National Laboratory of the Rockies

Gaps in PV-Coupled Battery Modeling

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System Advisor Model

Photo from Adobe Stock 256750697

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PSA: nrel.gov domain disappears May 29

Please update all **email addresses**, **bookmarks**, **API calls**, and **links** on websites

- nrel.gov → nlr.gov
- nrel.github.com → NatLabRockies.github.com

This includes all API calls to NSRDB and PVWatts

Why do PV modelers care about gaps in battery modeling?

Battery installation and attachment rates are increasing

U.S. planned utility-scale electric generating capacity additions (2026)

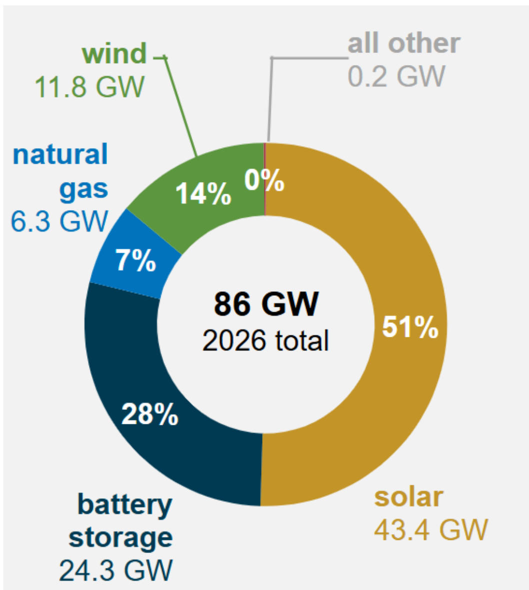


Image Source: EIA https://www.eia.gov/todayinenergy/detail.php?id=67205

15 GW were added in 2025

Behind-the-Meter Attachment Rates

- 71% across **all** Sunrun systems installed in Q4 2025
  - Some markets are much higher: Hawaii, Puerto Rico, California

Source: Sunrun
https://d1io3yog0oux5.cloudfront.net/_0ac6dd602591d88c74b7d96d3d8b1b21/sunrun/db/418/4110/earnings_slides/Sunrun-4Q2025-EarningsPresentation.pdf

Getting battery value predictions right can make (or break) financial feasibility

Categories for Discussion

1. **Battery Dispatch Modeling Gaps**
2. **Battery Performance Modeling Gaps**
3. **Battery-Relevant Data Gaps**

Gaps in Battery Dispatch Modeling

Modelers must select the right type of dispatch algorithm

Optimized dispatch

Estimates the *upper bound* of battery value

Most appropriate for larger-scale studies understanding how batteries *could* affect operations, cost, etc.

Heuristic dispatch

Estimates the value a battery *could achieve today*

Most appropriate for performance and financial feasibility analyses for individual systems

Dispatch algorithms can be tricky…

Accurate battery value depends on identifying the right dispatch goal…

- Peak shaving
- Retail rate arbitrage
- Self-consumption
- PV ramp rate smoothing
- Resilience

and on getting the details right…

- Can you charge from the grid?
- Can you discharge to the grid?
- What's the minimum state of charge?
- What's your forecast window?

And there are areas that still need some work!

- What type of forecast is your model using? (Perfect? Look behind? Historical forecasts?)
- How do you mix fundamentally different dispatch strategies (e.g. resilience + retail rate arbitrage)?

System Advisor Model *can cover these considerations, but modelers still need to get them right!*

Uncertainty in future utility rates

How do we reliably account for uncertainty in future rates?

A real-life scenario from Colorado- check out Brian Mirletz's PVSC presentation

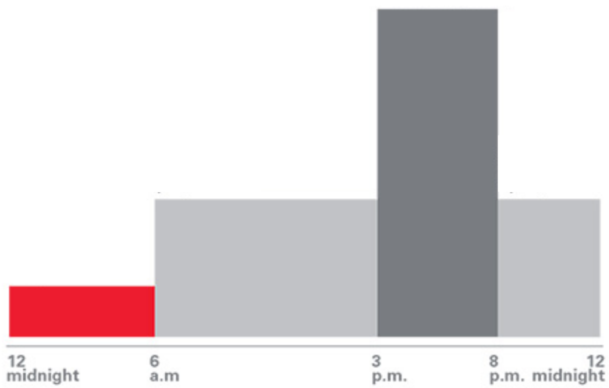


Image Source: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/TOU/FlexPricingChart-mobile.jpg

