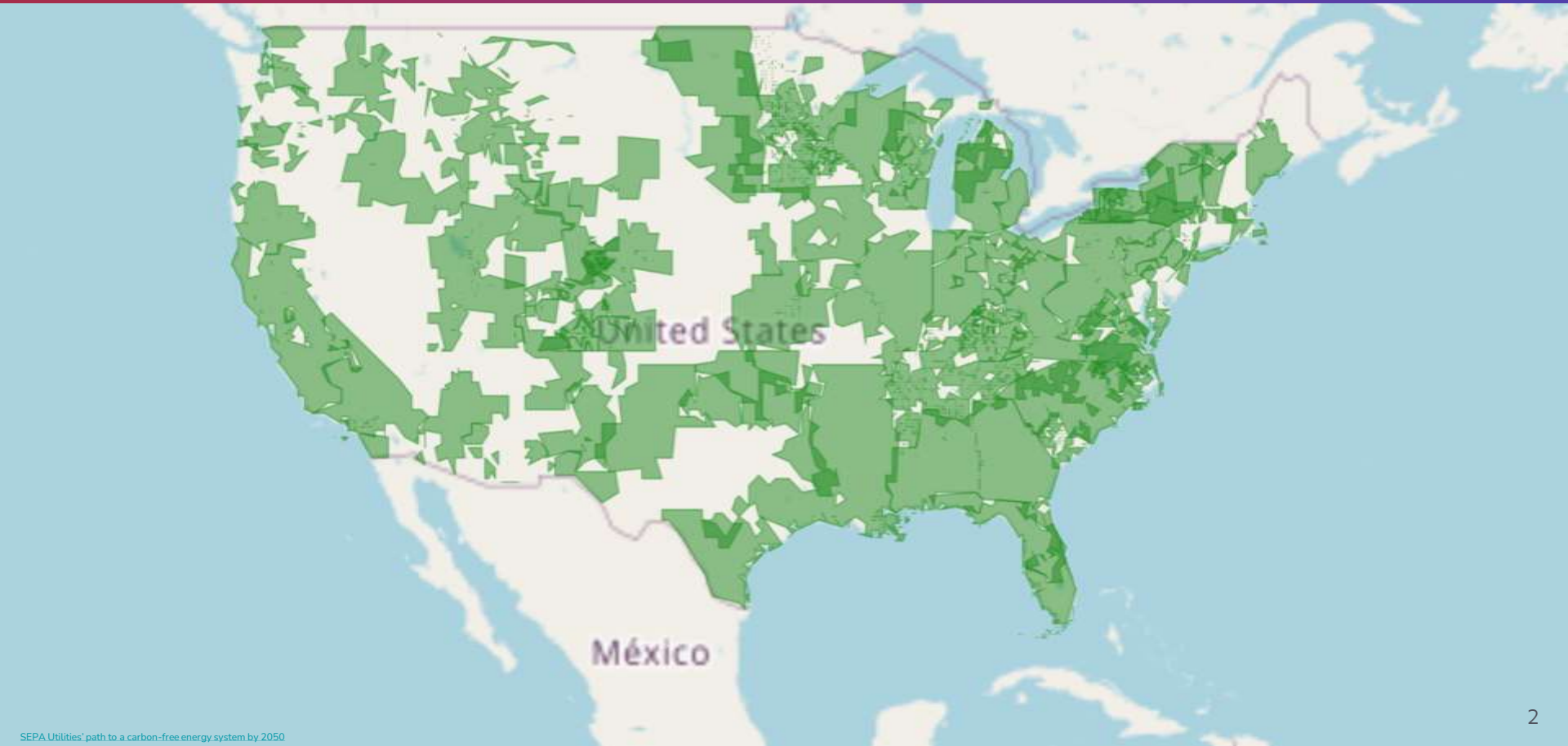
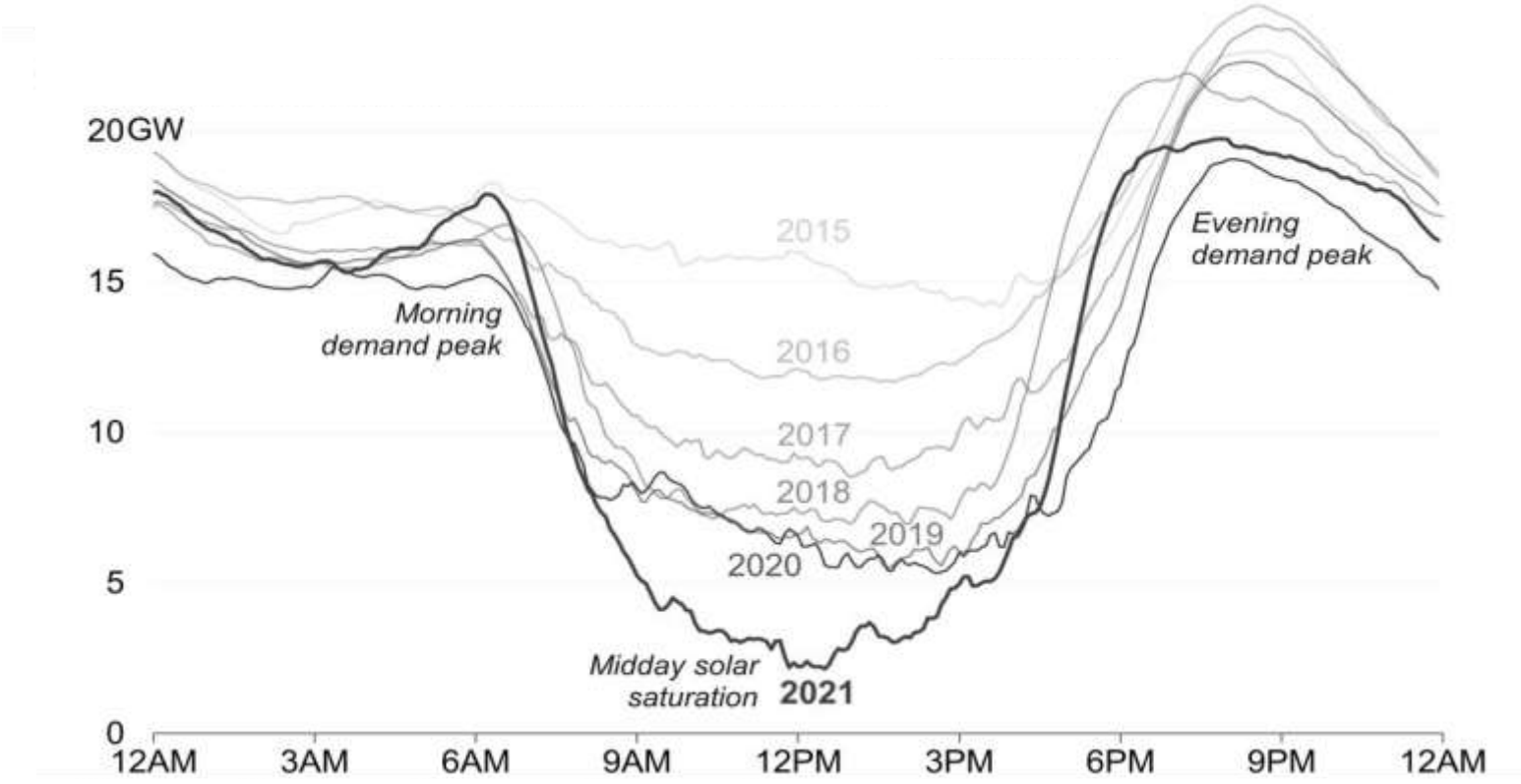

RECURVE
SHAPE THE FUTURE OF ENERGY

71% of customers served by utility with carbon goal



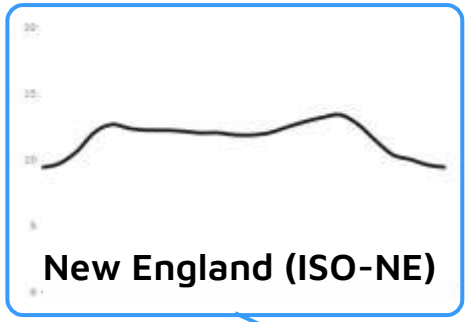
SEPA Utilities' path to a carbon-free energy system by 2050

