INDUSTRIAL LOAD FLEXIBILITY

An Opportunity for Decarbonization in California

Ammi Amarnath
Senior Technical Executive

CalPlug's 10th Anniversary
May 10, 2022

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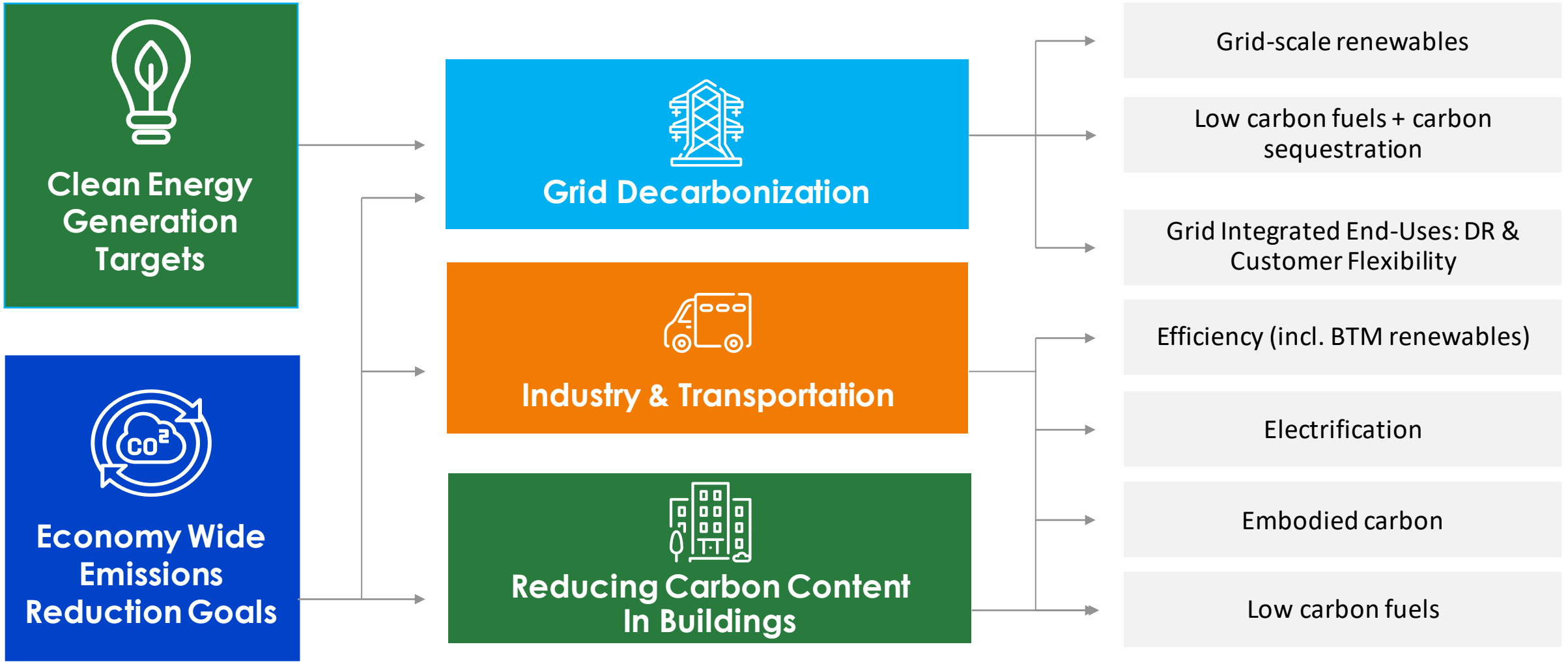
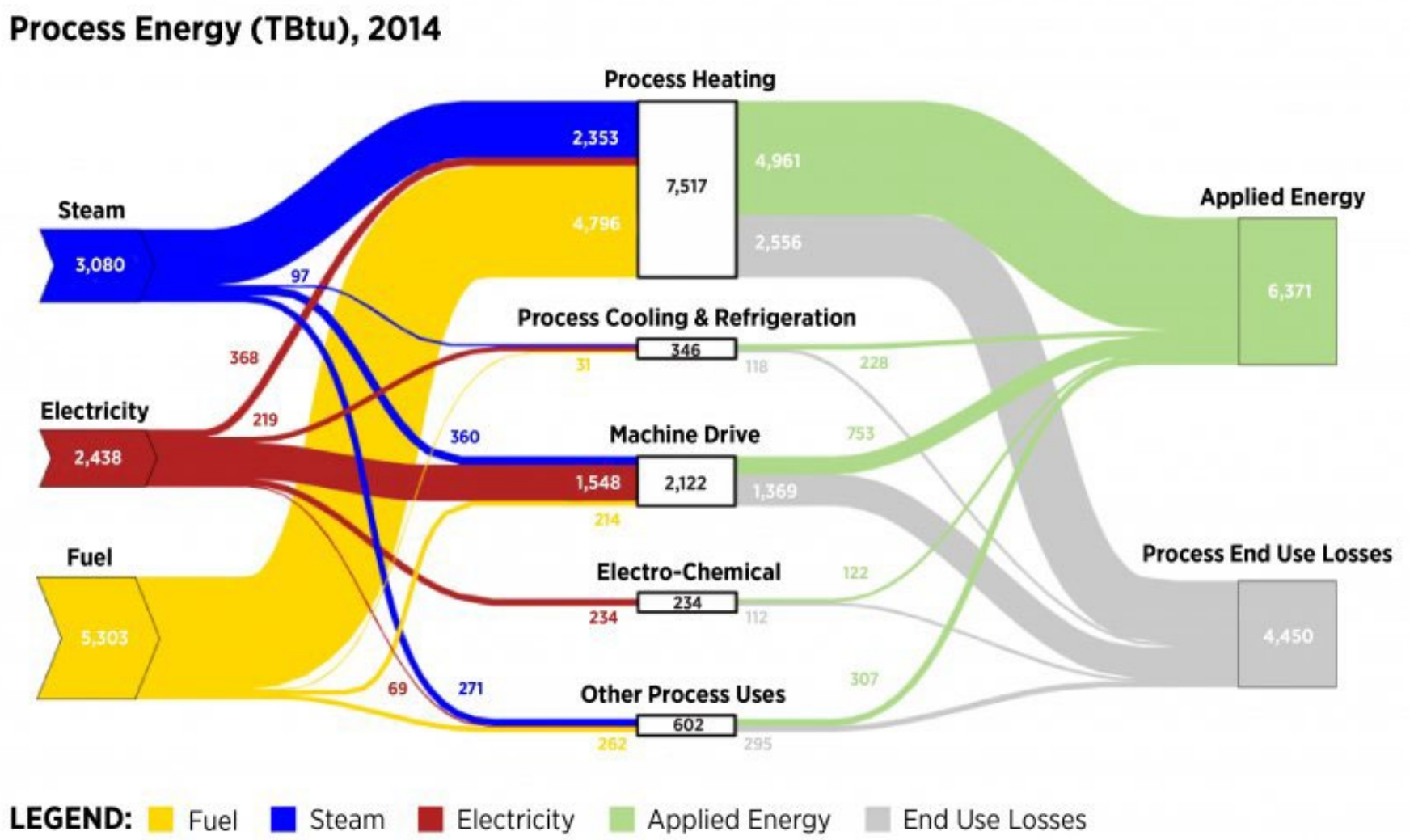
It is all About Decarbonization



