SOLAR+STORAGE AS A PEAKER REPLACEMENT

A CASE STUDY
FROM HAWAII

Derek Stenclik, GE Energy Consulting
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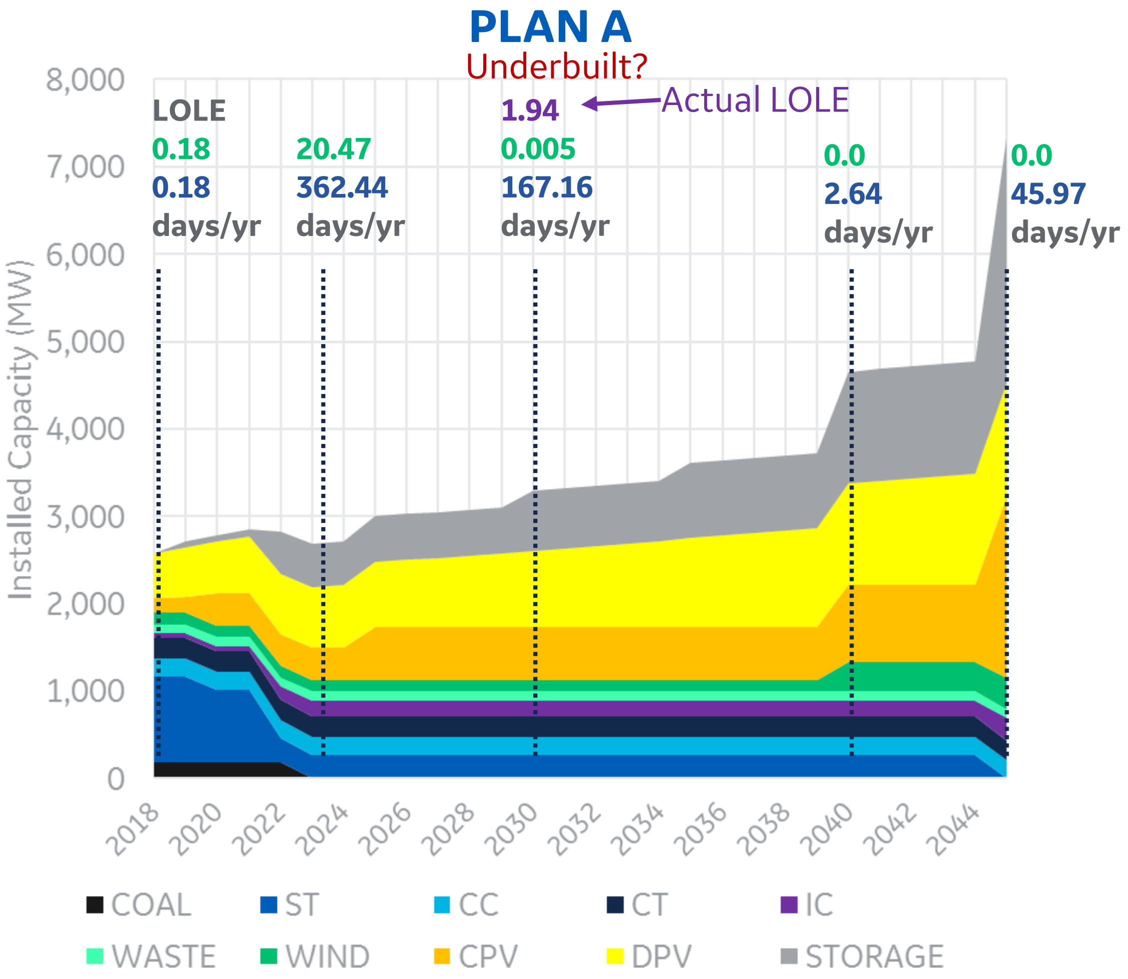
