



# Batteries in SAM 2020.2.29: Focus on Battery Technology

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2020 SAM Webinars  
August 19, 2020

# SAM Webinars for 2020

Introduction to SAM Workshop July 22

PV Systems in SAM 2020.2.29 Aug 5

Batteries in SAM 2020.2.29:

**Focus on Battery Technology** Aug 19

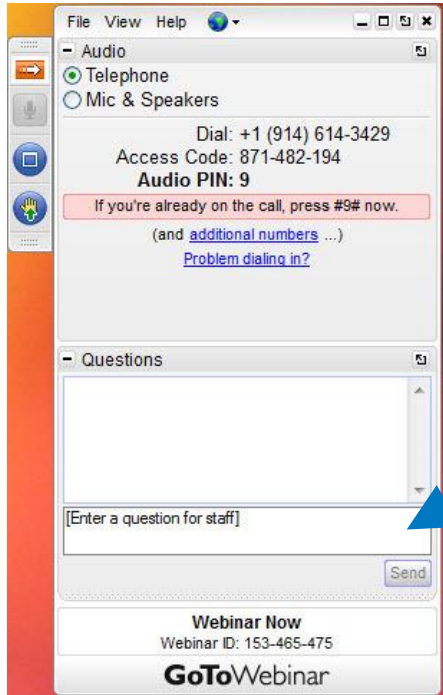
Behind-the-Meter Systems Sep 2

Front-of-Meter Systems Sep 16

Register for free at: <https://sam.nrel.gov/events.html>

*This webinar will be recorded and posted on the SAM website at  
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# Questions and Answers



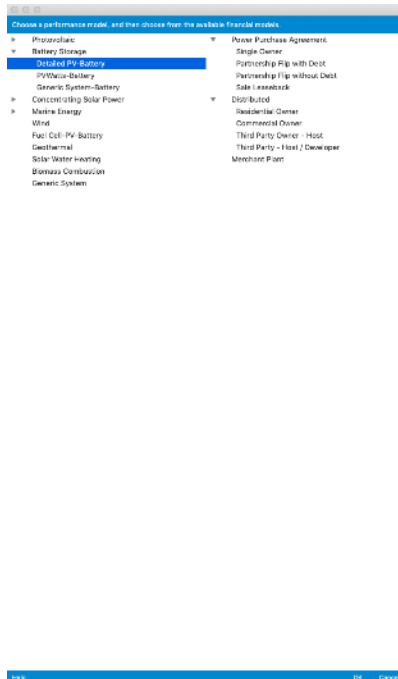
Desktop application



Instant Join Viewer

We will either type an answer to your question or answer it at the end of the presentation.

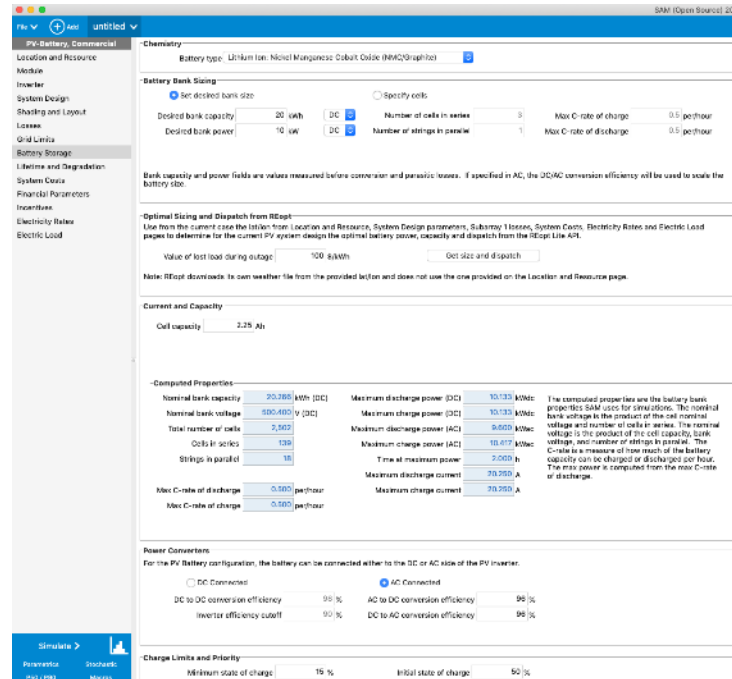
# Introduction



## Battery Storage Performance Models

- Detailed PV-Battery
- PVWatts-Battery
- Generic System-Battery

## Detailed PV-Battery with Commercial Financial model





**1** Component Models

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**2** Available Chemistries

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**3** Simple Use Case

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**4** Sizing from REopt Lite