Greater Decarbonization = More Renewables = More Flexibility

Industrial Flexibility – Energy Use in Industries



Source: https://www.energy.gov/eere/amo/static-sankey-diagram-process-energy-us-manufacturing-sector-2014-mecs

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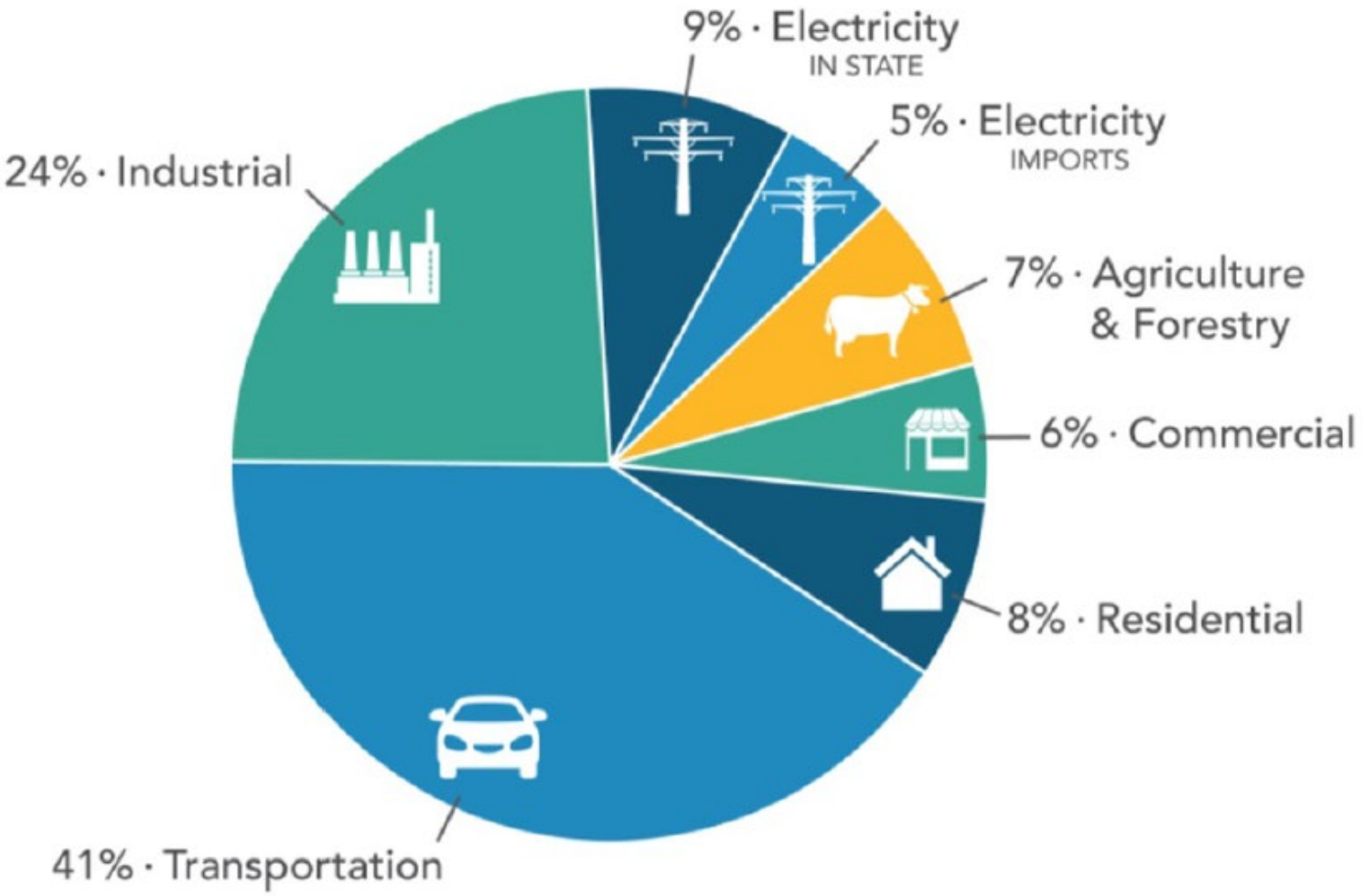
California Emissions – 2019



Source: Patty Monahan, CEC Commissioner
2022 UC Davis Symposium on Industrial Decarbonization

