Understanding the impact of consecutive days for energy storage modeling

Storage balancing time horizon for capacity expansion models

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Background

Energy storage coupled with clean renewable electricity is one way to transition a zero-carbon electrical grid. Utility scale storage deployment is on the rise and is considered in most of the tools used in for long-term planning processes. Yet modern tools consider only storage assets with up to 4-hrs of duration and undermine the potential for longer duration energy storage. (LDES)

Objectives

- Understand how additional consecutive days in the storage balancing horizon impact the selected storage capacity in MW and MWh.
- Identify opportunities and use cases for LDES technologies in a WECC-wide zero-carbon grid.

Methods

We created a set of scenarios using the open-source capacity expansion models SWITCH[1] for the Western Interconnect (WECC) region.

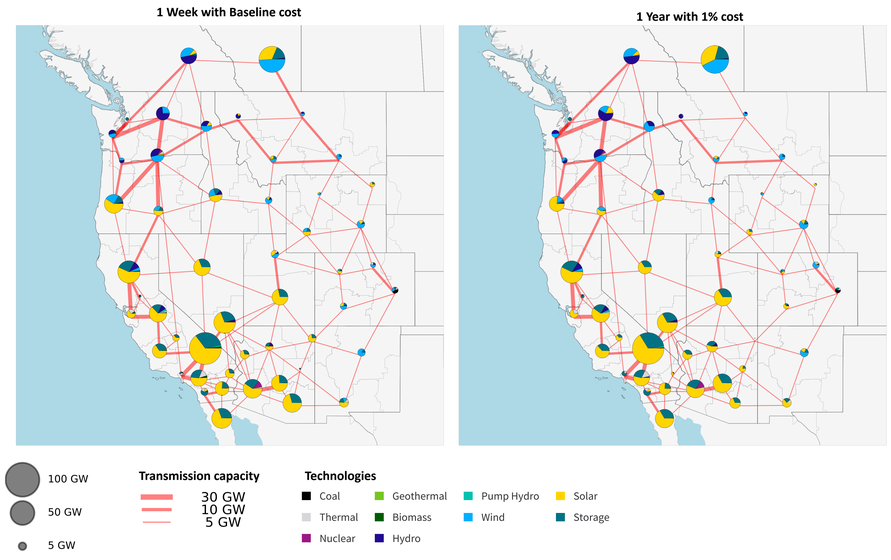
Model formulation

- Cost assumptions: NREL ATB 2020.
- Using the latest SWITCH-WECC model[2].
- Modeled a zero-carbon WECC-wide (50 load zones) by 2045.
- Only 2050 (10-year period) was modeled.
- 4-hour resolution for an entire year with a total of 2190 points modeled
- 7854 power plants (existing and candidate) modeled across WECC.

Scenario construction

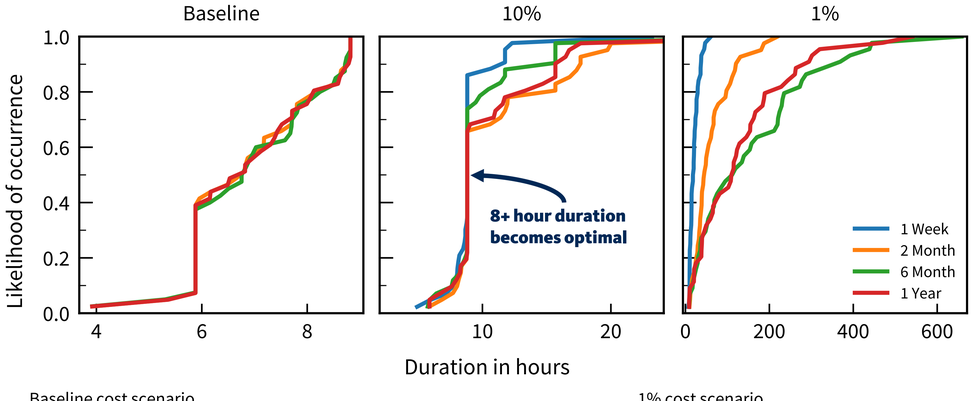
- We created a 4 storage balancing time horizons scenarios.
- We created two cost scenarios for LDES using a percentage (10% and 1%) of the energy cost from a 2020 Li-ion battery **$130/kWh.**