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**5** Resilience Metrics

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**6** How to Fit your own Battery

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**7** Updates and Upcoming Features

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# Component Models

## Cell Capacity

- Sizing for power and capacity of the battery system

## Lifetime Fade

- How capacity decreases overtime due to calendar (pure storage) and cycling fade
- Replacements

## Voltage Curve

- Voltage discharge curve as a function of the state-of-charge (SOC)

## Thermal

- Heat transfer with environment for instantaneous thermal effects on capacity and resistance



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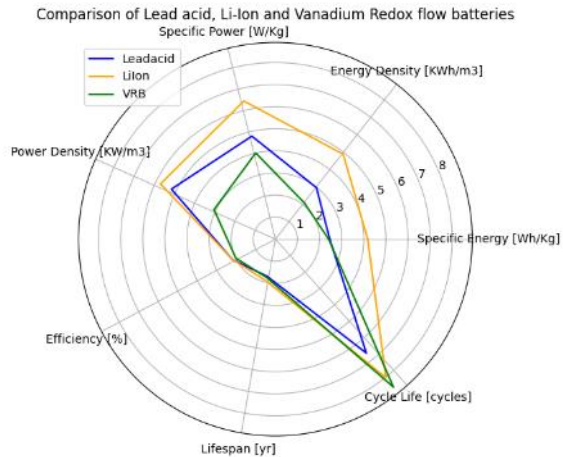
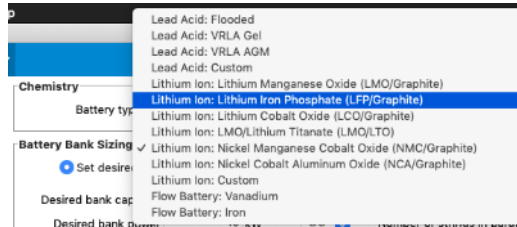
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**7** Updates and Upcoming Features

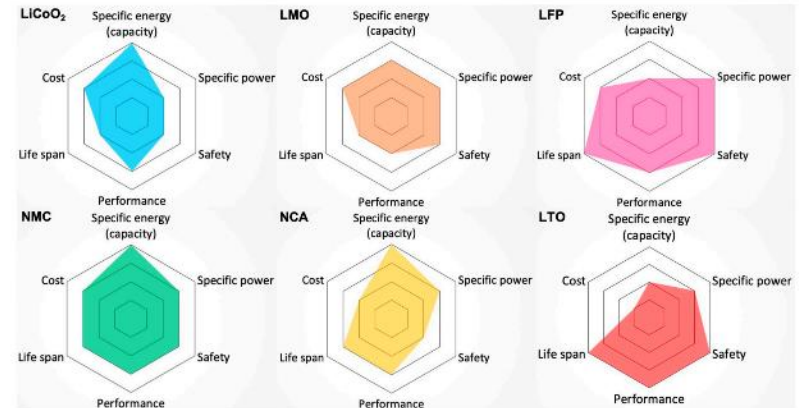
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# Available Chemistries