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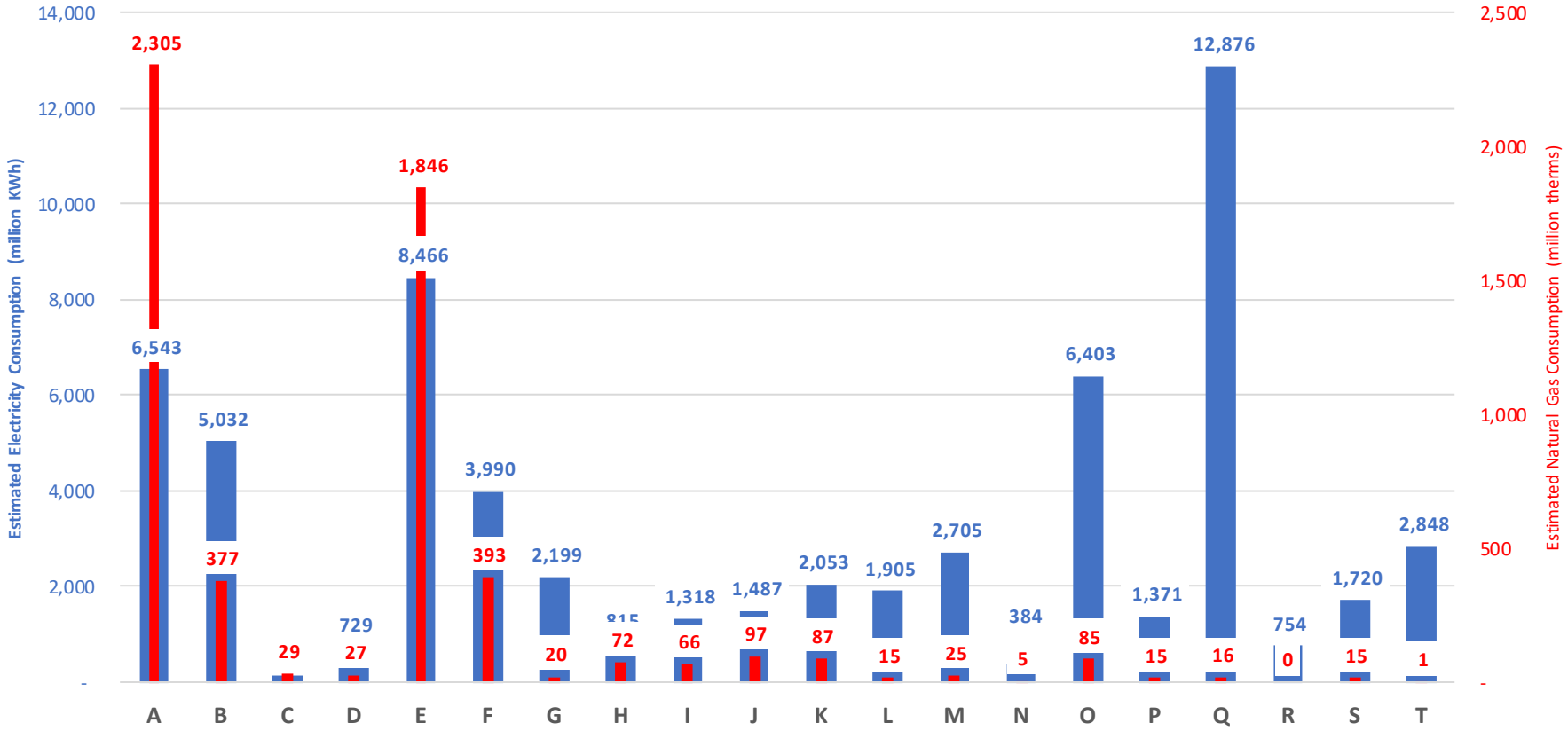
Electricity and Natural Gas Consumption in the IAW Sectors in California



Source: California Energy Commission, 2016

A Oil and Gas Extraction and Mining Support

B ***Food and Beverage***

C Textile Mills

D Pulp, Paper, and Paperboard Mills

E Petroleum, and Coal Products Manufacturing

F Chemical Manufacturing

G Plastics and Rubber Products Manufacturing

H Glass Manufacturing

I Cement

J Primary Metal Manufacturing

K Fabricated Metal Product Manufacturing

L Semiconductor and Other Electronic Component Manufacturing

M Computer and Electronic Product Manufacturing (excl. Semiconductors)

