NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Capabilities for TMCES

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Thermal-Mechanical-Chemical Energy Storage Workshop

July 30, 2025

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Crescent Dunes Solar Energy Facility, USA

The National Renewable Energy Laboratory

South Table Mountain Campus
Golden, CO

Flatirons Campus
Arvada, CO

Alaska Campus
Fairbanks, AK

Washington, D.C.,

NREL offers distinct capabilities in foundational science, experimental facilities, component R&D, and systems integration. High-level TMCES capabilities include:

- Experimental and demonstration facilities
- Component R&D
- Datasets and tools for techno-economic analysis

(This presentation does not discuss NREL's biofuels or hydrogen capabilities. Please visit their respective websites for more information)

ARIES by NREL

The *Energy Systems Integration Facility* (ESIF)

- Advanced research capabilities
- Experiments for 100s of devices
- Power levels up to 2 MW
- Voltage levels up to 13.2 kV


Energy Systems Integration Facility

The *Flatirons Campus*

- Extensive hardware and simulation resources
- Experiments for 1000s of devices
- Power levels up to 20 MW
- Voltage levels up to 34.5 kV


Flatirons Campus

The *Virtual Emulation Environment* (VEE)

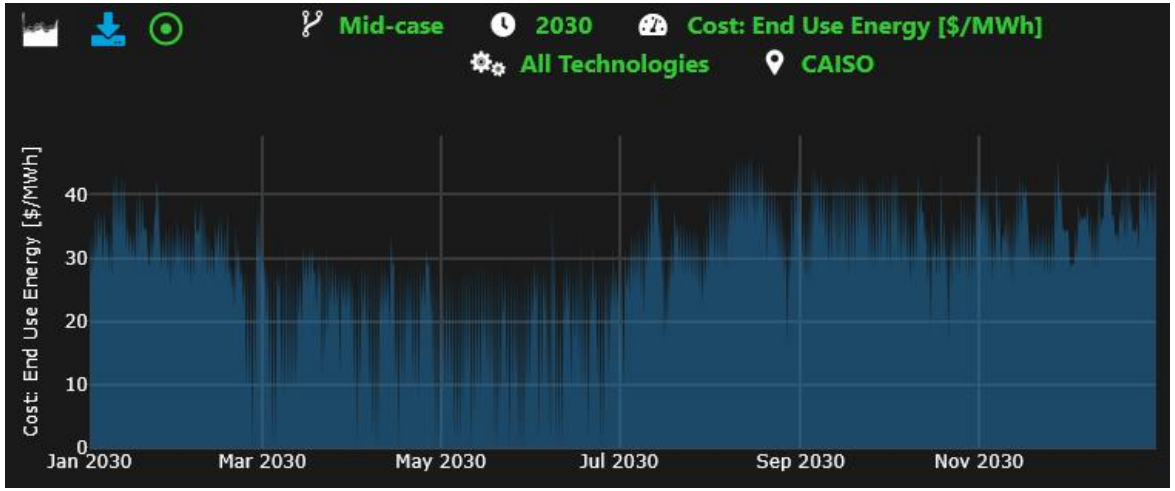
- Sophisticated digital platform
- Emulate experiments for 1,000,000s of devices
- Any utility power
- Any voltage level
- Local to national scales

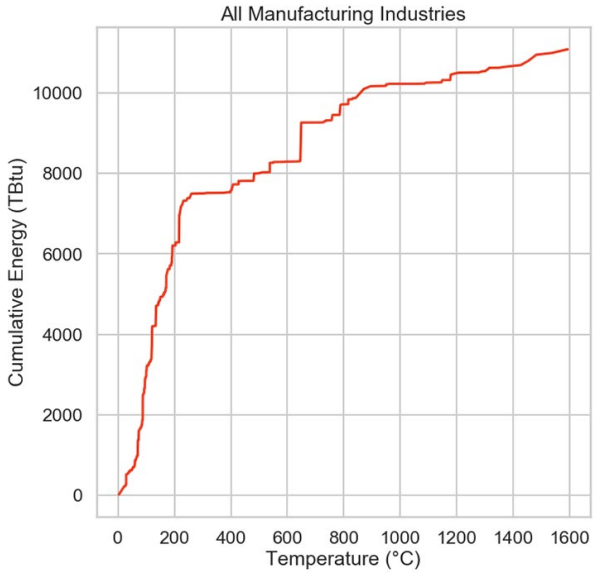

Virtual Emulation Environment

Datasets

Datasets provide easy access to standard inputs and scenarios to help emerging technology solutions estimate techno-economic performance for utility-scale and commercial applications