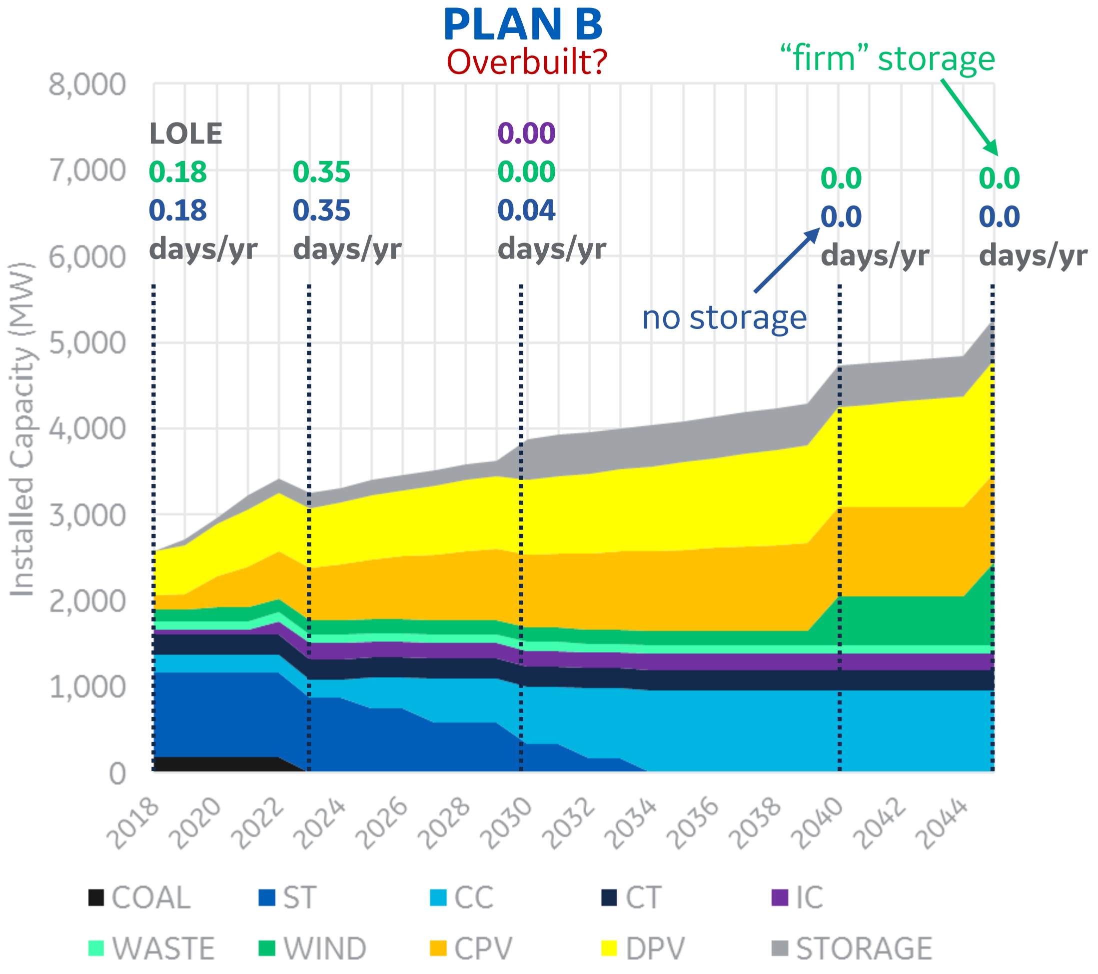
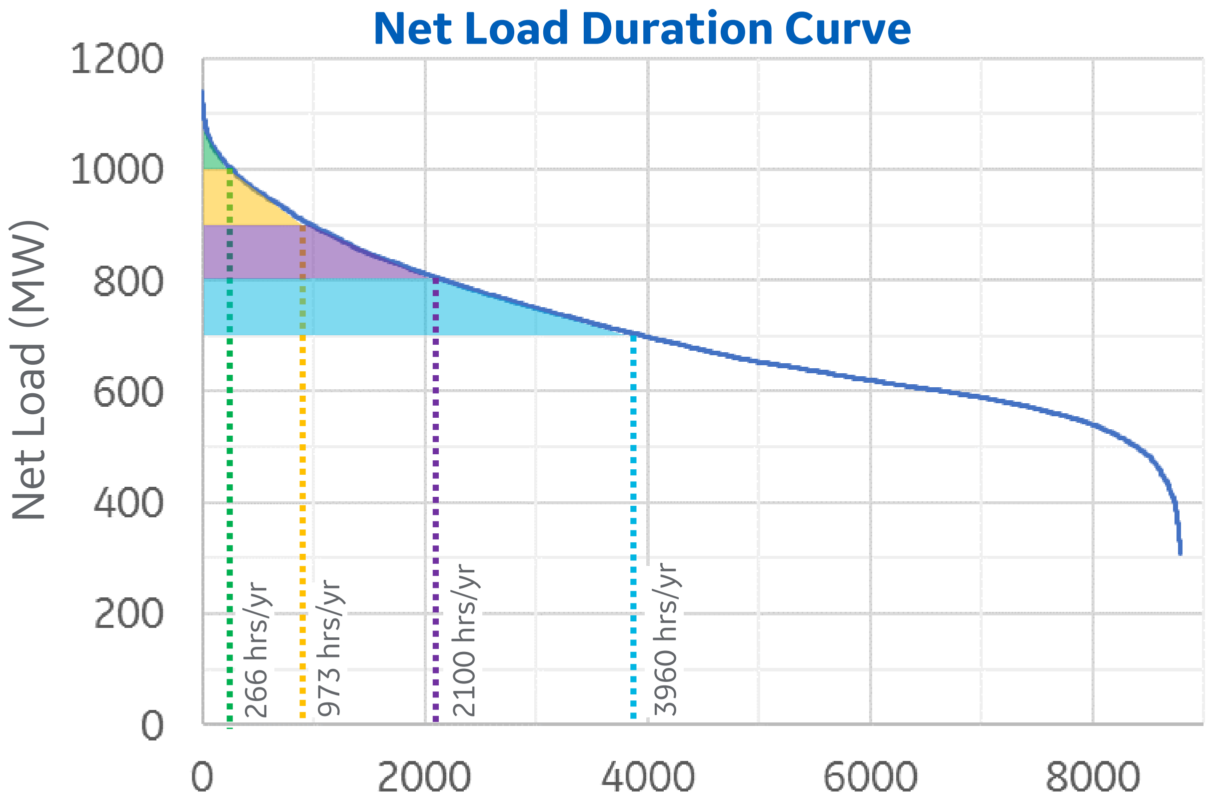
Long-term planning in Hawaii... is a solar+storage grid reliable?