N Electrical Equipment, Appliance, and Component Manufacturing

O Agriculture, Forestry, Fishing, and Hunting

P Animal Production

Q Water Supply and Irrigation Systems

R Irrigation Systems

S Sewage Treatment Facilities

T Data Processing, Hosting, and Related Services

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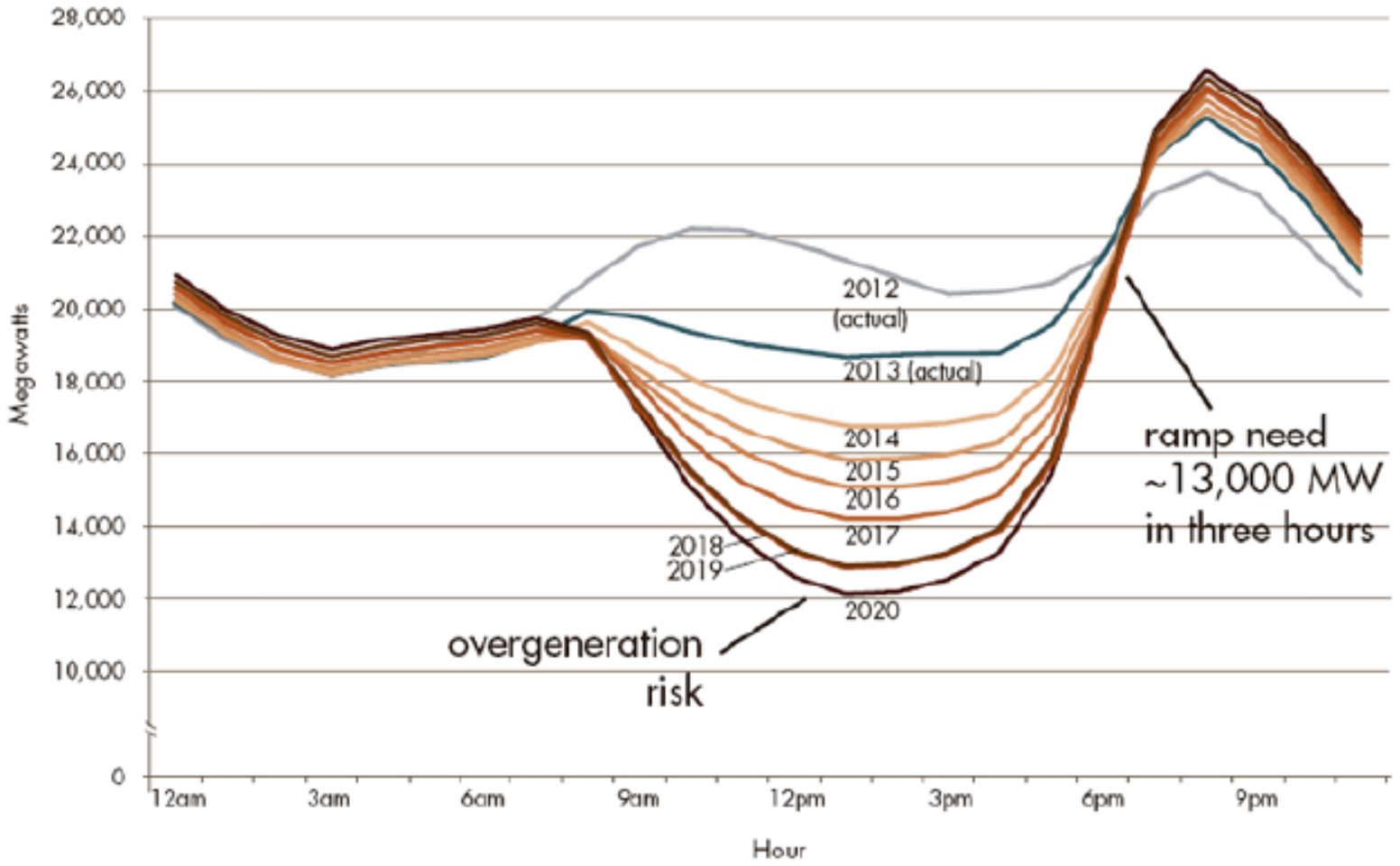
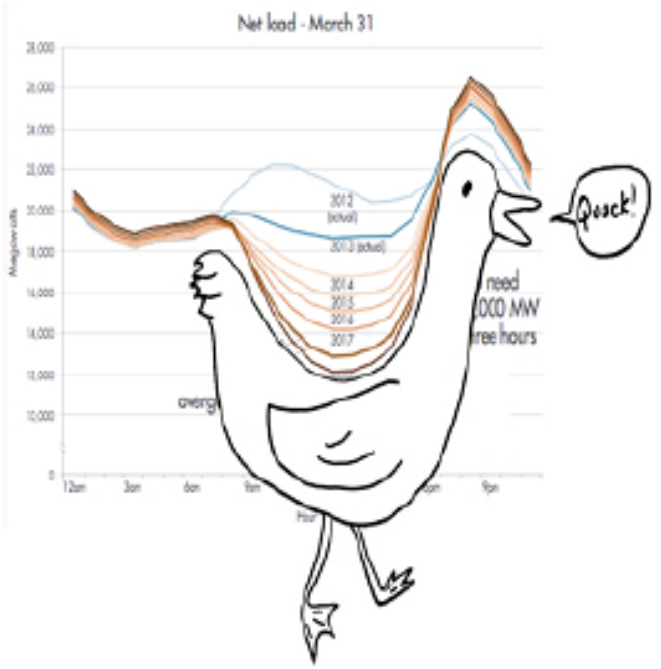
Increased Electrification and California's Duck Curve





Source: California ISO

End-Use Load Flexibility is Necessary to Support the Grid

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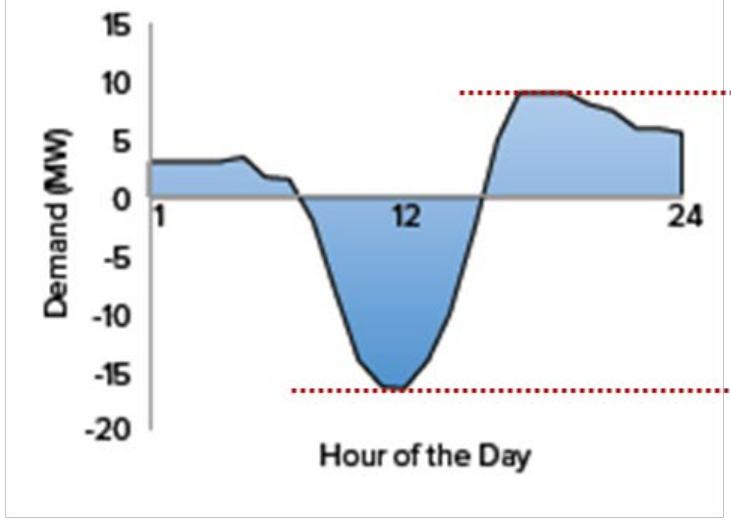
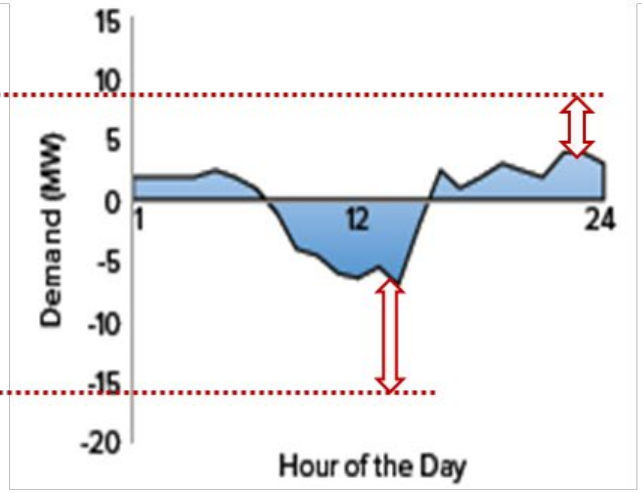
California Commercial Building Example – Grid View

Solar PV Only

Efficiency, Demand Response, THEN PV





Source: New Buildings Institute, PG&E Corp.