- Cambium: Dataset of hourly marginal costs in future grid scenarios
- Utility rate database (URDB)
- Annual technology baseline (ATB): current and projected cost of commercial technologies; e.g. PV, batteries
- Manufacturing thermal energy use in 2014: Estimates thermal energy use by end use, temperature, county, and facility employment size class for all U.S. manufacturing industries in 2014
- ComStock datasets: Estimate the timeseries and annual energy consumption of the U.S. commercial building stock

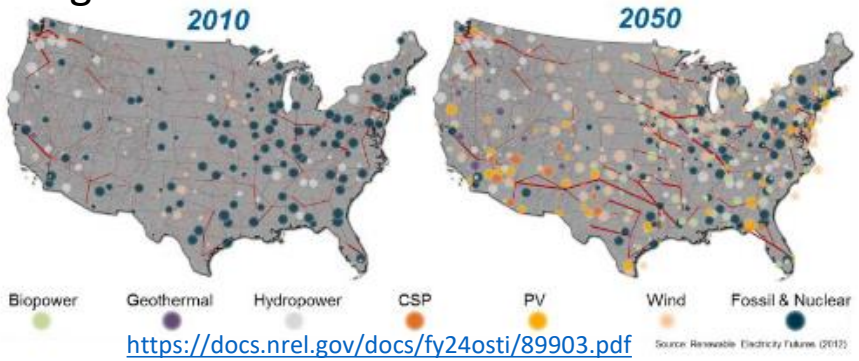




https://www.nrel.gov/analysis/solar-industrial-process-heat.html

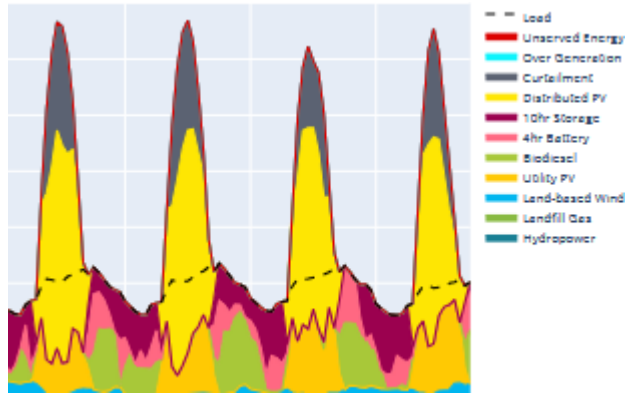
Modeling tools

ReEDS: models grid capacity expansion for new loads (e.g. data centers) and generator retirements



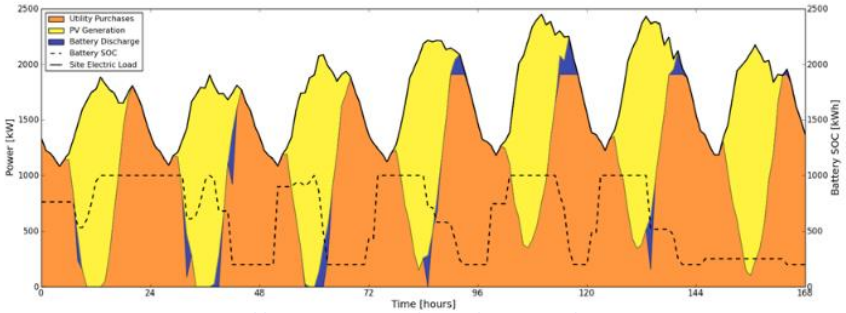
https://docs.nrel.gov/docs/fy24osti/89903.pdf

Sienna: grid operations modeling and optimization. E.g. estimate prices and operations in future grid scenarios