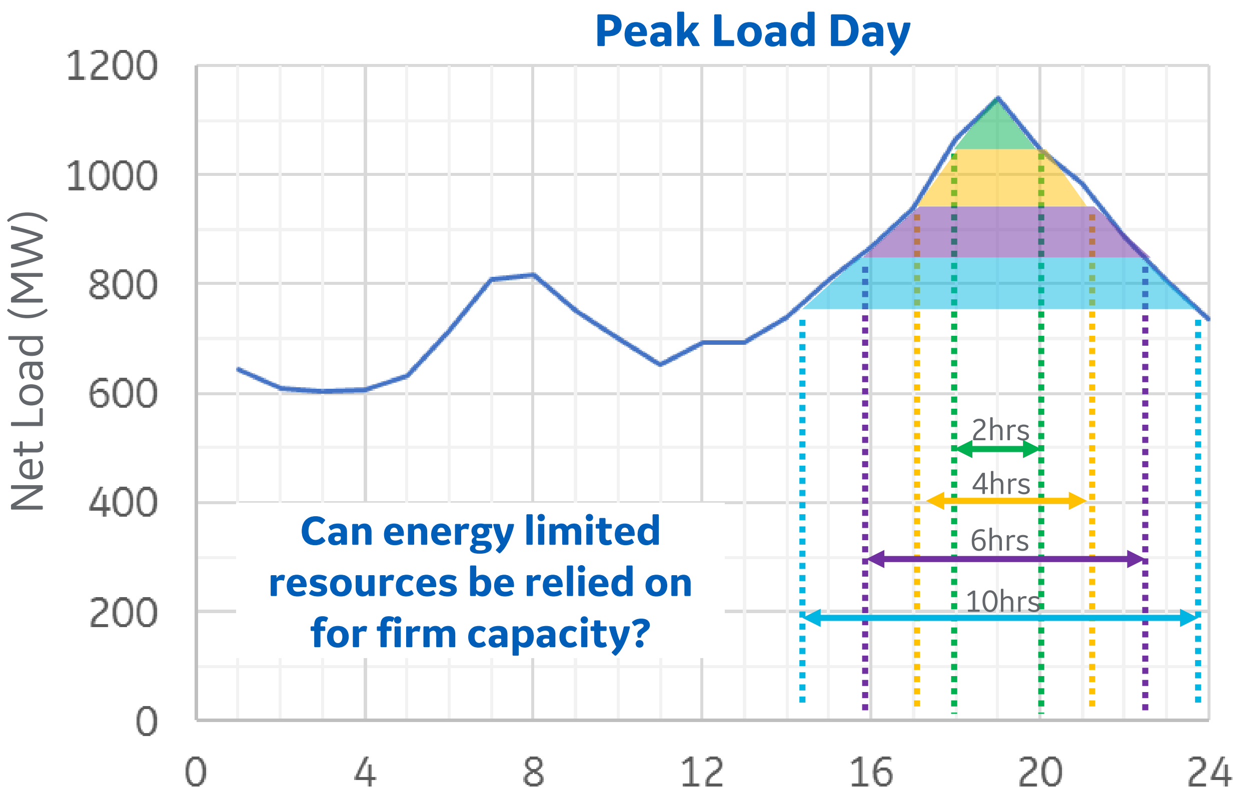




This has serious implications! could lead to over-build ($$$) or under-build (reliability risk)

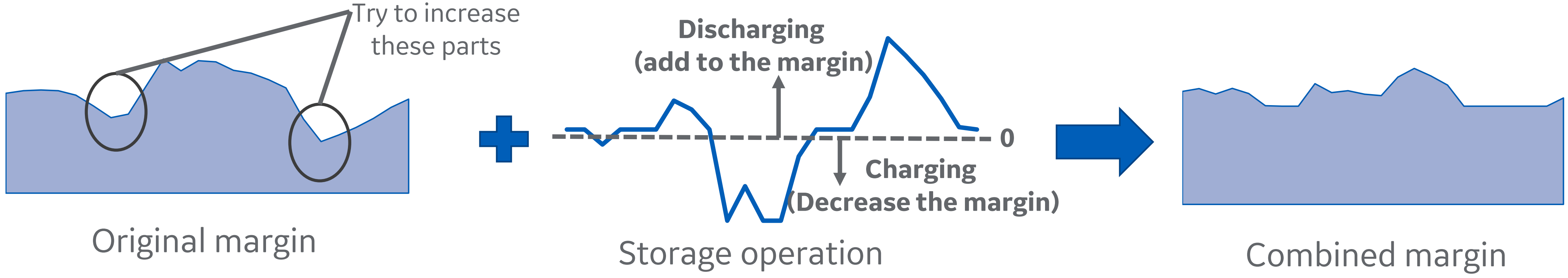
Storage and DR Capacity Benefits will Saturate with High Penetrations and Capacity Value will Diminish