Source: Andrew McAllister, CEC Commissioner

2017 NA Konwakai

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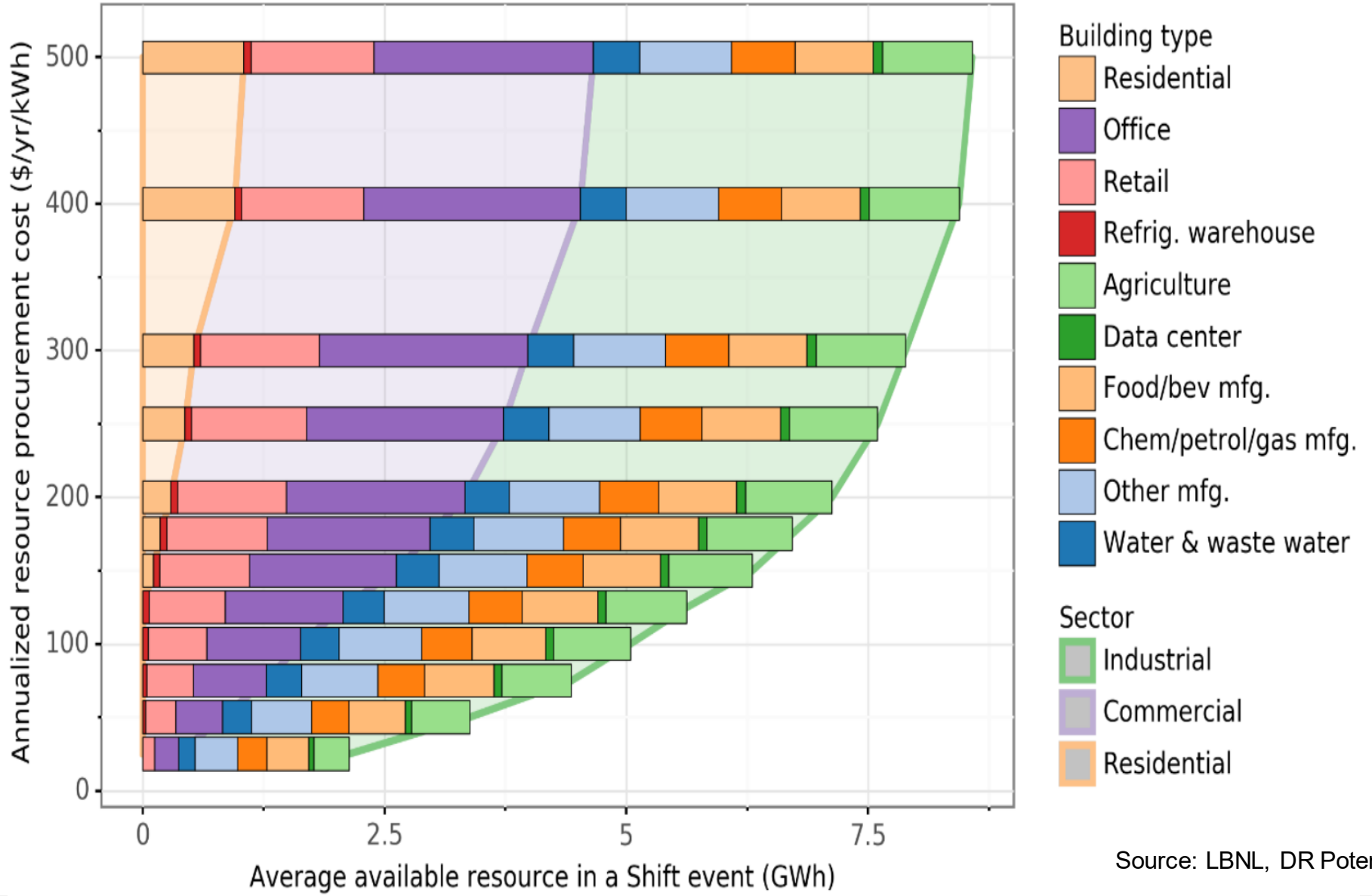
Available Demand Response Resources in Shift Events

The California Demand Response Potential Study, Phase 3, LBNL, 2020



Source: LBNL, DR Potential Study – Phase 3

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Opportunities for Demand Response in California Industries

- Chemicals Industry
- Data Centers
- Agriculture – Water Pumping
- Domestic Water Supply and Wastewater Treatment
- Food Processing and Storage
  - Mainly Refrigeration

