NOSTROMO

COOLING GLOBAL WARMING

Enabling Rapid Integration of Dispatchable and Measurable Resources

Creating the Right PEM for a Thermal Energy Storage System

March 3, 2025

Unlocking truly flexible demand

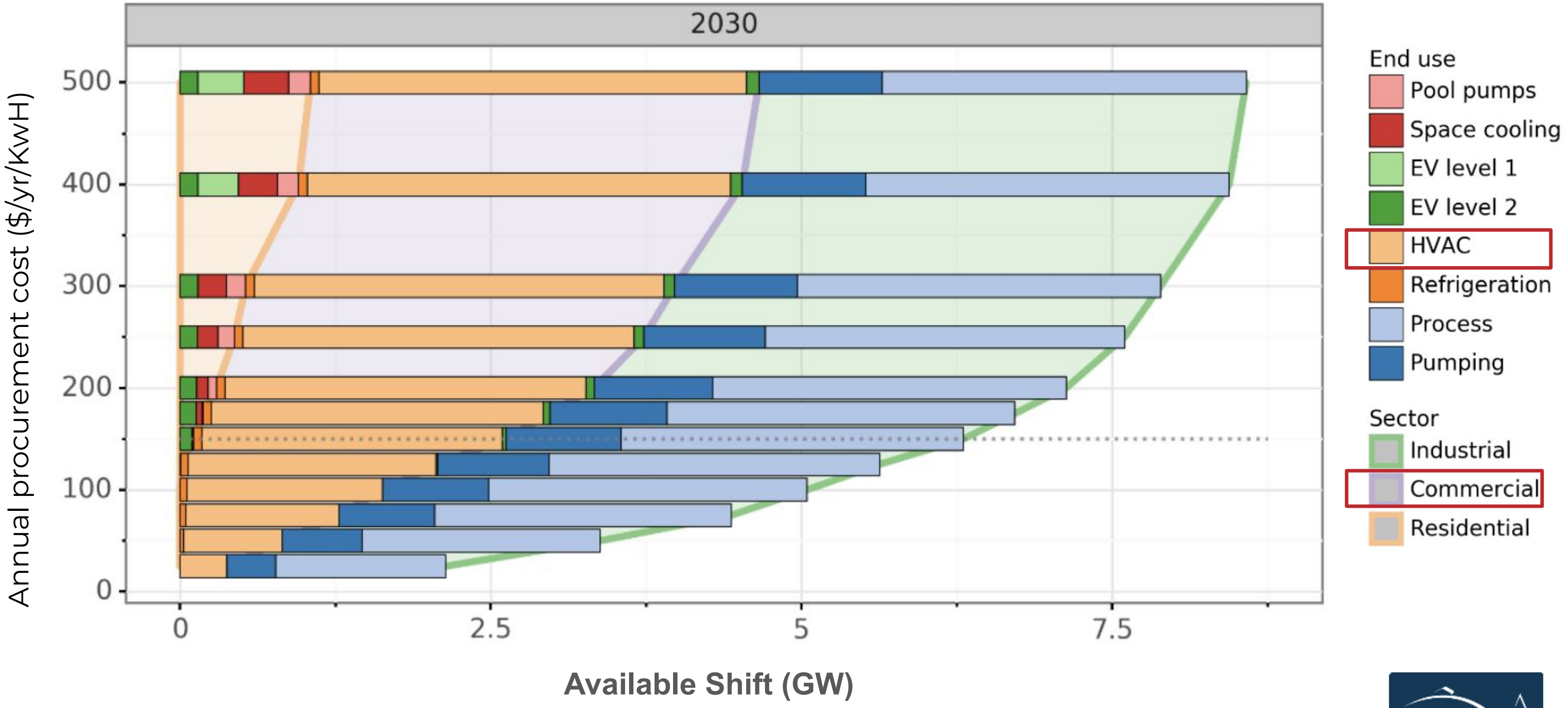
- Nostromo's first California system began operations in Sep 2023
    - *System is flexible, dispatchable, measurable*
- Nostromo applied to participate through the Weather PEM.
- Unlocking full value and creating transparency warrants a new PEM
- SB 846 Goal of adding 7 GW

Benefits:

- **Rapid, Low-Cost Deployment –** No interconnection required, fast implementation.
- **Stronger Grid Reliability –** Dispatchable TES enhances system stability.
- **Fair Market Treatment –** Aligns TES with other compensated storage.
- **Supports Clean Energy Goals –** Advances California's sustainability & resilience.

Untapped resources to meet the 7 GW Goal

LBNL's projects that by 2030, with annual procurement cost of $500 per kWh you can shift up to **~3 GW** daily only using commercial HVAC systems in a **traditional DR**.



* LBNL "Phase 3 Demand Response" report for California

BERKELEY LAB

The Existing Methodologies only apply to **specific measured electrical output, not to a corresponding electrical-equivalence**

- Electrical-equivalence regulated reporting mechanisms are currently recognized both at the **state** and **federal** levels **(CPUC, IRS)**
- Thermal Energy Storage systems have the potential to contribute hundreds of MW of Demand Response quickly
- The limitations of existing methodologies pose a barrier to the otherwise straightforward and equitable integration of these resources.