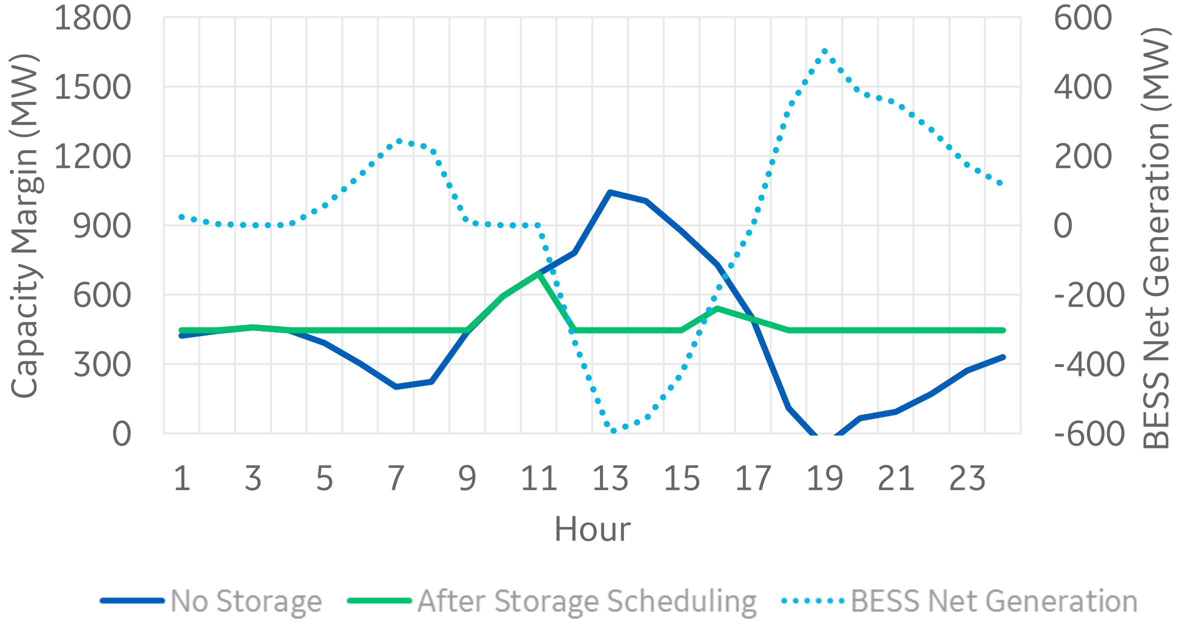
Simplified analysis, but illustrates diminishing returns and increased length of storage requirements for capacity benefits... requires detailed resource adequacy analysis (LOLE &ELCC)

Optimal Scheduling of Energy Storage (as a capacity resource)

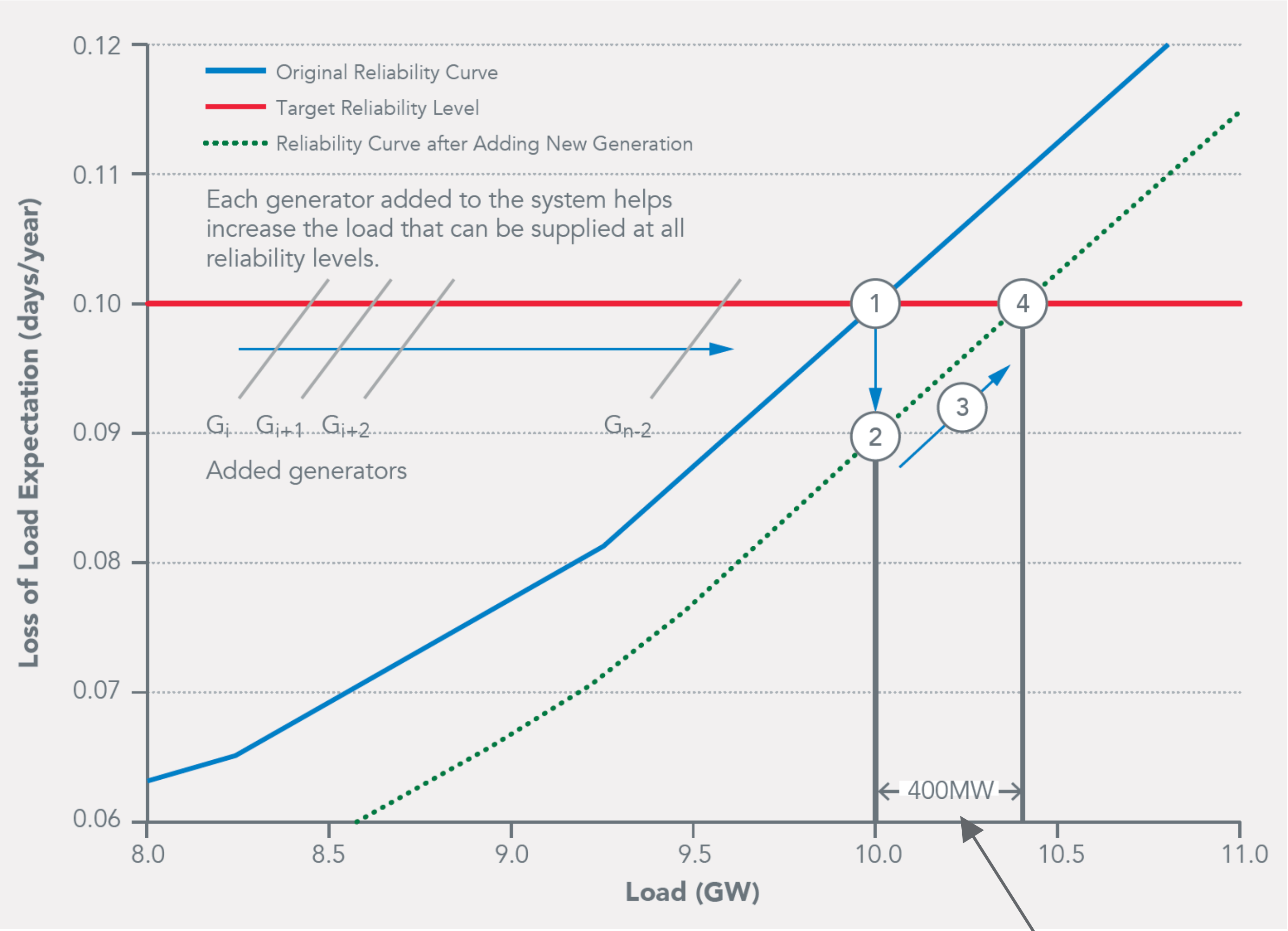


Objective : Increase the minimum margin of the system, through optimizing the operation (charging/discharging) of the energy storage.