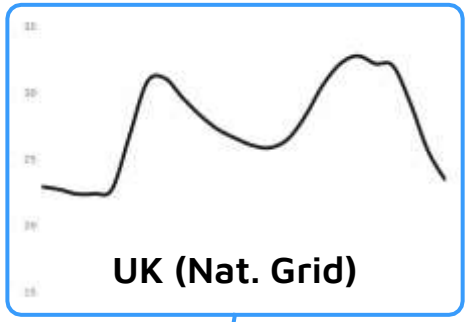
Renewables Are Creating Load Volatility

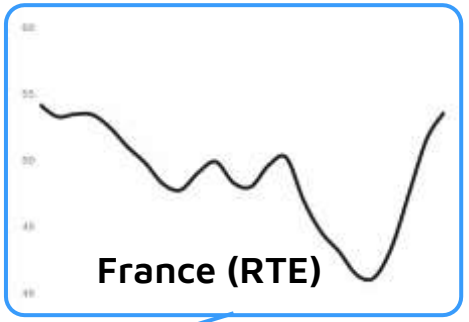


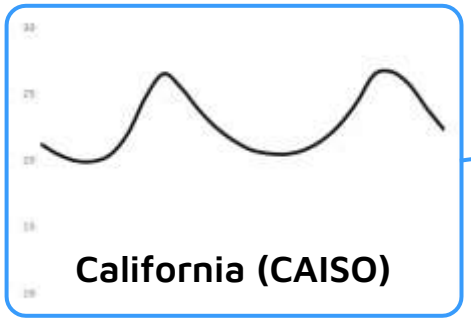
Lowest net load day each year in CAISO, 2015-2021

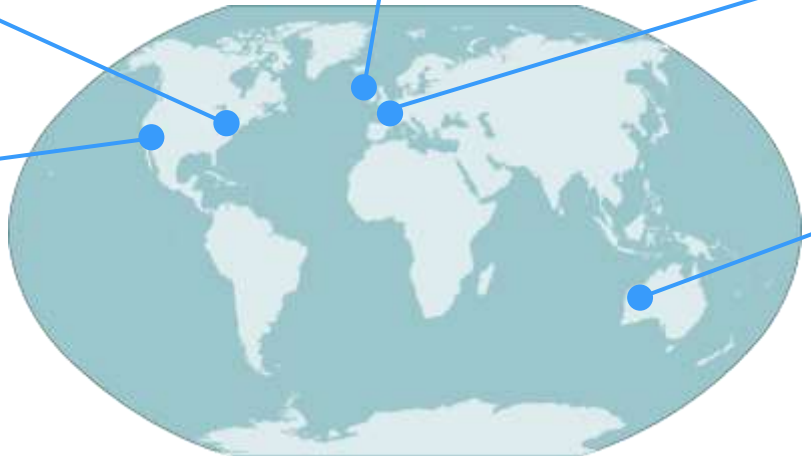
Grid Challenges are Global and Existential

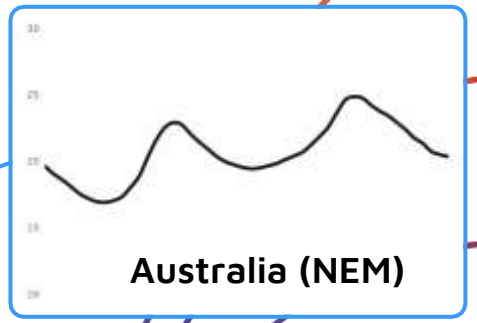






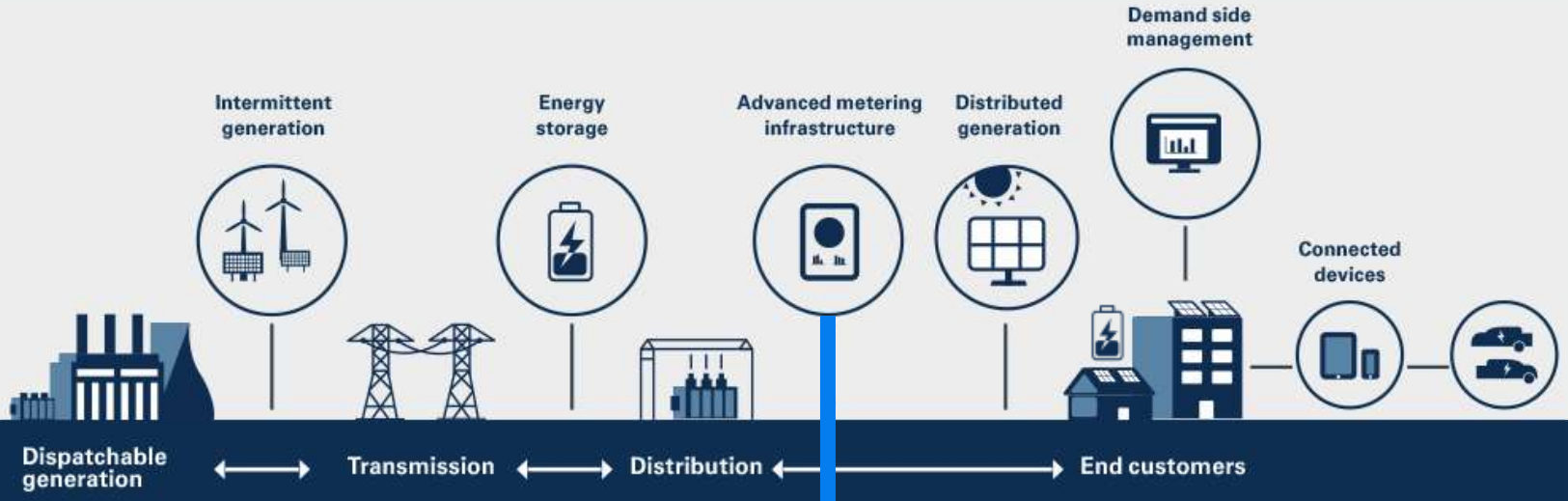






The Grid is a Balance of Supply and Demand

Supply = Demand



Supply: Energy Resources

Demand: Load Modifying Resources

Utilities Benefits From Demand-Side Resources

Load Modifying Resources (LMR)

- 15% price advantage over supply-side*
- Hedges market peak energy events
- Modifies forecast to reduce RA
- Provides benefits to local customers
- Incorporate the full value stack

Supply-Side

Energy

Ancillary

Market Resources

Demand-Side

Load Modifying Resources Enable the Full Values Stack

DEMAND FLEXMARKET

Losses

Non-Grid Priorities

- ❑ Equity
- ❑ Resiliency

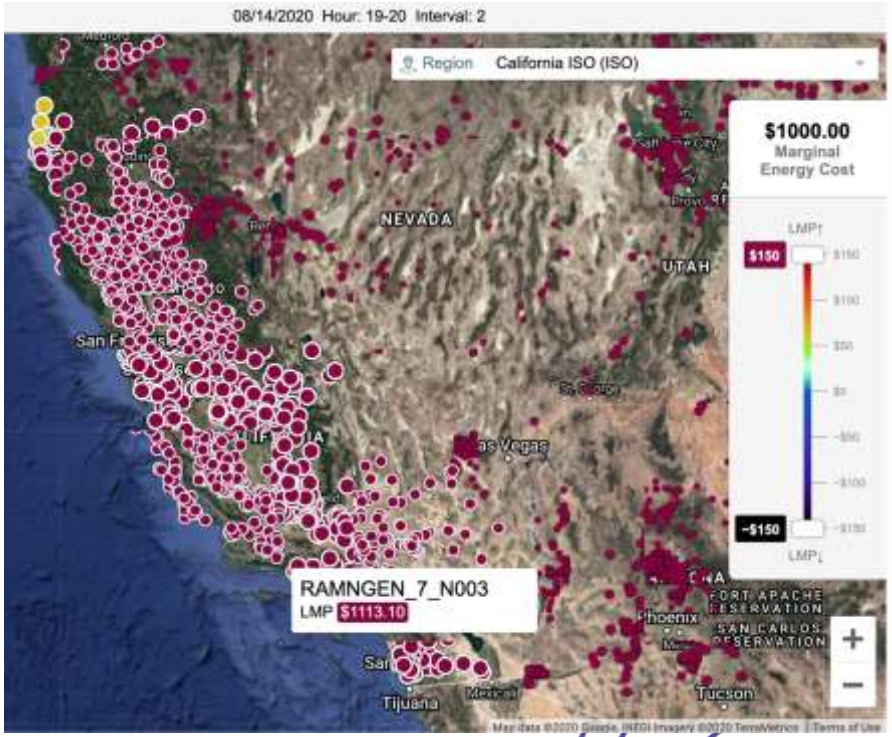
* IEA US Supply-Side Reserve Margins: https://www.eia.gov/todayinenergy/detail.php?id=39892