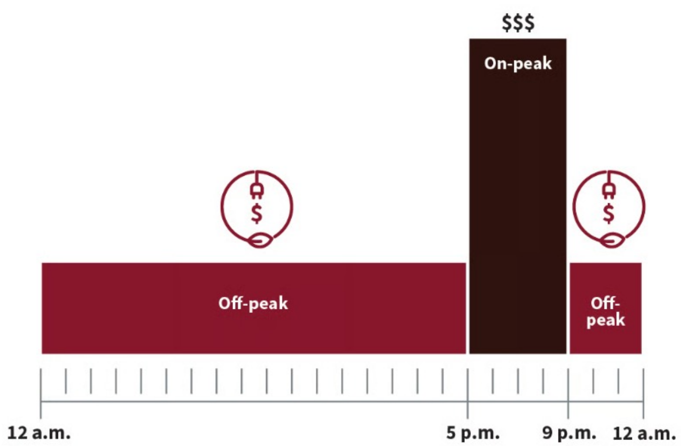
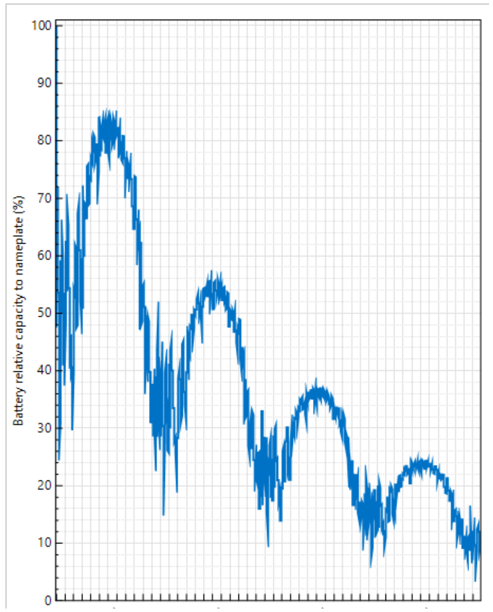


Image Source: Xcel Energy https://co.my.xcelenergy.com/s/billing-payment/residential-rates/time-of-use-pricing

Gaps in Battery Performance Modeling

Parasitic losses from thermal conditioning

- Most battery models do not model the energy required to keep a battery at an acceptable temperature for performance and lifetime
- Users can set the battery enclosure temperature to ambient (i.e. the battery is actually sitting outside)… but in extreme environments, this can rapidly degrade the battery, and most users do not do this.
- Or, users can include the energy required to keep the battery in a conditioned space in their load inputs… but most users do not do this either.



A simulated 4 MWh, unconditioned battery in Fairbanks, AK degrades to 30% of it's nameplate capacity in 3 years. It would require at least 22 MWh of resistive heat per year to keep this battery at 20 deg C year-round.

A Balance of Optimization and Realistic Behavior

- Most dispatch optimization models require battery models to be linearized
- Linearizing battery models loses important information about how batteries actually (1) degrade and (2) perform at low states of charge
- Oversimplified degradation predicts unrealistic battery lifetimes and replacements, which has a large effect on lifetime costs
- However, heuristic battery dispatch algorithms cannot quickly find the best system size and dispatch, depending on parametric sweeps instead of optimization
- Right now, you would use an optimization tool to find sizing and optimal dispatch (e.g. REopt) and then feed into a heuristic tool to understand realistic performance (e.g. SAM)
- *Is there a better way?*

Gaps in Battery-Relevant Data

We need a battery database!

We lack a public, programmatically accessible, comprehensive database of available batteries with sufficient details for modeling realistic voltage and current performance, thermal behavior, losses, and degradation.

Image Source: https://www.livescience.com/technology/engineering/days-numbered-for-risky-lithium-ion-batteries-scientists-say-after-fast-charging-breakthrough-in-sodium-ion-alternative

Mismatch between weather file and load and/or prices

- Common practice is to use TMY weather data with a recent actual year of load data (behind-the-meter) or a recent actual year of timeseries market prices / future projection of timeseries prices such as NLR's Cambium data (front-of-meter)
- However, weather affects load and timeseries market prices!
- If the two are not properly correlated, system value estimates suffer
- *BUT… it's hard to get correlated data*

Preliminary research suggests that pairing TMY weather with actual year load data could introduce bias errors that ***underestimate battery value by up to 9%*** *for net billing with a demand charge (e.g. Arizona)*

See ***Brian Mirletz's presentation at PVSC*** *for more information!*
"Updating PV and Battery Bill Savings Calculations for Net Billing: New Best Practices for Input Data and Uncertainty"

Where do we go from here?

Future Work

- Develop dispatch methodologies that can better mix different dispatch goals
- Expand understanding of the availability and pros/cons of different types of forecasts in battery modeling
- Add thermal conditioning losses to battery models as needed
- Develop a computationally tractable methodology to correct the mismatch between TMY and actual year load or price data without a lot of additional required information
- Establish better approaches to quantify uncertainty in future utility rates for behind-the-meter customers
- Develop standards for quantifying battery uncertainty generally
- Work towards a battery specifications database! (Ideas?)

Please talk to me if you're interested in collaborating on any of these ideas!

Thank you!

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