"Margin" = available capacity – load
Higher margin = Lower risk



How is Capacity Value Calculated? aka effective load carry capability, (ELCC)



J. Katz, P. Denholm "Using Wind and Solar to Reliably Meet Electricity Demand, Greening the Grid" http://www.nrel.gov/docs/fy15osti/63038.pdf

Capacity value

CAPACITY VALUE

Contribution towards meeting a reliability target

Determined by output during riskiest hours

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CAPACITY FACTOR

Measure of annual energy produced by resources

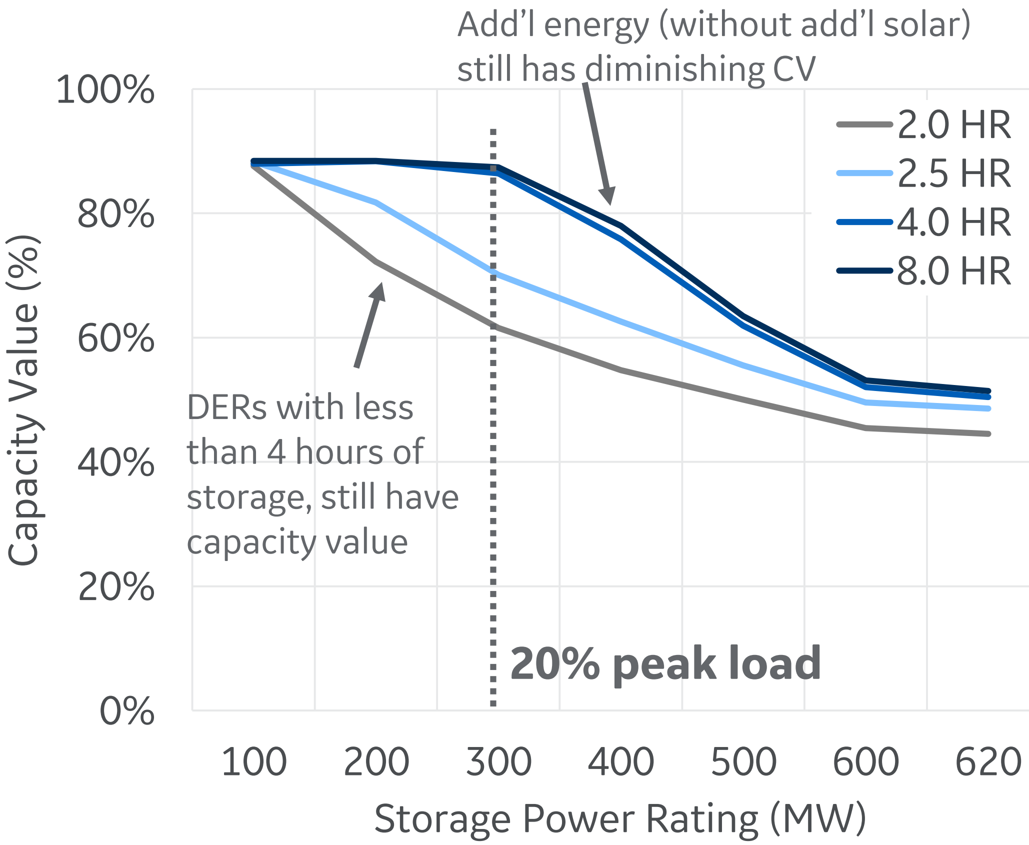
Determined by output during all hours

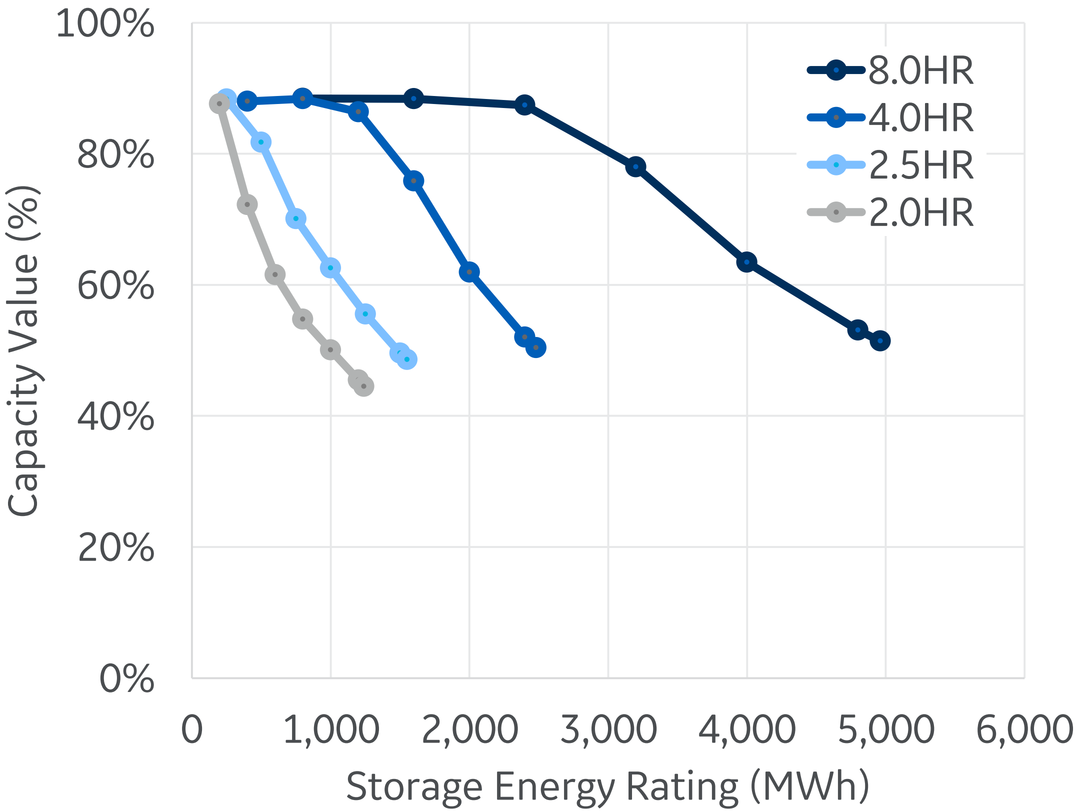
Methodology for Capacity Value

1. Bring LOLE of Initial system to reference point (0.22 for Oahu)
2. Add resource, reliability improves
3. Increase system load, reliability decreases
4. Match initial reliability target

Amount of load added to bring system back to reference LOLE = capacity value

ELCC of energy limited resources diminishes at high penetrations





Energy limited resources (storage or demand response) cannot be relied on to the same extent as conventional generation… diminishing capacity value at high penetrations

Why does capacity value of storage and energy limited resources diminish at high penetrations?

Saturation Effects

Daily load profile flattens, any additional shift of energy will reduce reliability during charging