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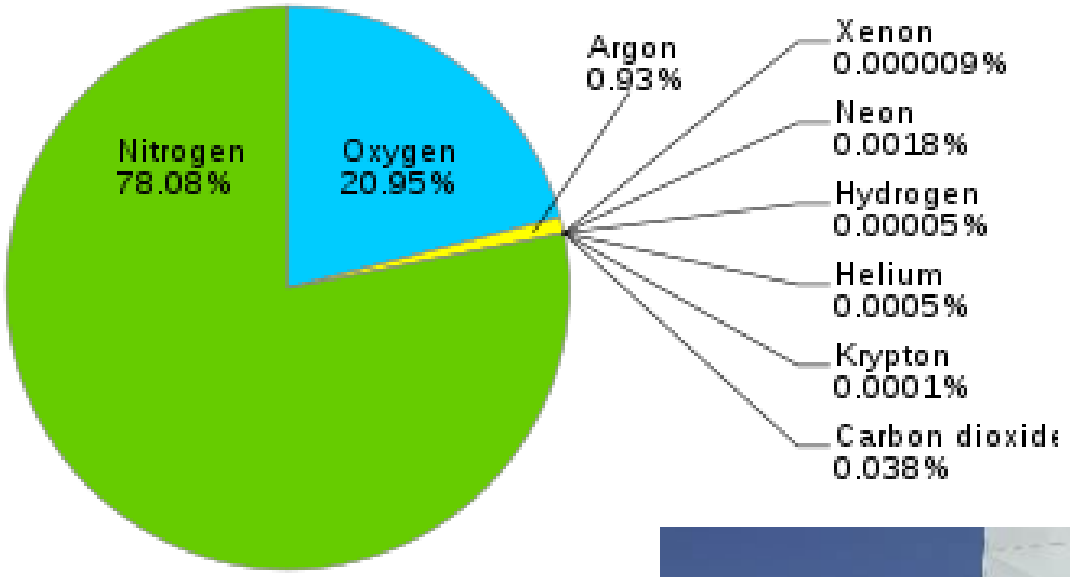
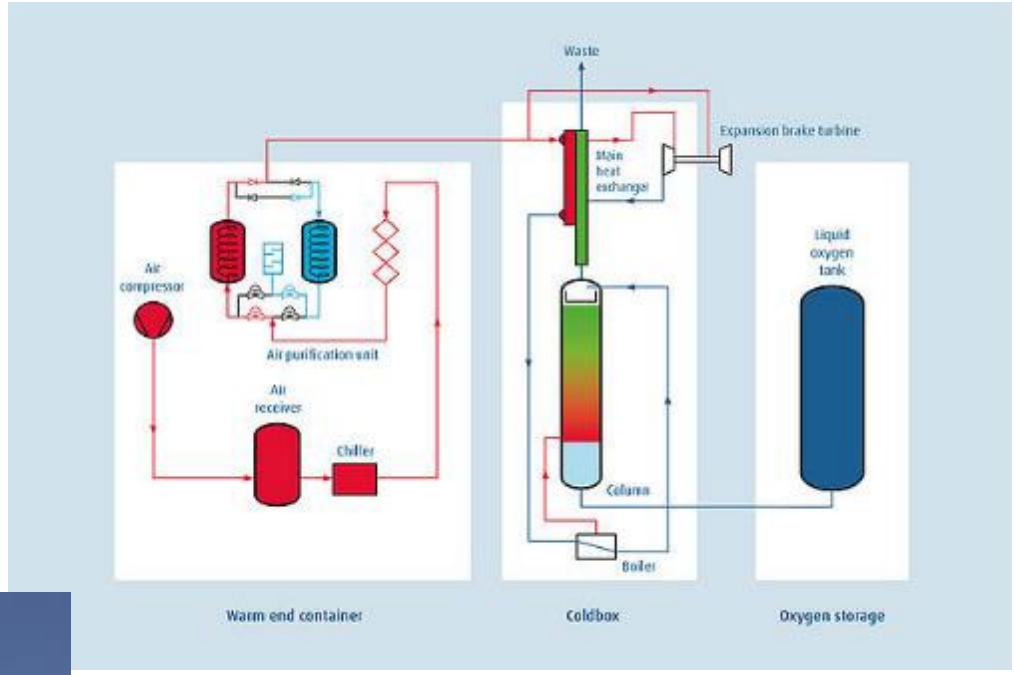
Chemicals Industry – Cryogenic Air Separation Plants





Source - Wikipedia

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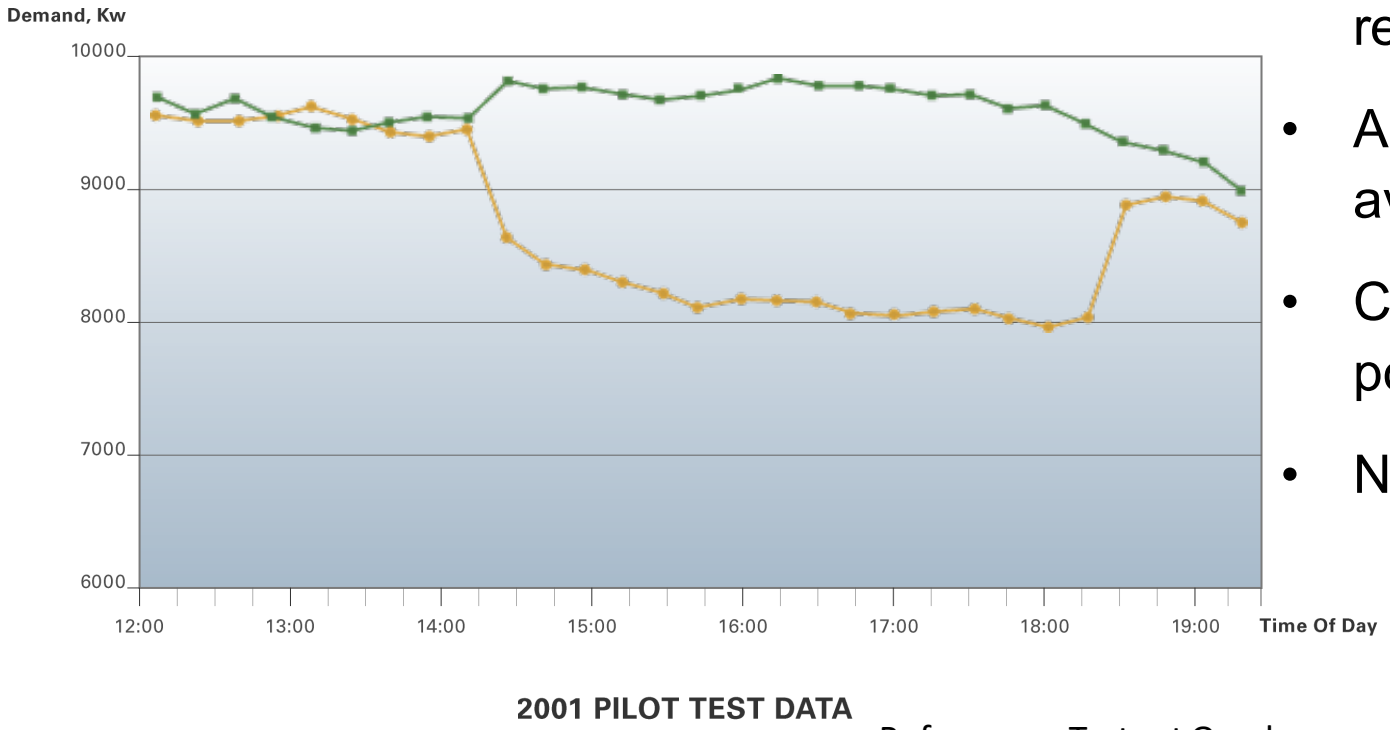
DR in Data Centers – Power Capping