https://docs.nrel.gov/docs/fy24osti/90227.pdf

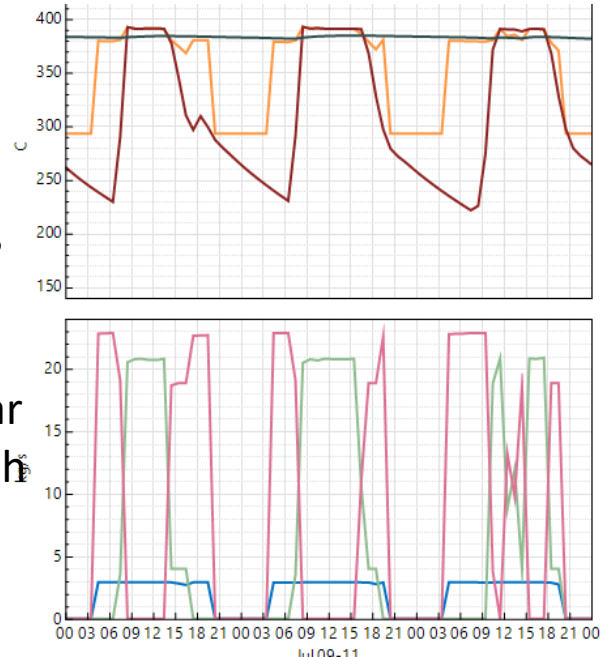
REopt and STEP 1: Optimizes technology mix, sizing, and operation of *distributed* energy/storage



https://docs.nrel.gov/docs/fy14osti/62320.pdf

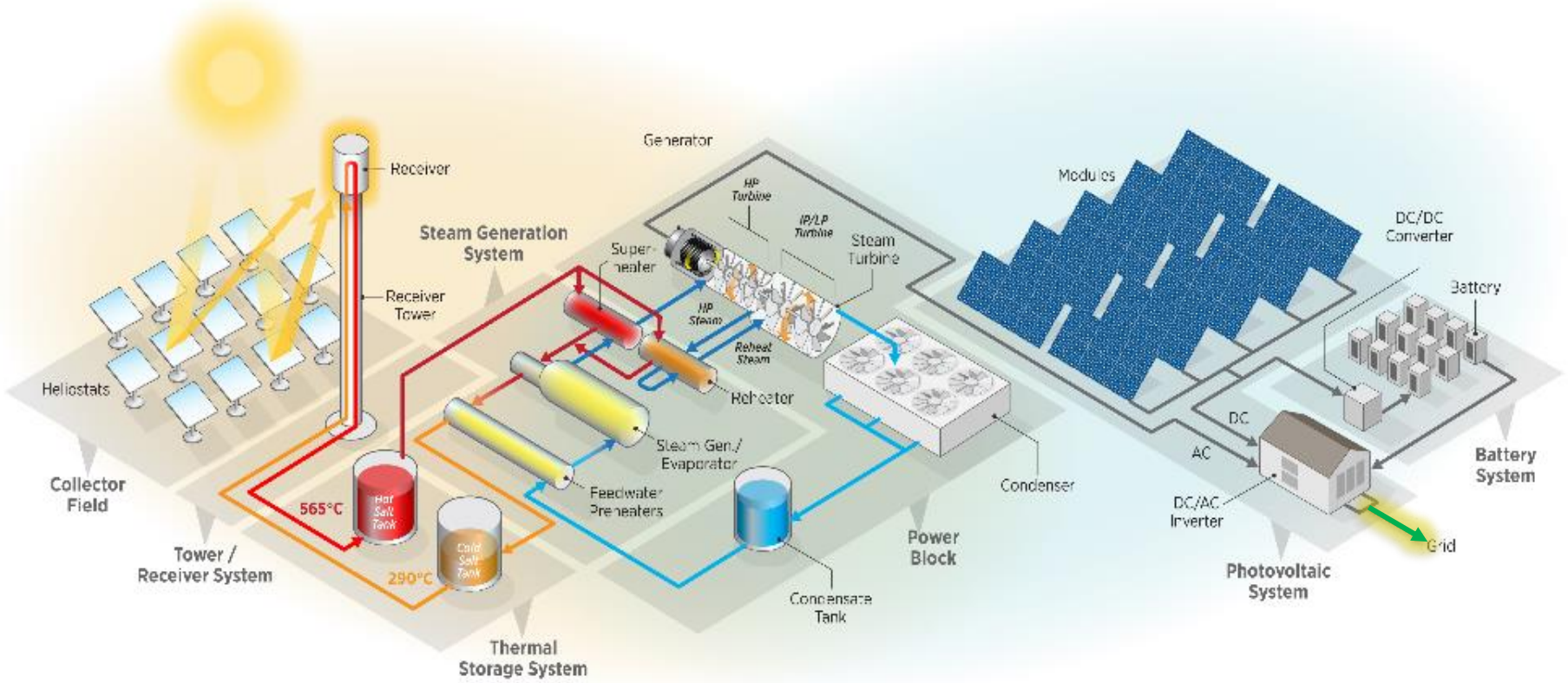
SAM: First-principles time-series performance modeling of renewable energy and storage technologies. Evaluate non-linear off-design performance with high level dimensional inputs