Forecast Uncertainty

W&S forecast errors could yield sub-optimal storage scheduling

Multi-Day Events

Sustained low output of wind or solar limits ability to charge

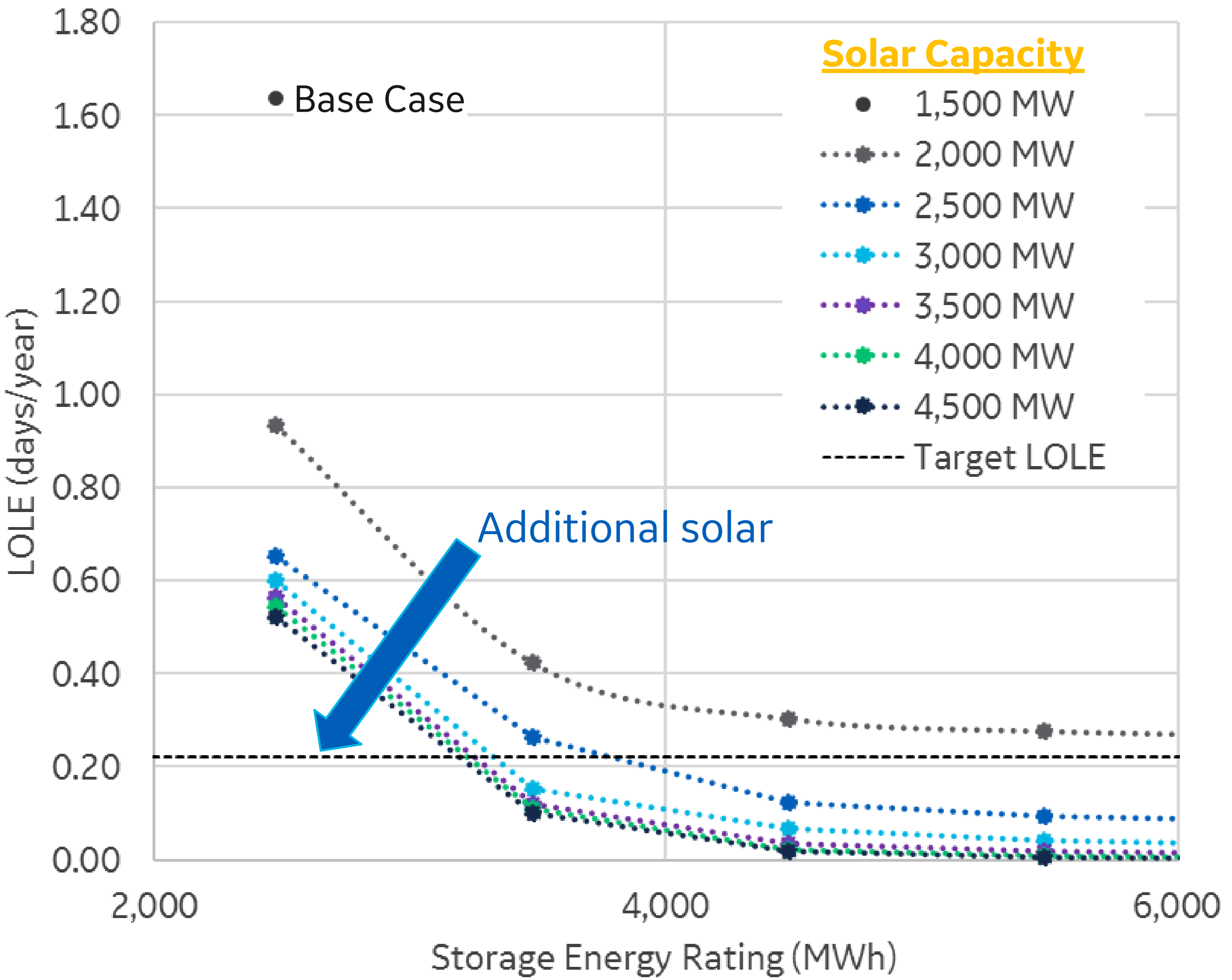
Competing Objectives

Likely that assets are used for multiple services (arbitrage, reserves, T&D, etc.) which may compete with capacity needs

Unexpected Outages