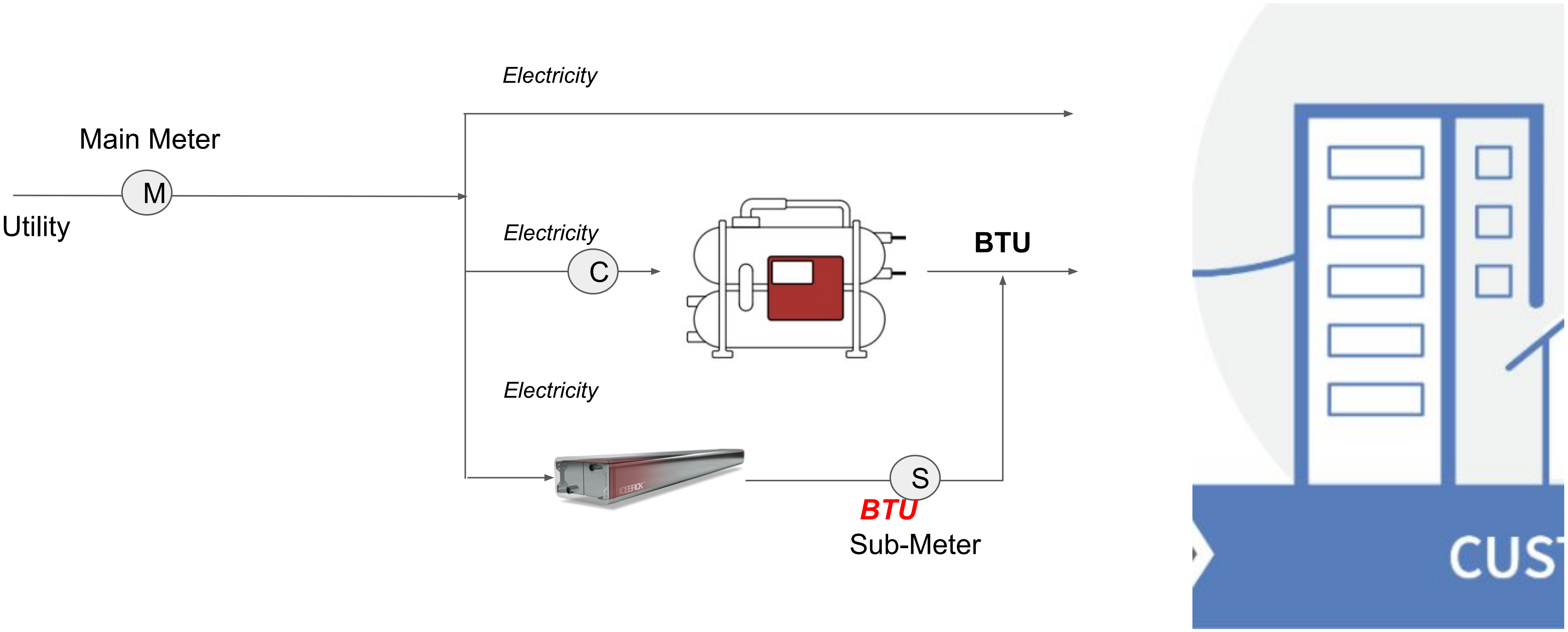
Create a new Thermal PEM modelled on the existing MGO PEM

- Provide a formal approach to more accurately evaluate the performance of behind-the-meter TES systems
    - *Measure Thermal BTUs and convert to an electrical equivalent value*
- Model this new PEM on the existing MGO PEM to reduce the risk of errors, miscalculations, and potential strategic gaming.
- Use high-quality interval-metered components of the TES system to generate a corresponding kWh performance measurement
- Support the SB 846 Goal of adding 7 GW

Holding thermal energy storage to a similar standard as electric energy storage in determining incremental production

Nostromo proposal modeled after existing PEMs

Thermal behind-the-meter energy production



Thermal Energy Storage output S reduces Main Meter consumption M

Battery reduces electricity consumption by supplying stored energy in its electricity form to the chiller.

Nostromo reduces electricity consumption by supplying stored energy in its BTU form to the chiller.

Electricity = BTU x Conversion Factor

kWh (Electricity) — kWh (BTU x Conversion Factor)

Thermal Metered Generation Output (TMGO PEM)

- Use high accuracy electric sub-meters to directly measure the facility chiller consumption and thermal energy storage system ancillary kWh consumption
- Use high accuracy BTU sub-meters to directly measure the BTUs serving the facility's cooling demand
- Since the BTU meter directly captures the BTUs the chiller would have provided to the building, apply conversion factor to arrive at the kWh reading
- Determine the conversion factor each day based on the chiller kWh consumption and BTU production in the 2 hours prior to the dispatch


GLYCOL RETURN
GLYCOL SUPPLY
GLYCOL SUPPLY
CONDENSER WATER SUPPLY
SMARDT
CH-3

Questions?