Demonstrate potential of automatic IT loads reduction without disruption and minimal user impact



Reference – Tests at Oracle

- Prepare for the future grid with greater renewables
- Adjust data center power needs to electricity availability
- Coordinate operations with utilities to avoid power interruptions
- Newer power capping technology available

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Server Power Capping/Demand Reduction Testing

- Evaluate power cap technology for automatic power demand reduction from IT equipment
- OpenADR signal to remotely trigger the event for automatic operation
- Tested in EPRI laboratory and at field site at Calit2 at University of California, Irvine
- Evaluate impact to IT equipment performance
- Lower core chip temperature a byproduct

Source – EPRI Report 3002019756

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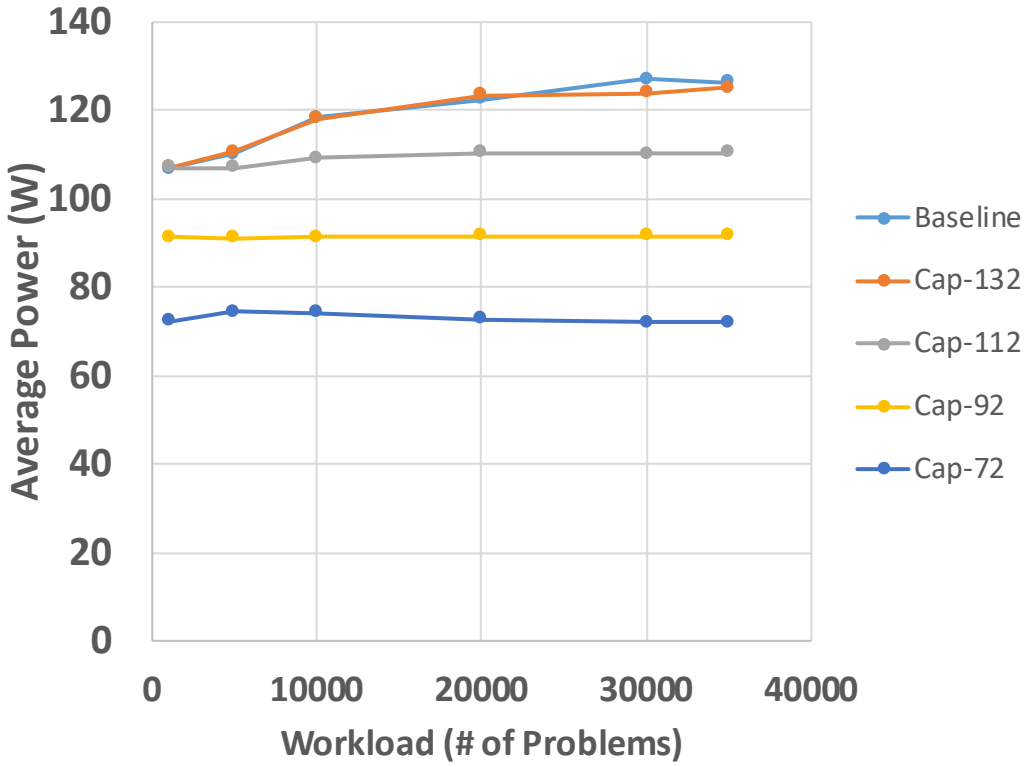
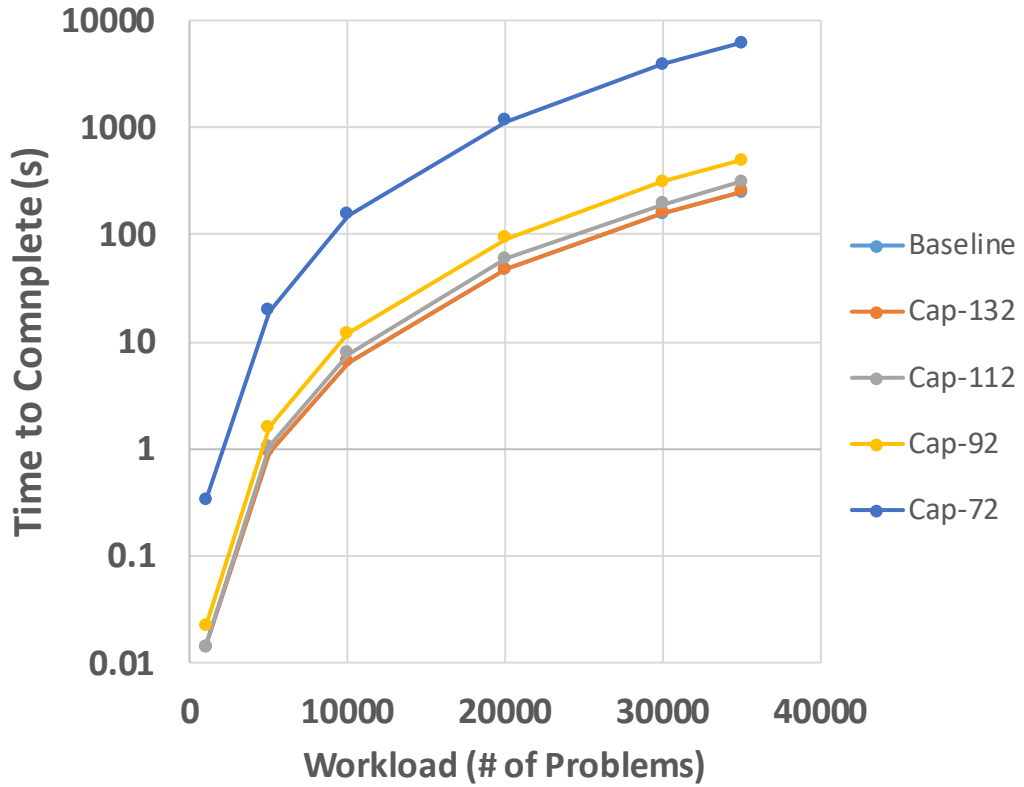
Power and Time to Complete Workload