An unexpected generator outage could occur after storage discharge (not just about peak load)

How is the capacity value of ***storage and solar*** interdependent?

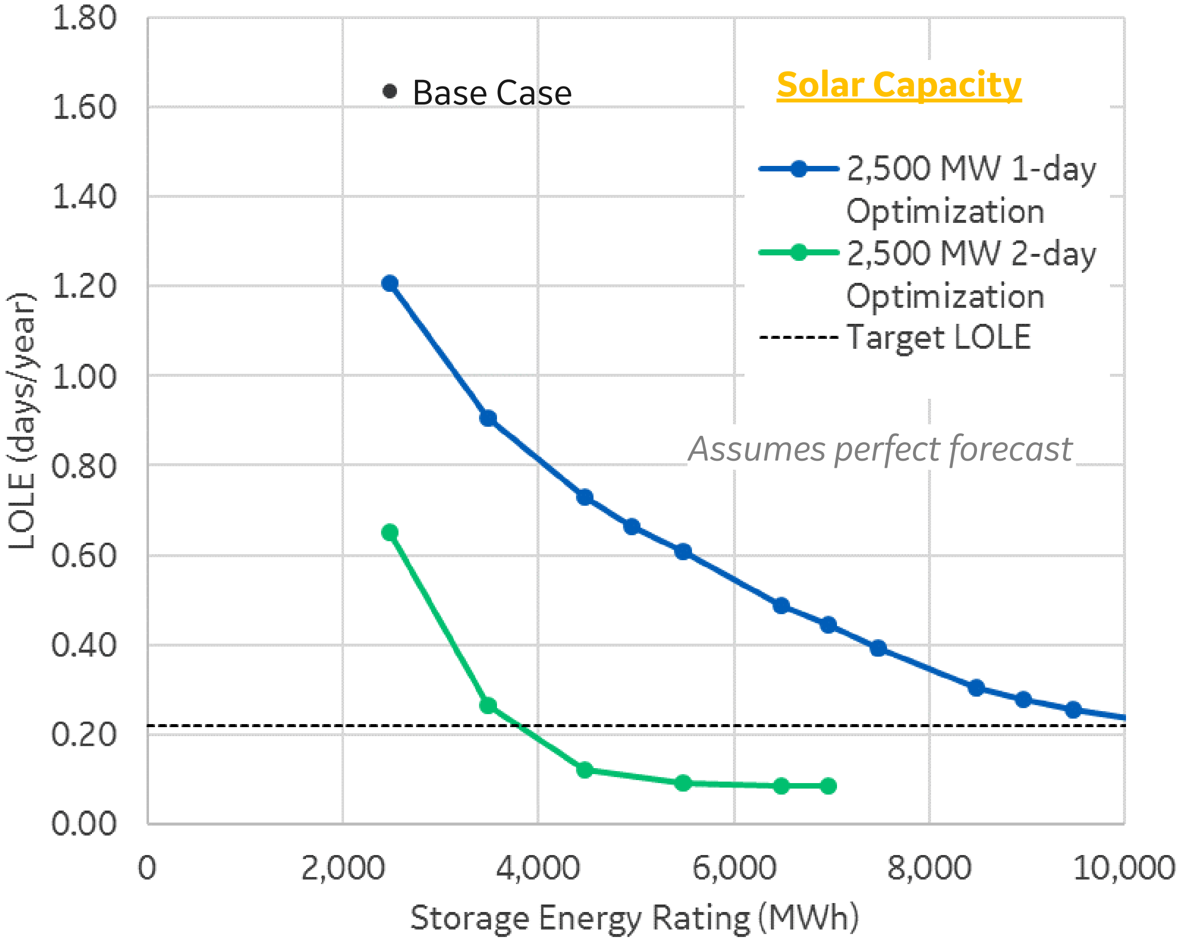


- Adding storage only to base case will not create a reliable system… additional solar and storage are required

2,500 MW solar & 3,800 MWh storage
or…
3,000 MW solar & 3,400 MWh of storage
or….
115 MW of IC or CT capacity