Aug. 14, 2020: Widespread Blackouts

- Temperatures > 100 °F+
- $1,000+/ MWh
- Rolling Blackouts

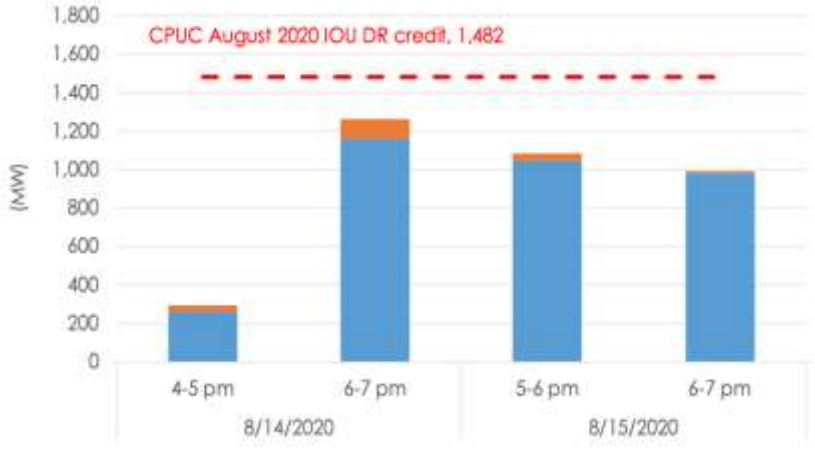

Los Angeles Times

California begins rolling blackouts after first Stage 3 emergency since 2001



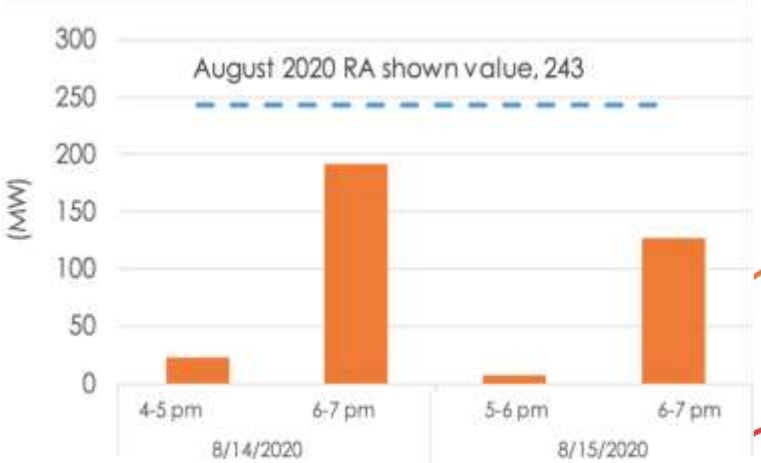
PROBLEM: Did Demand Response Fall Short?

Utility Demand Response



Credited IOU Demand Response: Preliminary Estimated RDRR Response and PDR Dispatch vs. CPUC August 2020 DR Credit

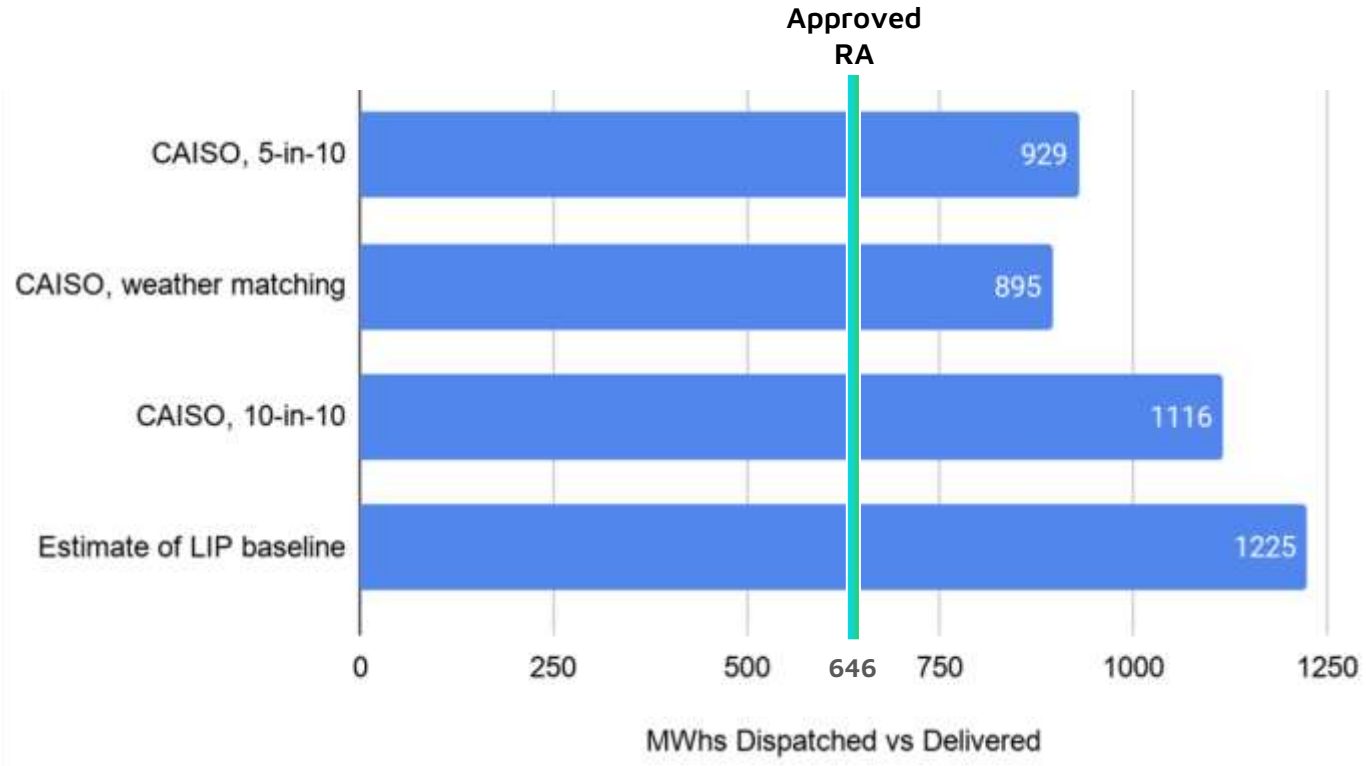
Market Demand Response



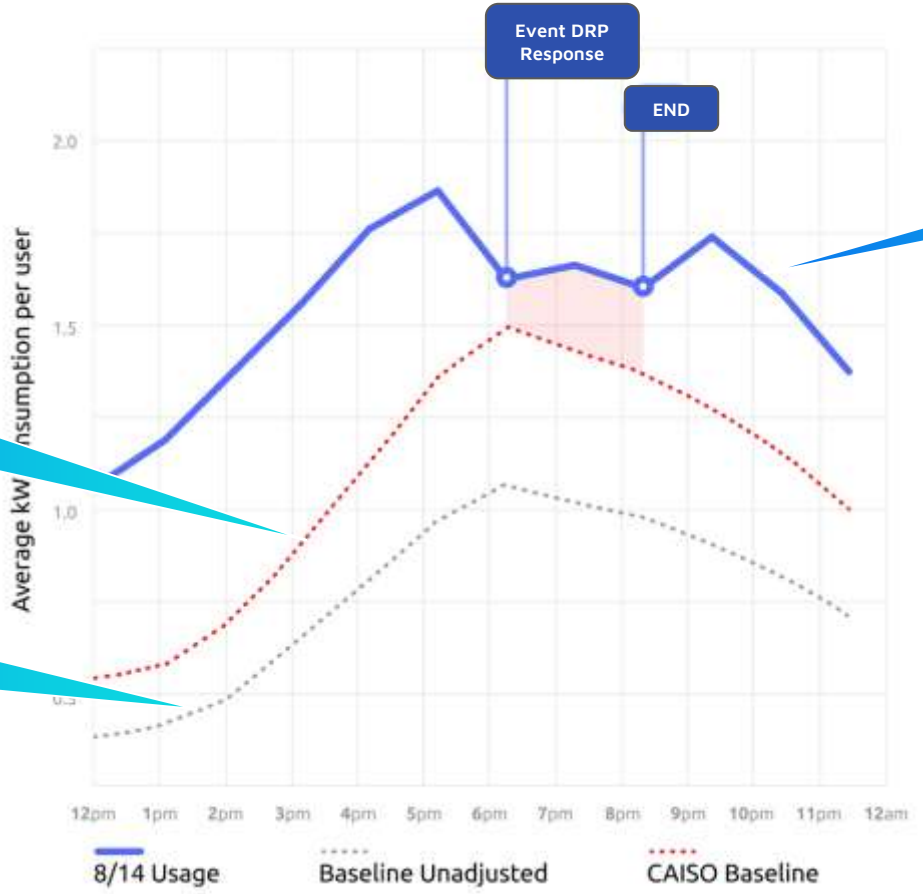
CAISO Dispatch of Non-IOU PDR (Actual Load Drop Not Yet Available)

http://www.caiso.com/Documents/Preliminary-Root-Cause-Analysis-Rotating-Outages-August-2020.pdf

