration storage relates to offshore wind**

Slide 37 of Stakeholder Session #2 results lists reliability modeling next steps, including a scenario that considers the loss of Massachusetts offshore wind. Because the study correctly concluded that the ELCC value of long-duration storage is particularly sensitive to offshore wind assumptions, we recommend that the study consider additional scenarios with higher levels of offshore wind to develop an ELCC surface describing the relationship between LDES and

[4] *See https://www.iso-ne.com/committees/key-projects/operational-impacts-of-extreme-weather-events/*

offshore wind. This is particularly important because the CECP study limited how much offshore wind could be selected in the optimal portfolio. Especially in the “no thermal / 100% renewable” scenario, we recommend that the study consider higher levels of offshore wind relative to solar. For example, we encourage E3 to study between 40-55 GW of offshore wind. These high levels of wind could also be modeled with relatively lower levels of solar (e.g. 55 GW of offshore wind, 40 GW of solar) to understand how the ELCC of long-duration storage is tied to levels of wind and solar.

Conclusion

Form Energy appreciates the opportunity to provide comments and looks forward to continuing to engage with DOER, MassCEC and E3 on these important issues.

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