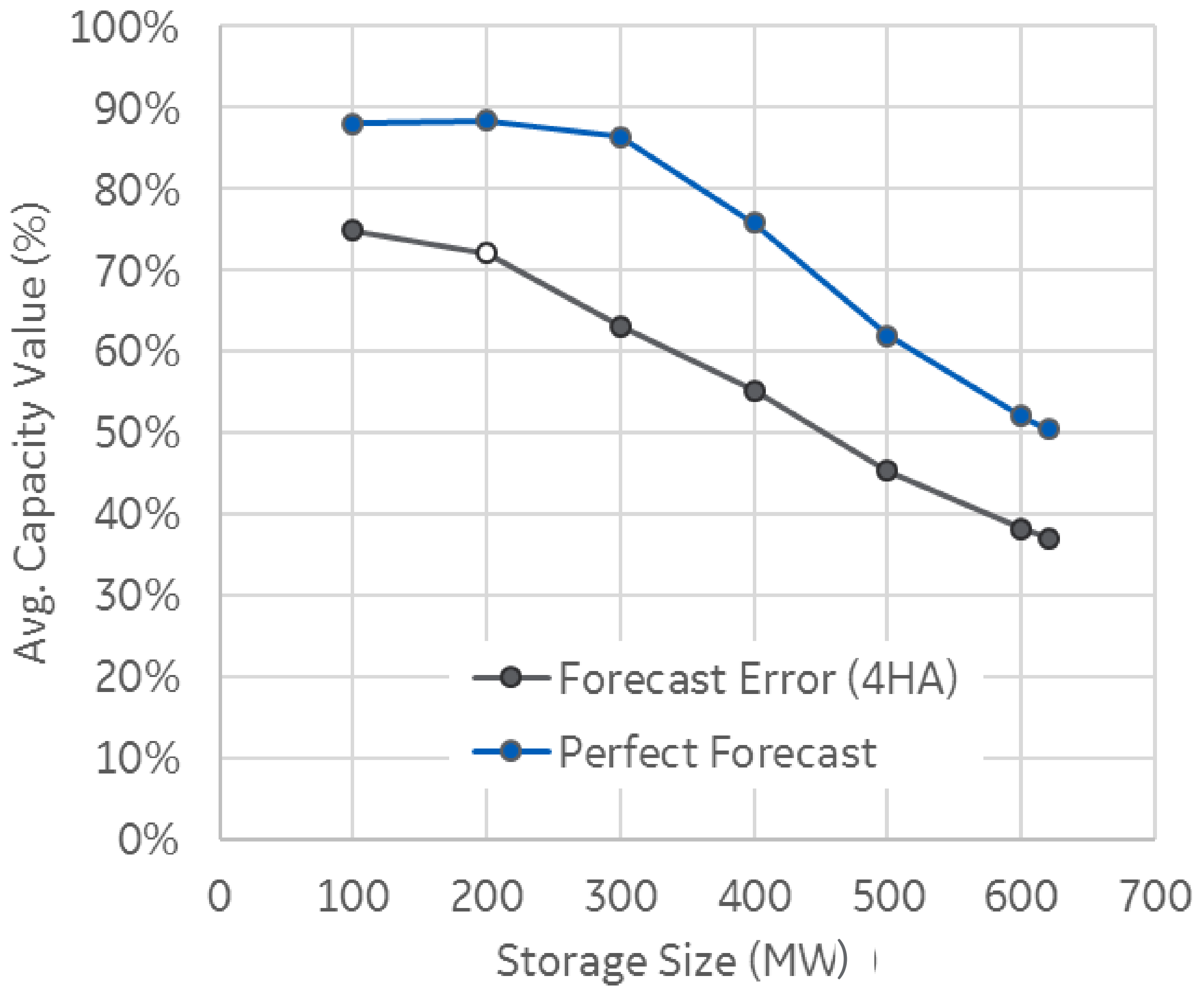
- At a certain point (3,000 MW of solar), additional solar does not help system reliability, even when storage is also added
- The rate of saturation for storage depends on the amount of solar added
- Eventually both solar and storage capacity value saturates.

Capacity value at high penetrations requires energy shifting across ***multiple days***



- At high penetration of solar and storage, multi-day scheduling and optimization of storage will be important
- Highlights the needs for accurate, longer duration forecasting of solar
- Reduces amount of storage required to meet reliability criteria by ~5-7,000 MWh
- Reliability criteria can be achieved with 2,500 MW of solar and ~3,800 MWh or storage

How do the results change with the ***solar forecast*** uncertainty?



- Simulations accounted for some uncertainty because storage is scheduled against the *average* margin from the Monte Carlo simulations
- The solar resource did not change per replication, thus the available of solar was assumed to have a “perfect forecast”
- The analysis was repeated assuming the storage was scheduled against a 4-hour ahead solar forecast, and the capacity value calculation was done using the ‘real-time’ solar resource

Six Key Conclusions to Keep in Mind!

1. Storage capacity value saturates at high penetrations (similar to wind and solar),
2. Energy limited resources cannot be relied on the same extent as conventional generation for capacity & resource adequacy,
3. Still a huge opportunity for storage, up to 20% peak load (in this example),
4. A balanced resource mix is important… Resource planning is an *AND not OR* decision, the future grid may require a *portfolio* of storage,
5. Capacity value of storage is interdependent with the amount of solar on the grid,
6. Multi-day scheduling of storage & forecasting will become increasingly important when utilized as capacity resources.

Thank you!

Want to learn more?
Stenclik, et al., *Energy Storage as a Peaker Replacement*, IEEE Electrification Magazine, Vol 6. No 3., September 2016

Derek Stenclik
Manager, Power Systems Strategy
GE Energy Consulting
derek.stenclik@ge.com

For more information and recent reports:
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