PROBLEM: Measurement Uncertainty



PROBLEM: Outdated Methods = Flawed Results



Demand Exceeded Baseline All Hours

Capped "Same Day Adjustment"

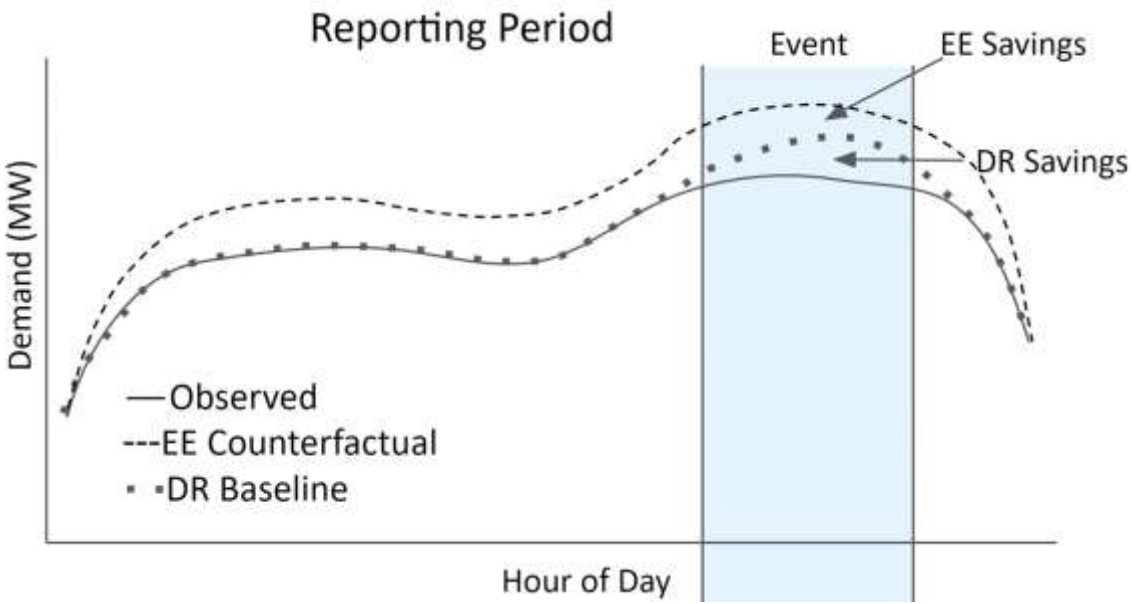
10x10 Baseline last 10 days

SOLUTION: Open-Source Meter-Based Telemetry

Unified Field Theory of Demand Flexibility:

- ➔ Measure all BTM DERs based on grid impacts at the meter
- ➔ FLEXwatt = hourly NMEC site-baseline Δ population stratified comparison group
- ➔ Attribute impacts to appropriate contract (EE/DR)
- ➔ Revenue-grade open-source and verifiable from raw data

=



EE / NMEC / Load Shifting
365 day CalTRACK model

Demand Response
60 day CalTRACK model

SOLUTION: Open-Source NMEC

Open-Source Methods and Code

CALTRACK

LFENERGY OPENEEMETER

OPEN GRIDMETER

FLEXVALUE

ENERGY DIFFERENTIAL PRIVACY

LFENERGY

- **CalTRACK:** hourly flex M&V methods
- **OpenEEmeter:** open-source code implementation of CalTRACK methods
- **GRIDmeter:** code and methods for automated stratified comparison groups
- **FLEXvalue:** hourly avoided cost calculations and cost-effectiveness tool
- **Energy Differential Privacy:** mathematically robust privacy protection

California Public Utilities Commission

Pacific Gas and Electric Company

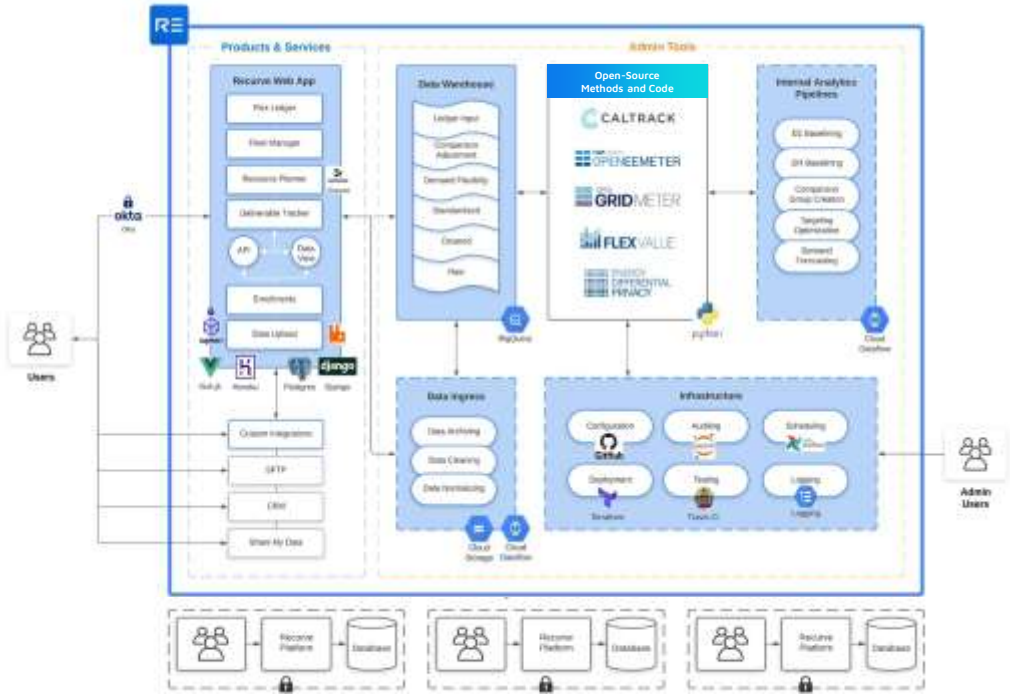
California Energy Commission

U.S. Department of Energy NREL

U.S. Department of Energy NREL

SOLUTION: Revenue-Grade Verification

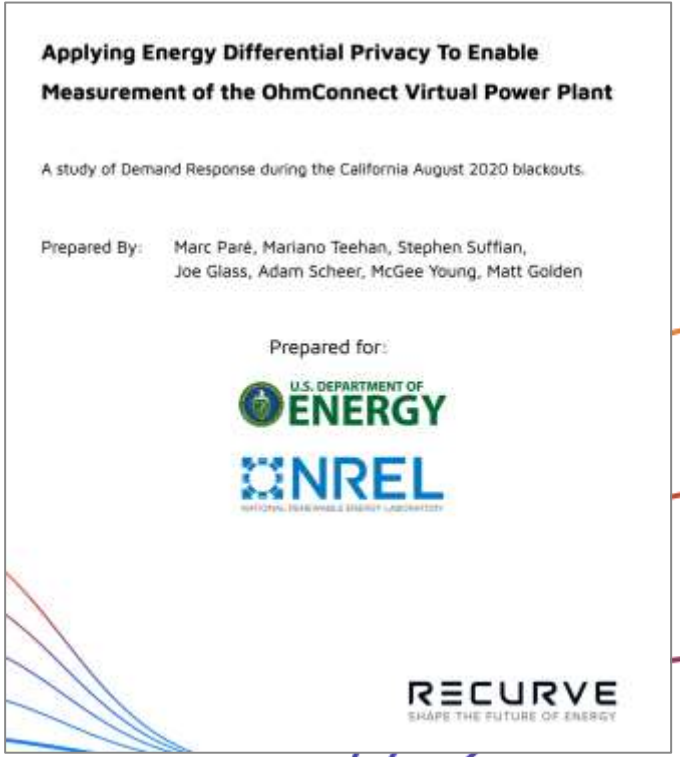
Recurve Platform



- **Revenue-Grade** open-source, auditable, reproducible
- **Verifiable** standard for demand flexibility calculations
- **Scalable** to every meter on the grid
- **Automated** from meter data to settlement-quality transaction
- **Secure** single tenancy, SOC2 certified