Energy mix for an optimal zero-carbon WECC electrical grid

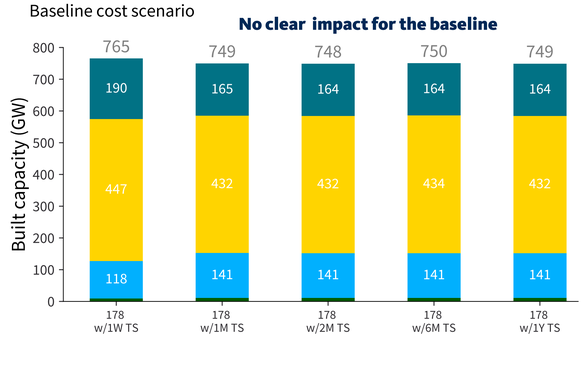


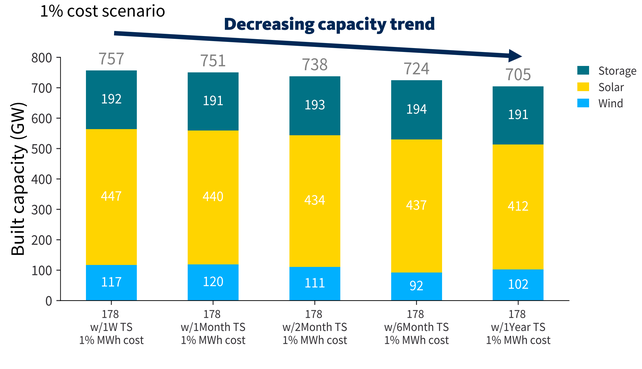
- Year-round balancing horizon reduces transmission expansion in northern regions of the WECC.
- Less wind gets for selected in the year-round horizon as most of the capacity shifts into energy storage.
- Solar and storage dominate capacity additions in both scenarios

Optimal power to energy ratio by storage balancing horizon



- No substantial difference observed for the baseline cost scenario.
- The balancing horizon changes the optimal duration if we reach 10% and 1% of the storage cost by 2050.

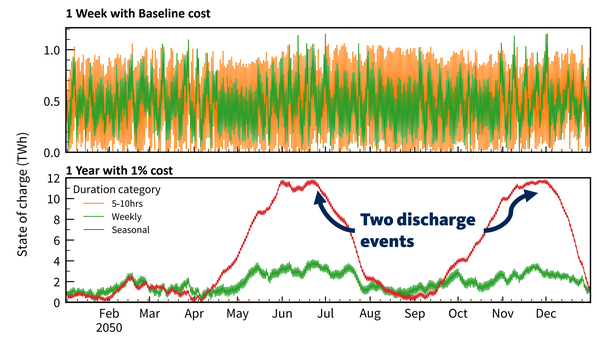




State of charge formulation

The SWITCH model keep tracks of the energy in storage using a state of charge equation and constraining the beginning and end state of charge for a storage balancing horizon.

Storage balancing horizon shifts short duration energy storage to weekly/seasonal assets



Conclusions

- The length of the storage balancing horizon impacts the optimal duration when the price reaches 10% of the baseline cost.
- Storage utilization changes depending on the length of the balancing horizon. Storage shifted to optimize for summer and winter peaks for the WECC.

Acknowledgments

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References

1. J. Johnston, R. Henriquez-Auba, B. Maluenda, and M. Fripp,, doi: 10.1016/j.softx.2019.100251.
2. M. Wei et al., EPIC CEC-500-2019-033, Mar. 2019 https://tinyurl.com/36mu656h