Appendix 1: TMGO Calculation Details

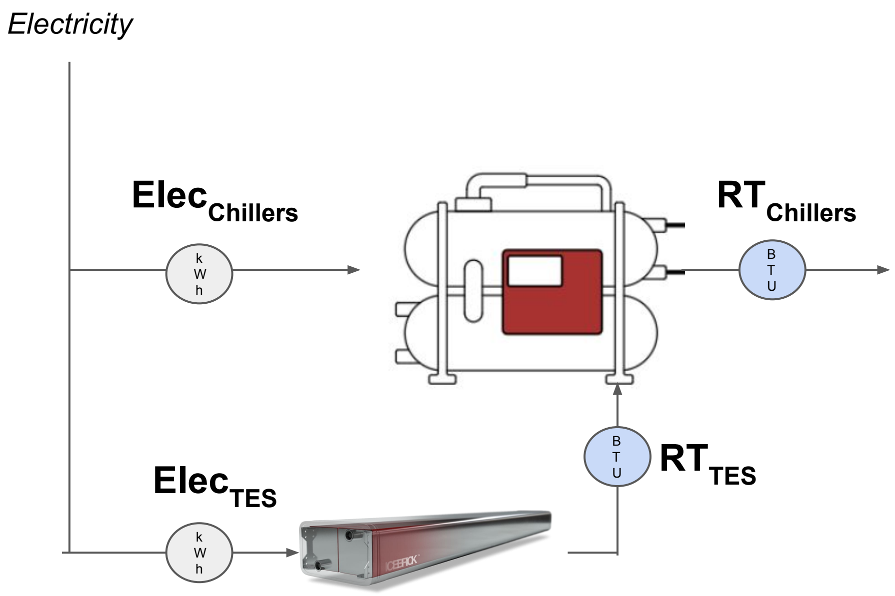
$Elec_{Chillers}$ = Sub-metered electricity consumption of the host facility chillers producing RT and consumption of associated equipment such as cooling towers in the case of water cooled chillers.

$BTU_{Chillers}$ = Sub-metered RT production measurement (BTU meter) of the host facility chiller cooling production in Tons.

$Elec_{TES}$ = Sub-metered measurement of the electricity consumed by the TES system, including pumps, controls etc.

RT_{TES} = Sub-metered RT production measurement (BTU meter) of the TES system in Tons, measured at the point of delivery to the customer (after heat exchangers etc).

COP_D = Host facility chiller Coefficient of Performance on the measurement day



1. **Determine COP_D based on $Elec_{Chillers}$ and $RT_{Chillers}$ in the 2 hours preceding dispatch**

Average of each interval COP in the 8 (15 min) intervals preceding the start of the dispatch

$$COP_D = \underset{i \in I}{Sum}\{ Elec_{Chillers,i} / RT_{Chillers,i} \} / 8$$

Where,

I = set of 8 15-minute intervals preceding the start of the dispatch

i = interval in set I

2. **Calculate TMGO**

$$TMGO_t = RT_{TES,t} \times COP_D - Elec_{TES,t}$$

Where,

t = measurement interval during dispatch

Appendix 2: Using Real-Time Forecasting to Improve Demand Response Resource Scheduling Accuracy

Propose a DR forecasting process to improve market awards to all resources and to improve operational accuracy for system operators

- CAISO currently uses regulation energy and exceptional dispatch to ensure reliable operations when DR is not available to meet day-ahead schedules in the real-time market
- Most DR output is directly tied to local temperatures and weather conditions, like VERs
- Hourly DR bids cannot be modified within the hour to limit the resulting awards to their expected “fuel availability”

CAISO's history with VERs necessitated the current process to limit bid curves based on forecast

- The real-time dispatch process is intended to produce accurate, economically appropriate signals for the supply resources within its footprint
- Following dispatch instructions is trivial for conventional resources
- CAISO has implemented additional features to ensure the market only dispatches VERs aligned with their forecasted availability
- Great success in reducing burdens on regulation and exceptional dispatch

DMM identified that DR fleet performance averaged 37% on high load days in summer 2023

- Current performance level is concerning since it imposes a considerable reliability and financial burden on the grid.
- Because CAISO cannot issue economic signals to resources beyond the final five-minute dispatch operating target, any deviations must be addressed using regulation energy.
- Prolonged deviations cause operator exceptional dispatch

Department of Market Monitoring Demand response issues and performance 2023, Published March 6, 2024
https://www.caiso.com/Documents/Demand-Response-Report-2023-Mar-6-2024.pdf

Proposal

- Develop a forecasting process similar to what is already in place for qualified VER units
- Allow DR providers to submit interval forecasts aligned with existing market timelines
- CAISO uses interval forecasts to limit the DR bid curves used by the market optimization
- CAISO would then be able to economically dispatch other units to fill the performance gaps that would otherwise have occurred, resulting in a more reliable and economically efficient market outcome