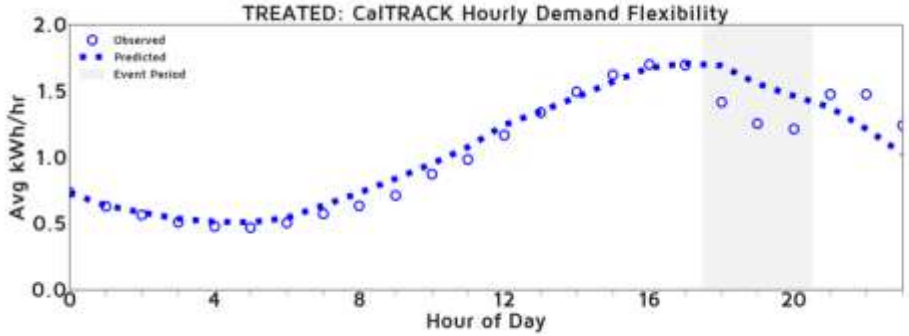
SOLUTION: Revenue-Grade Verification

- **Analysis of OhmConnect's response in MCE territory During the 2020 blackout remand response events**
  - Sample of 1,500 residential MCE participating customers
  - CalTRACK baselines for all population meters
  - GRIDmeter open-source advanced non-participant comparison groups
  - Energy Differential Privacy protection



https://www.recurve.com/blog/revenue-grade-analysis-of-the-ohmconnect-virtual-power-plant-during-the-california-blackouts

OhmConnect's VPP During the 2020 Blackouts



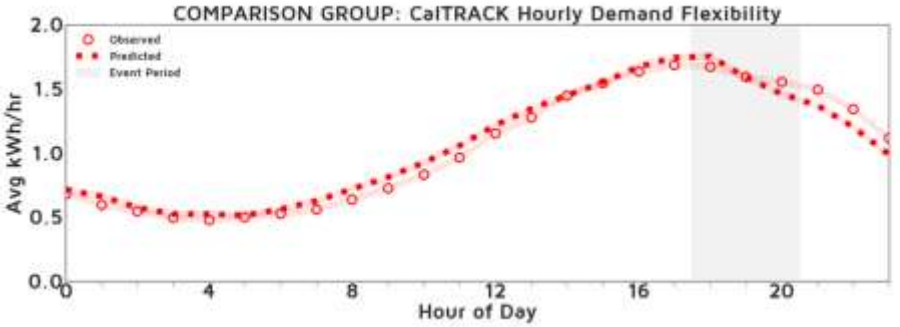
TREATMENT GROUP:

-17.5%

Event Demand Reduction

CALTRACK

OPENEEMETER



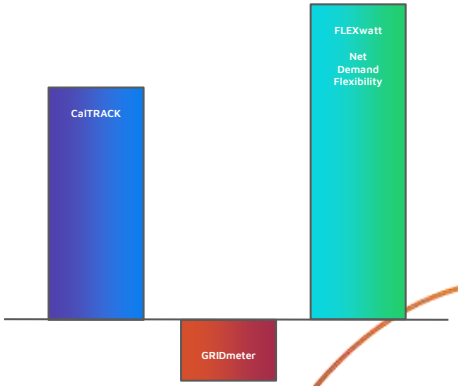
COMPARISON GROUP:

1.8% ±0.5%

Event Demand Reduction

OPEN GRIDMETER

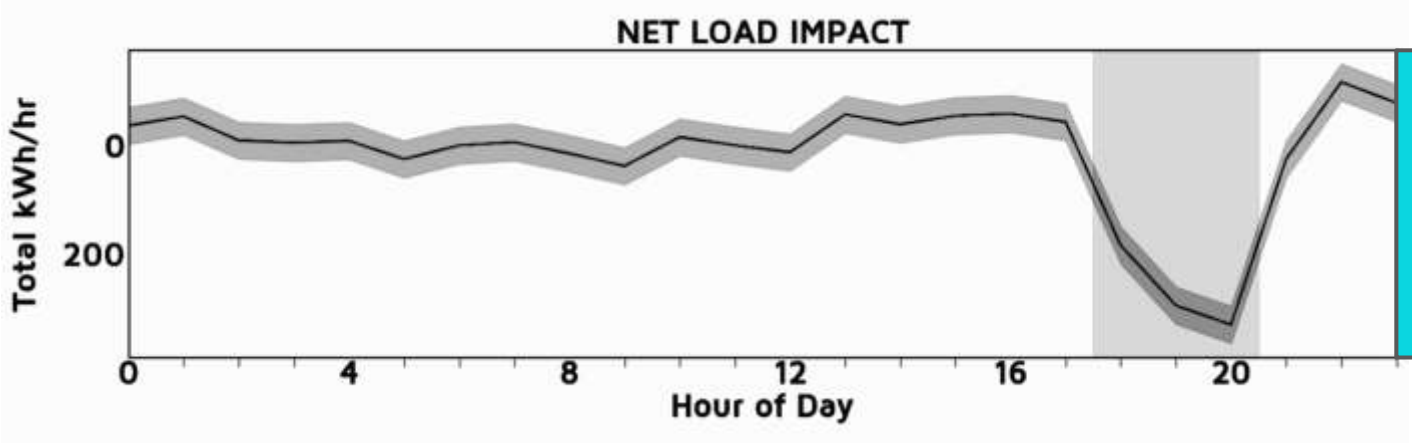
ENERGY DIFFERENTIAL PRIVACY



Δ Comparison

(e.g., COVID Impacts)

OhmConnect's VPP During the 2020 Blackouts



-19.3% ±0.5%

Demand Flex

CAISO Advanced Methods

CAISO funded Recurve Analysis to enable revenue-grade methods for supply-side demand response.

California ISO

April 9, 2021

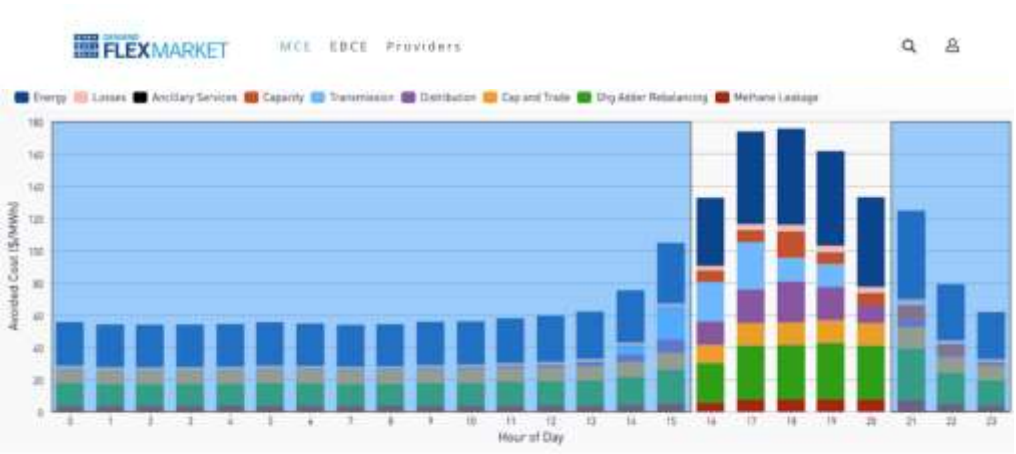
The CAISO has contracted with Recurve to evaluate the impacts of demand response during the events of summer 2020 using their open-source comparison group methodology. The data pipelines established for this study will be applicable to further expansion of DR impact analysis in 2021. Recurve will also provide a point-by-point review of the control group method currently approved by FERC for the CAISO DR Tariff.

The purpose of this analysis is to:

- Understand and operationalize the baseline and comparison group methods in relation to existing guidance and practice;
- Understand barriers to data access and identify a viable path to overcome them;
- Understand the 2020 heat storm events based on the baseline and comparison group methods implemented by Recurve to inform and support decision making; and
- Understand impacts of demand response events in 2021 and operationalize methods at scale.

As a result of this effort, the CAISO hopes a DR provider or resource(s) can use this methodology as a performance methodology for settlement of market dispatches in summer 2021, conditional to the methodology's compliance with the CAISO tariff. Following this, the CAISO hopes the methodology will be applied broadly amongst the DR community to measure performance.