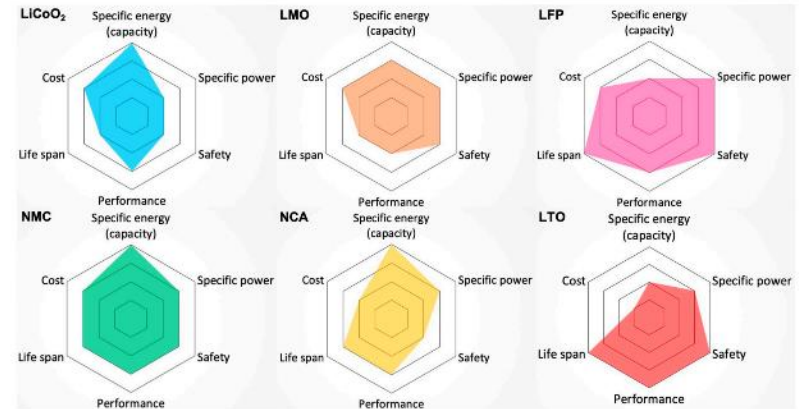
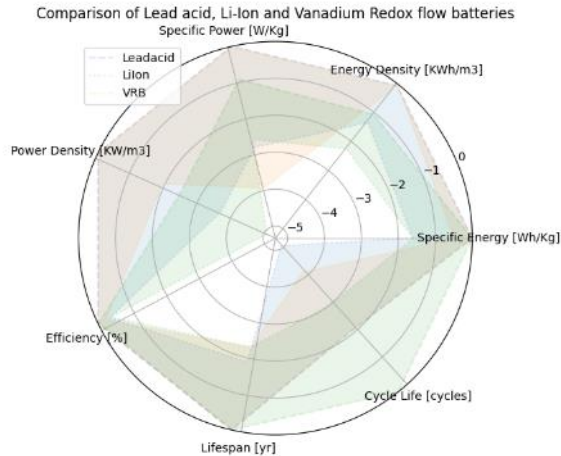
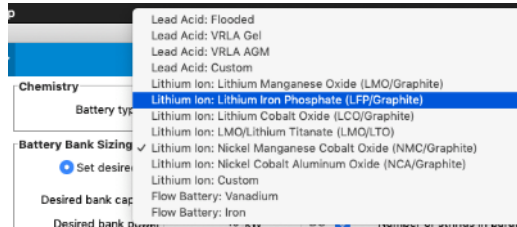


Sabihuddin et al. A Numerical and Graphical Review of Energy Storage Technologies. Energies 2015.



Miao et al. Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for Advancements. Energies 2019.

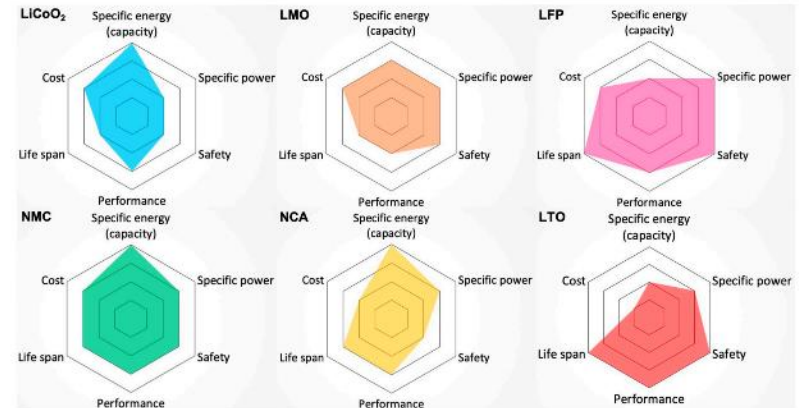
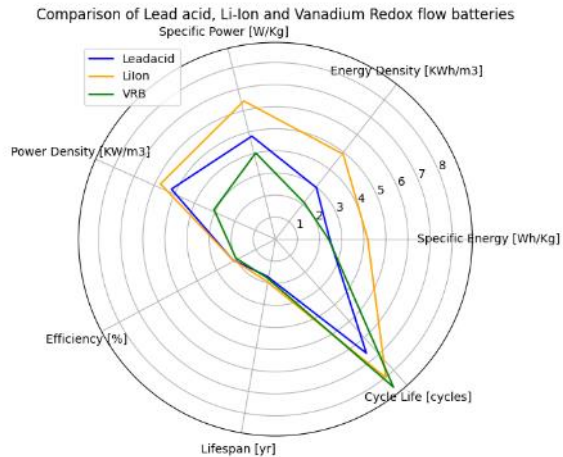
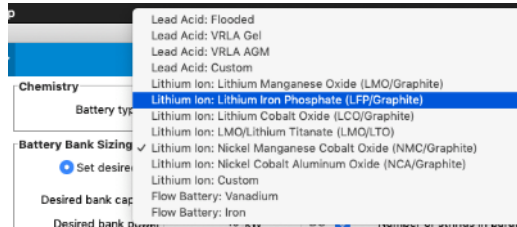
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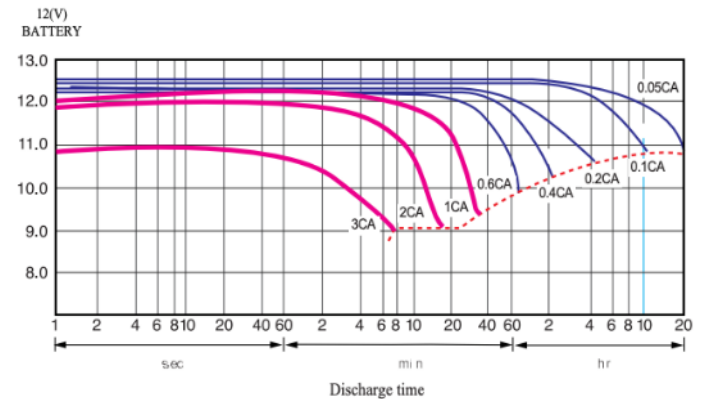
Miao et al. Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for Advancements. Energies 2019.