- Solar thermal, ETES, PTES

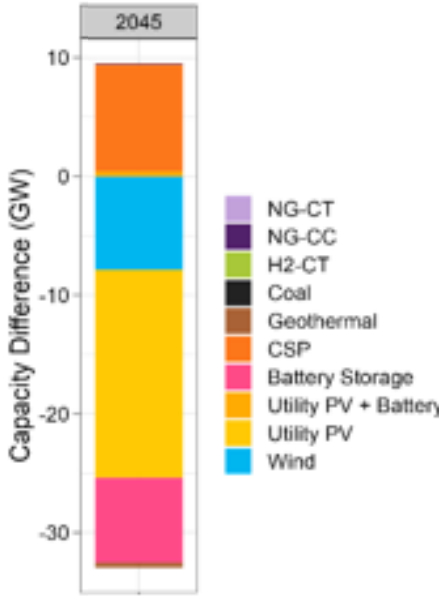


CSP as a LDES technology

- CSP+PV hybrids are the norm for recent international CSP deployment
- Direct heat generation to TES is a low-cost option to increase capacity factor



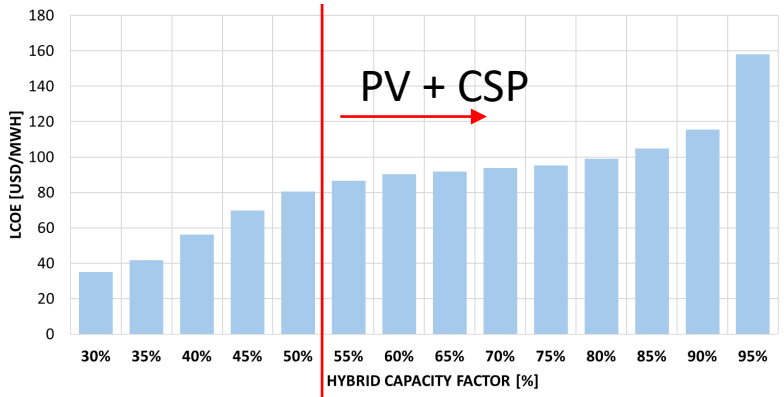
CSP as a LDES technology



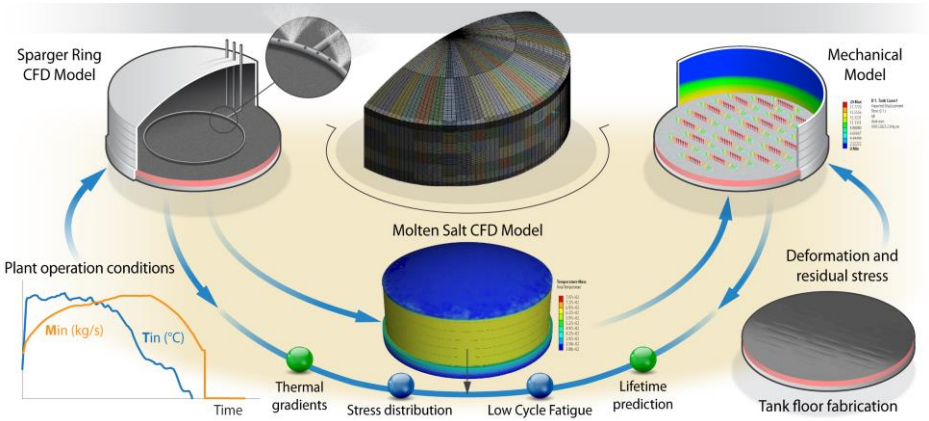
Capacity expansion modeling in US SW shows future “high renewables” scenarios require significantly less capacity if CSP is included in model.

Preliminary results from:
Augustine, C., Awara, S., Price, H,. and Zolan, A., "Deployment Potential of Concentrating Solar Power Technologies in California" (2025), Under Peer Review.

- Decision support tools optimize the size of PV, CSP, TES, and battery
- Detailed TEA modeling shows systems with CSP have competitive LCOE at high capacity factors



Preliminary analysis and plots from Bill Hamilton



Component R&D to develop guidelines to improve molten salt tank lifetime:

- Design
- Materials
- Fabrication
- Hot tank operations

Led by Julian Osorio

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Thank you!


Crescent Dunes Solar Energy Facility, USA