DEMAND FLEXMARKET



~$150/MWh during peak: June 1 - September 30, Weekdays

Peak FLEXmarket

Utility Procurement

Additional Flex as a Energy Market Hedge, and Load Modifying Resource (**LMR**)

- Seasonal Summer Peak Savings at $150 a MWh
- Day ahead signal based on CAISO price

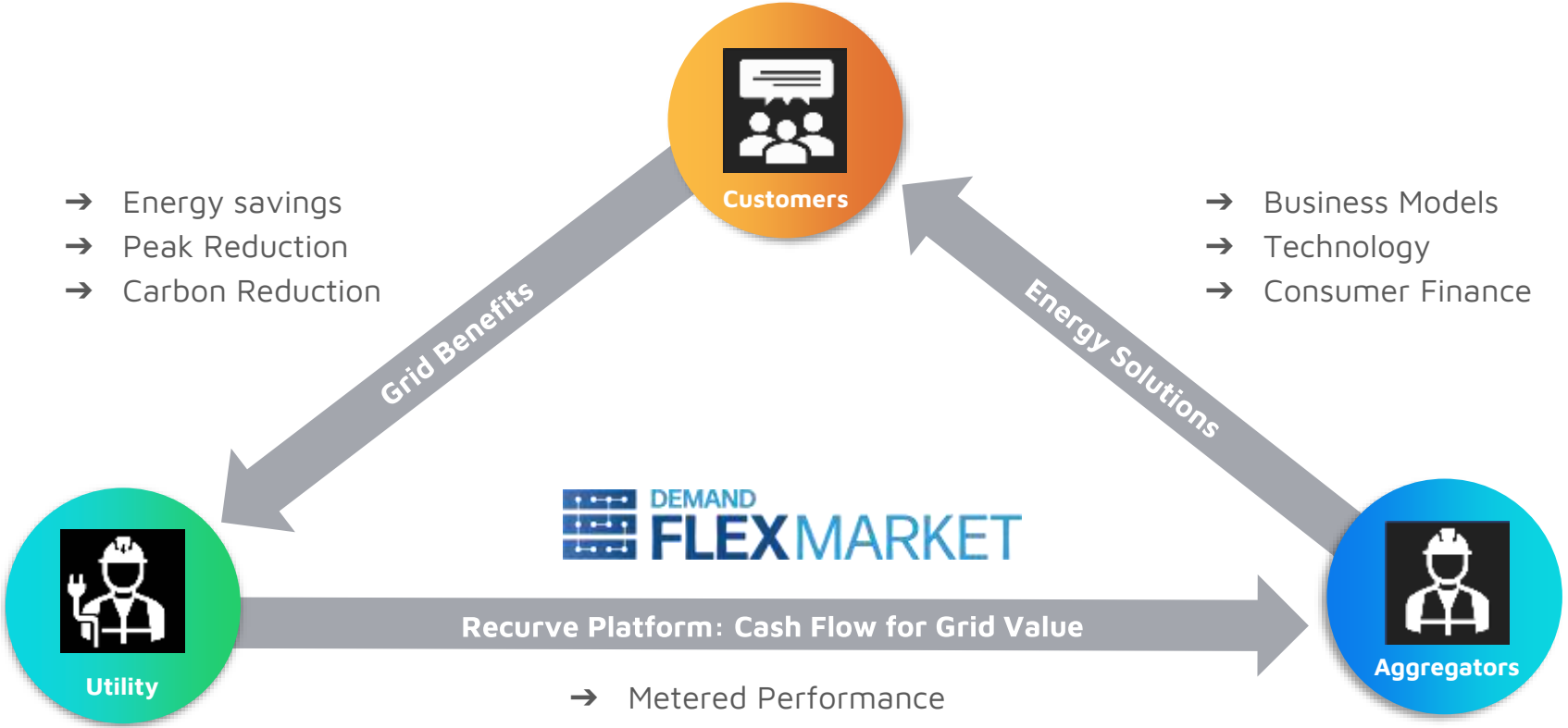
Commercial Efficiency Market

CPUC Program

Market for Cost Effective Long-Term Savings
(Population NMEC + P4P)

- Paid for at the rate that makes every project cost effective (TRC=1)

Making Markets for Demand Flexibility



FLEXMARKET Aggregators

BlocPower
Increase your building's profitability with a modern heating and cooling system.

Bright Power
Bright Power is the premier provider of energy and water management services.

Carbon Lighthouse
Cut Energy at a Portfolio Scale. Because one building at a time doesn't cut it.

Elevation Home Energy Solutions
We are on a mission to Elevate the Home Energy Experience.

EverWatt
Stop wasting money on old lighting.

Halco
Halco is a leading residential and commercial energy services provider in NY

CH Energy
CH Energy is an expert in providing a turnkey energy solution.

CLEAResult
CLEAResult
We make energy efficiency smarter, faster, and more accessible for everyone.

Conectric IoT
Operational Asset Risk Management.

Joule Smart
Joule Smart will save you time, money, and give you peace-of-mind.

Leap
Leap is a marketplace for grid services, to help balance the grid.

National Resource Management
If your business relies on refrigeration systems, NRM has a way to help you.

Dividend Finance
A smarter, faster way to finance home improvements and commercial upgrades

ecobee
ecobee
A smart home technology helping customers maintain comfort and cost savings.

EcoGreen Solutions
We help companies save energy and cut costs.

Northern Pacific Power Systems
Premier Energy Solutions for the North Bay Area in California

OhmConnect
OhmConnect
Use energy when it's cleanest and earn rewards for saving when it's dirty.

Packetized Energy
Packetized Energy makes electricity flexible.

Ecology Action
Ecology Action is creating a thriving environment and low-carbon economy.

Edgewise Energy
Helping property owners to improve resiliency, sustainability, and profit.

Electrum
Electrum provides a home electrification concierge marketplace.

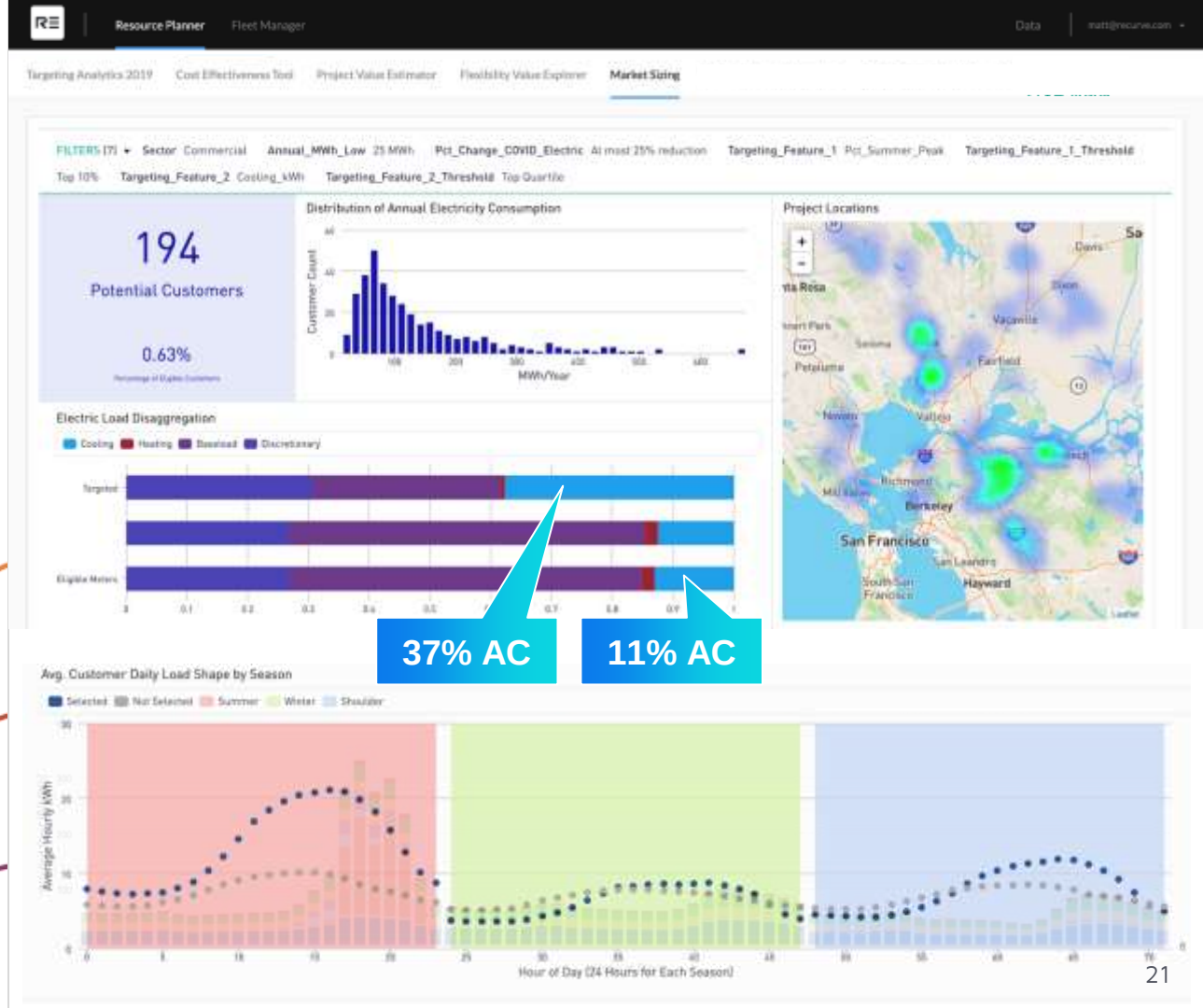
Sealed
Sealed
Stress-free home upgrades? With Sealed, they've not just a fantasy.