# Lead Acid

## Examples

- US Battery 2000 XC2 (20C) - Flooded
- GNB GF 12 076 H (20C) – VRLA Gel
- Global Battery ESL 10-12 (C10) - VRLA AGM

Uses the Kinetic Battery Capacity Model to account for Peukert's effect



Lead Acid Discharge Curve as a function of discharge current. Source: Global Battery ESL 100-12 spec sheet.

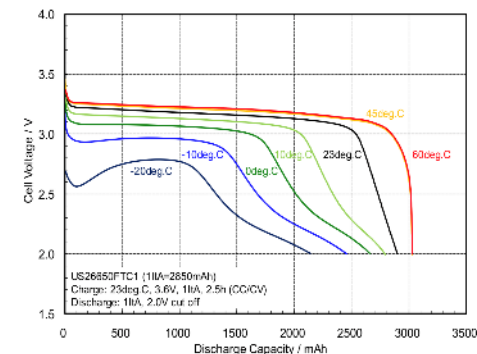
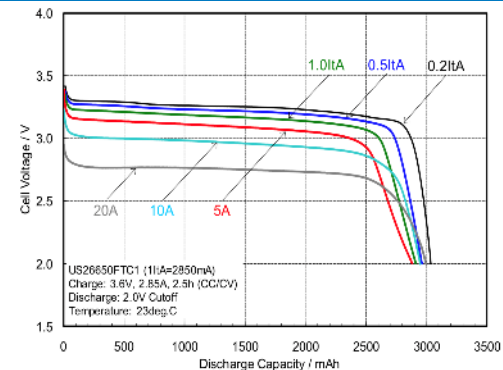
# Lithium Ion

## Examples

- Sony Fortelion IJ1001M - LFP
- Toshiba SCiB SPCS-LIB010A – LMO/LTO
- LG Chem RESU HV - NMC

Share the same capacity, voltage, and lifetime models

Parameters from scientific paper and manufacturer datasheets



Yasuda, Masayuki. Sony energy storage system using olivine type battery.

# Vanadium Redox Flow

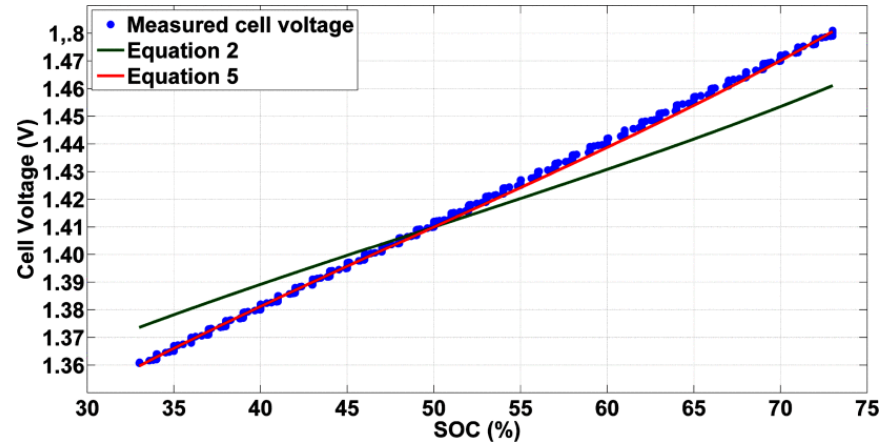
## Examples

- UET ReFlex

VRFB voltage model from D'Agostino

Little degradation and thermal dependence

Ancillary losses used for pumps or other equipment



Riccardo D'Agostino et al. A Vanadium-Redox-Flow-Battery Model for Evaluation of Distributed Storage Implementation in Residential Energy Systems. IEEE Transactions on Energy Conversion 2015.



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# Simple Use Case

## PV-Battery Commercial Model

- 179.580 kW AC PV
- 20 kWh, 10 kW DC LFP/Graphite Battery, AC-connected
- Peak shaving

How does it effect the annual electricity bill? The payback period?

What does the battery do over the lifetime?

Do I need to replace it?





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# Sizing from REopt

Battery size and dispatch strategy to maximize net present value\*

1. Determine the latitude and longitude of the location
2. Set up the PV system
3. Set up the load
4. Select a utility rate
5. Adjust battery capital and O&M costs
6. Adjust Value of Lost Load
7. Click Get Size and Dispatch



\*Only available for Distributed financial models, e.g. Residential, Commercial



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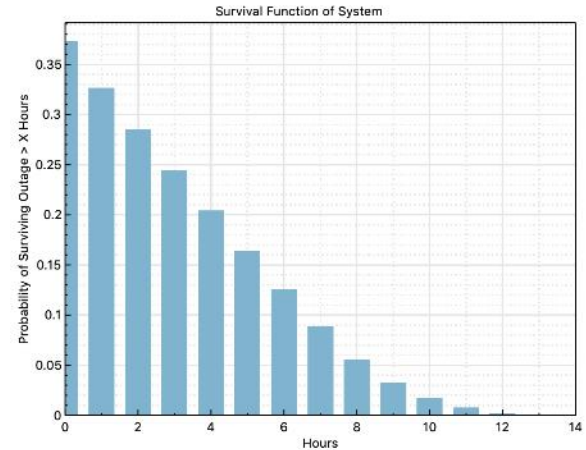
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# Resilience Metrics

- Min, max and average hours of autonomy (hr)
  - Average critical load (kWh)
  - Probability and cumulative distribution function of autonomous hours
  - Survival function of autonomous hours
  - Hours of autonomy during outage at each timestep
1. Set up the PV-Battery system
  2. Set up the load and critical load
  3. Click Simulate





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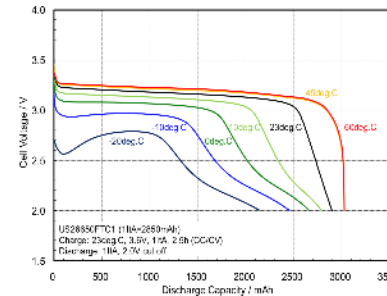
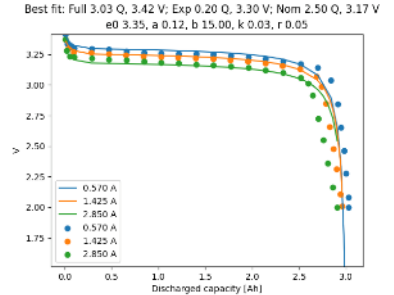
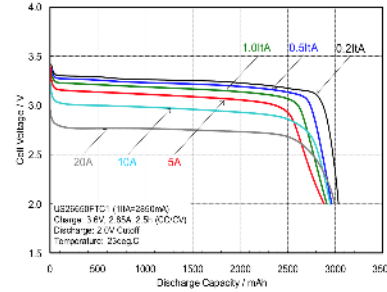
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# How to fit your own battery

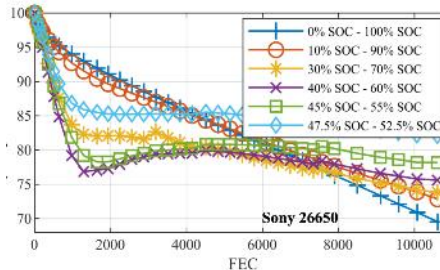
Manufacturer specs

Scientific paper

Test data



Celsius	Capacity
-20	72.3333333
-10	81.8
0	88.8
10	93
23	96.6666667
45	101
60	101



DOD	Cycles	Capacity %
100	100	0
100	128	98.7906648
100	202	97.9632249
100	277	97.3903819
100	371	96.6265912
100	523	95.9264498
100	666	95.2263083
100	1012	93.9533239
...		

Yasuda, Masayuki. Sony energy storage system using olivine type battery.  
 Naumann M et al. Analysis and modeling of cycle aging of a commercial LiFePO4/graphite cell. 2020 J. Power. Sources.



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# Updates and Upcoming Features

## Recent Updates

- Improved controller resulting in closer match with target battery power and higher roundtrip efficiency
- Fixes to the thermal model
- Cleaner interface

## Upcoming

- Default values for battery parameters for some chemistries
- Cycling as a function of Temp
- Resistance as a function of Temp
- Sub-minute battery simulations (PySAM or SDK only)
  
- New dispatch algorithm for BTM systems



# Questions?

Battery performance for frequency regulation on second timescale – Fernando M.