Swell Energy
Swell Energy is an energy and smart grid solutions provider.

Voltus
Better Energy. More Cash.

Resource Planning

Forecasting Virtual Power Plant potential by highest value customers



Fleet Management

SMB Controls / HVAC NorCal

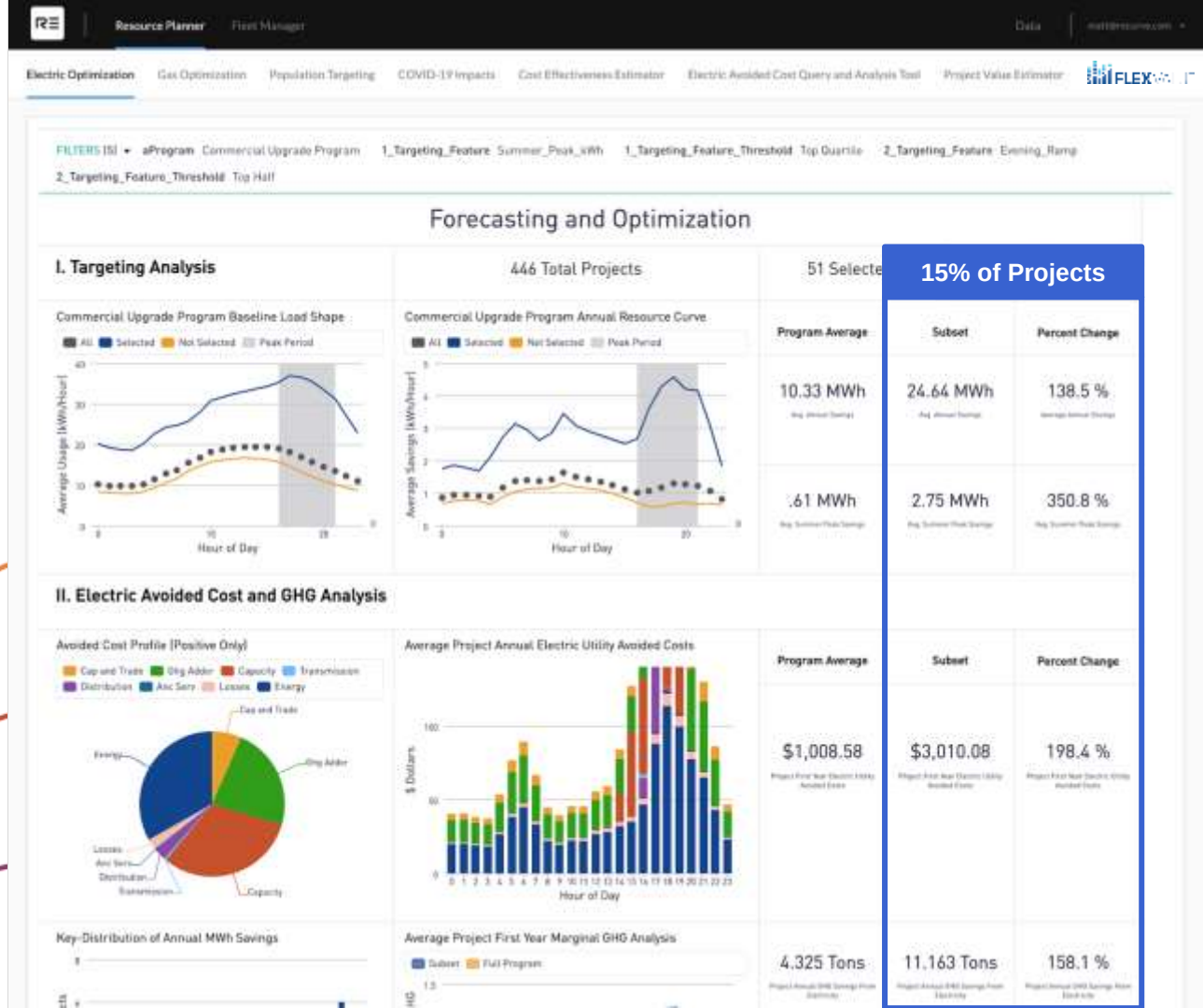
Selected Projects

2.5x Energy Savings

4.5x Peak Reductions

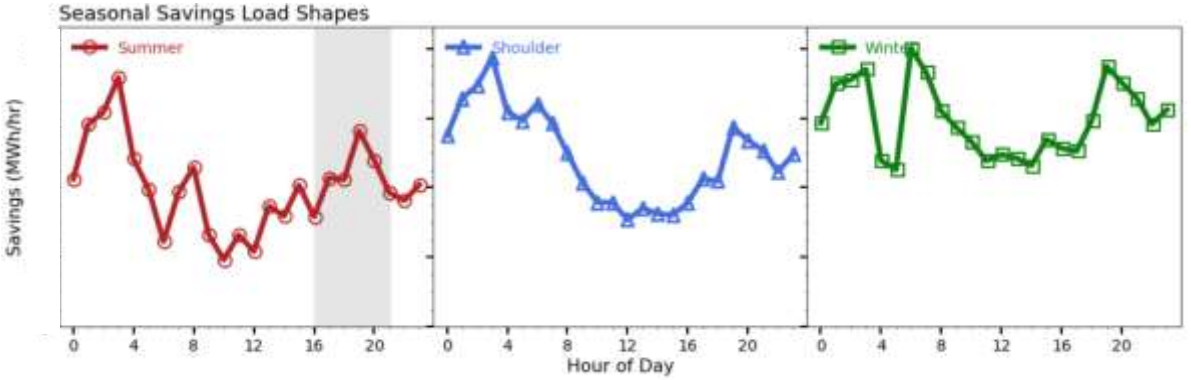
3x Grid Value

2.5x GHG Savings

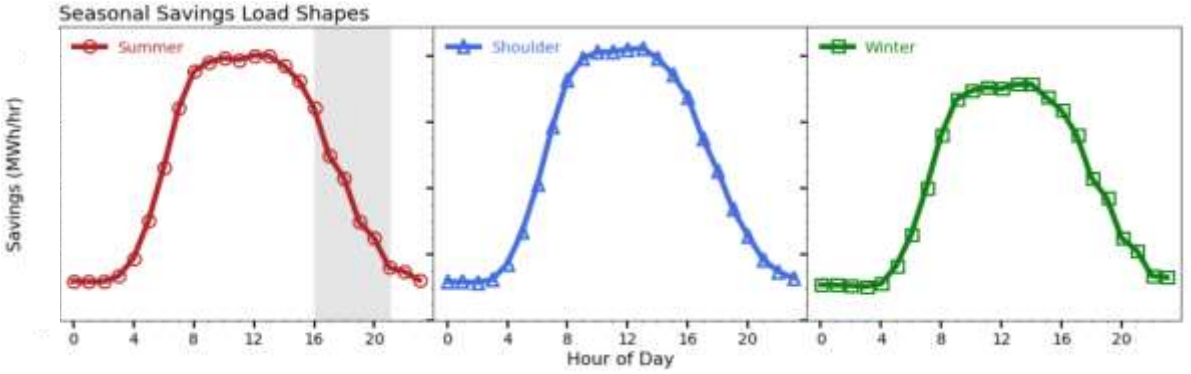


What Does Stuff Do In The Real World?

Measured Savings:



Deemed Savings:

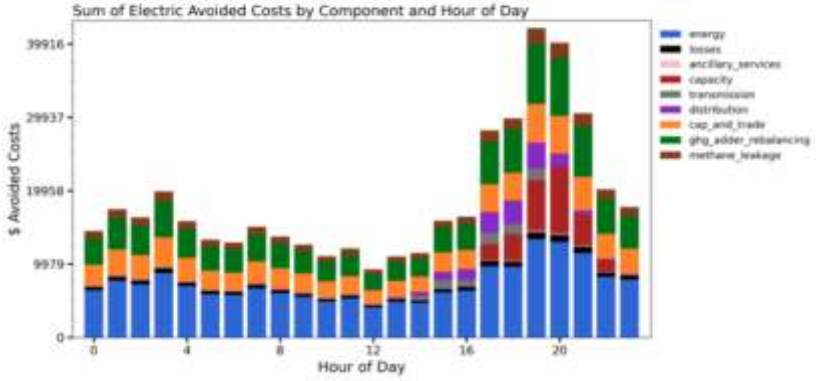


FLEXVALUE

Averages Trap Us In Mediocrity

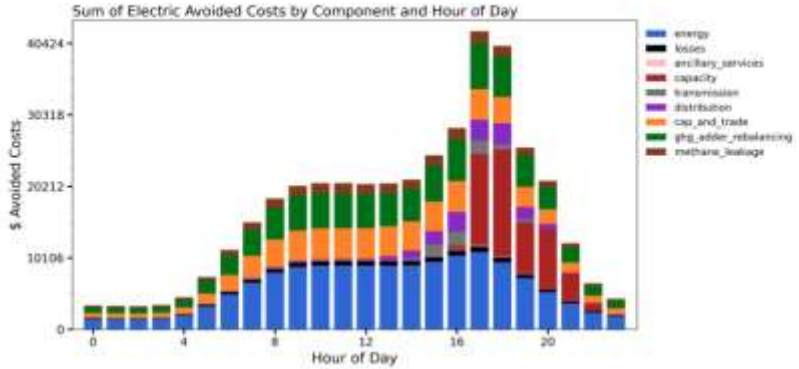
Measured Value:

From CalTRACK Hourly Measurements:



$447k Grid Value

Using DEER Load Shape:



Deemed Value:

$399k Grid Value

Δ $48,000

FLEXVALUE

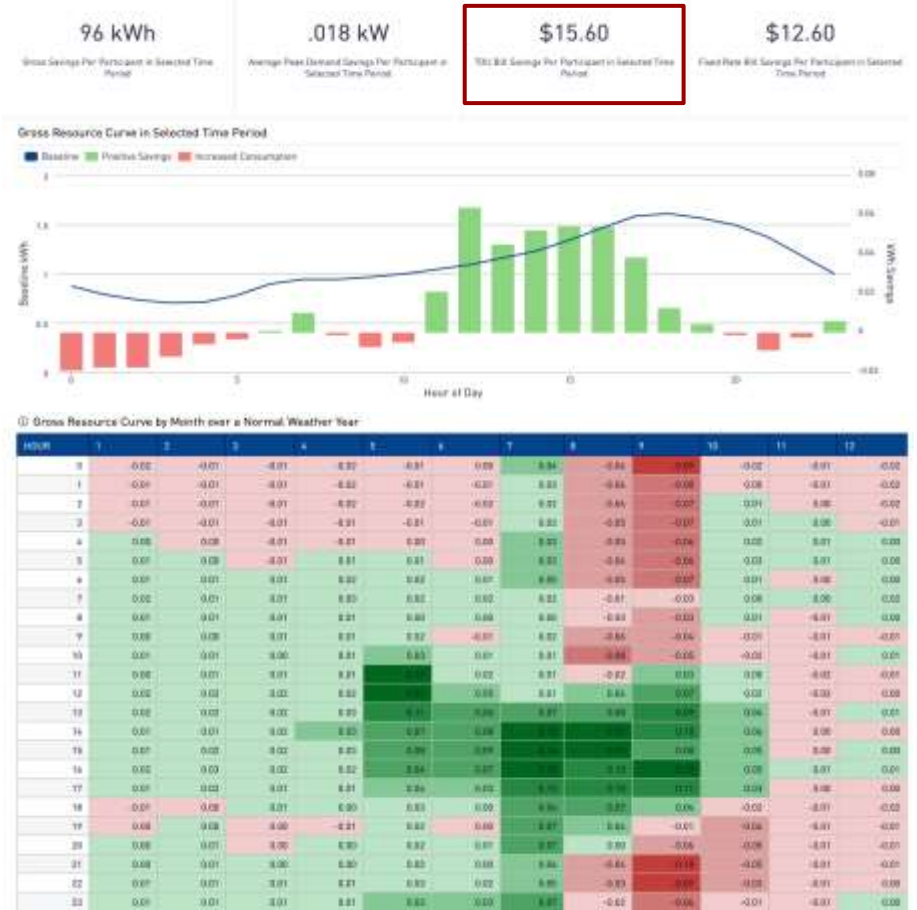
RESOURCE CURVE: Smart Thermostat

Positive grid value observed due to shift from peak to midday, despite an increase in total usage

FLEXVALUE

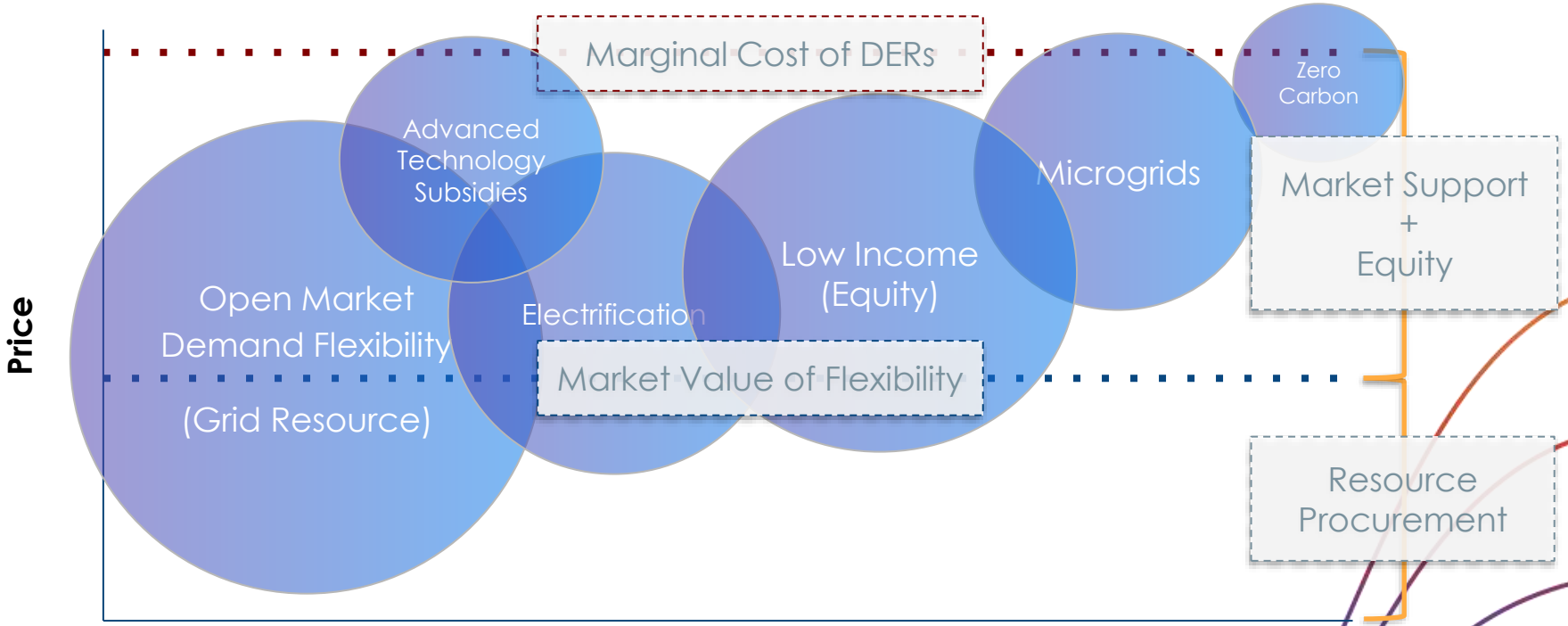
RESOURCE CURVE: Heat Pump

Negative grid value observed due to increase in night and morning loads



FLEXVALUE

Program Design → Market Design



The Foundation for Flexibility as a Resource

Data Access & Privacy

- ✓ Secure
- ✓ Functional
- ✓ Risk-Based

Meter-Based Quantification

- ✓ Transparent
- ✓ Open-Source
- ✓ Accessible

Performance Payment

- ✓ Accountable
- ✓ Flexible
- ✓ Financeable

Competitive Procurement

- ✓ Standard
- ✓ Integrated
- ✓ Open Market

Optimizing Energy Efficiency to Serve Small Businesses in Disadvantaged Communities

Matt Golden, CEO
matt@recurve.com