- **Power cap successfully limits average power, increases time to complete workload**
- **15% power reduction (132-112W) with minimal increases time to execute (~10%)**
- **Further reductions dramatically increase execution time**

Source – EPRI Report 3002019756

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Agricultural Pumping

- Agriculture in California
  - Large User of Electricity
  - ~1.6 GW Summer Peak Load
- DR Programs Offered by Utilities
  - Pumping Interruptible Program
  - Other Auto DR Pilot Programs

SOUTHERN CALIFORNIA EDISON
Energy for What's Ahead®

Agricultural and Pumping Interruptible Program (AP-I)

PG&E's Emerging Technologies Program ET21PGE1290

Agricultural Demand Response Study

ET Project Number: ET21PGE1290

Source – SCE and ETCC

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DR Opportunities in Agriculture Pumping in California

- 1.1 GW DR Potential [1]
- Relatively flat daily profiles
- Large, binary (on/off) loads
- Dual-use storage potential (reservoirs, canals)

[1]LBL Energy Technologies Area: Opportunities for Automated Demand Response in California Agricultural Irrigation, 2015

Source:

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Proof of Concept for Transactive Energy Based Load Shifting
CEC EPC-16-045 Project (Polaris Energy)

- 67% of load shifted from ramp hours of 94% that can potentially be shifted
- Energy users responded to signals for an average $0.14/kWh in incentives
- Reported improved crop and 30% labor savings
- ROI on automation investments for farmers range from 7-41% based on energy savings alone

Hourly Total Usage by Pump Before and During Transactive Energy Pilot: Apr - Jun

Source:

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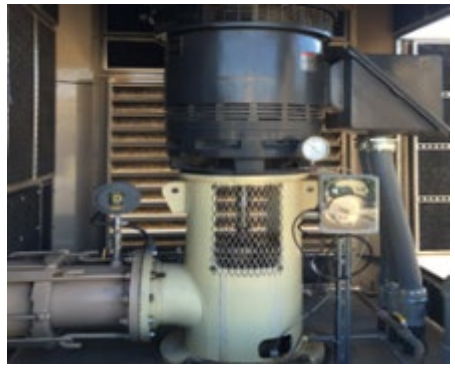
Flexible Water Pumping
CEC EPC-16-026 Project (EPRI)

Big Picture
- Large electricity user – ~6 GWh/year
- Demonstrate what it takes to make pumping flexible
- Prepare for future DR Programs

Objective
- 20% demand adjustment
- Support California policy goals for Demand Response and Renewable Integration

Activities
- Conduct industry interviews, data collection
- Identify DR Strategies, operational constraints
- Pilot test developed strategies
- Technology demonstration and final reporting





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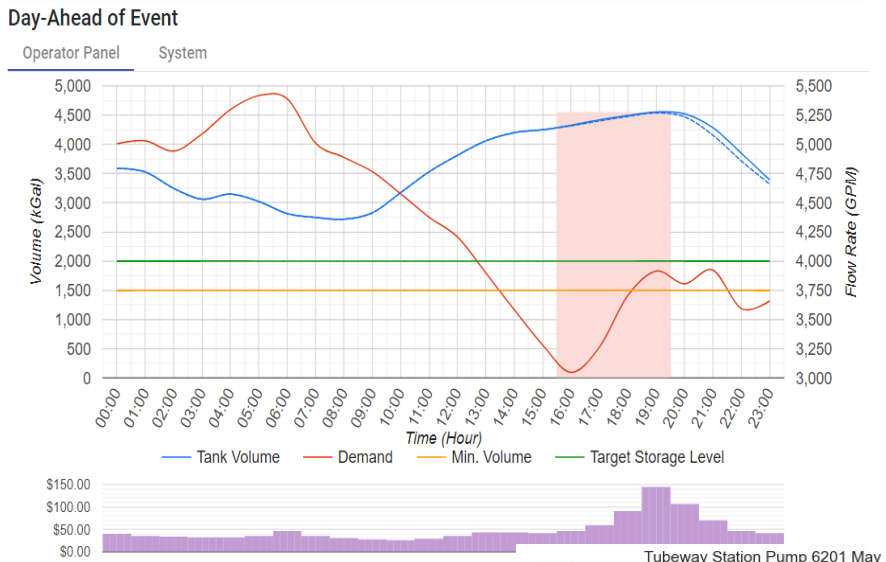
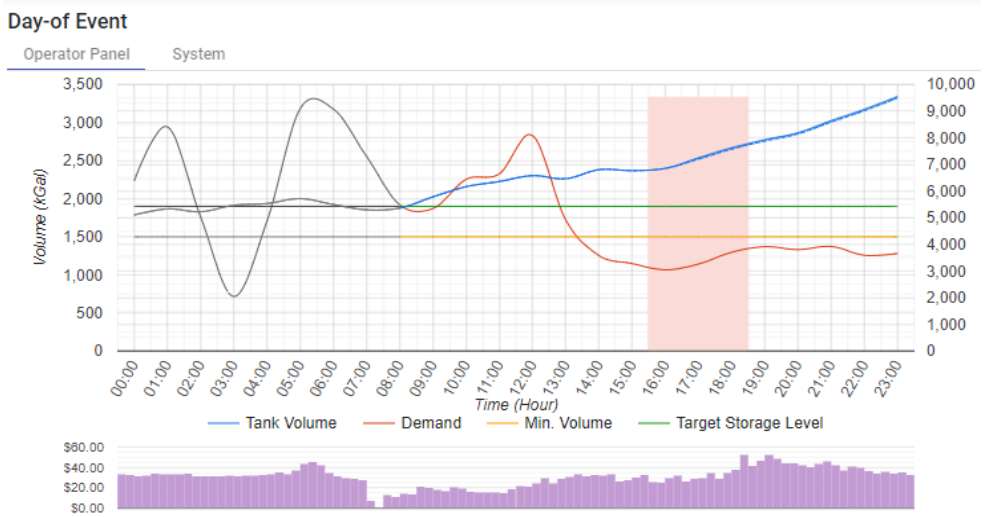
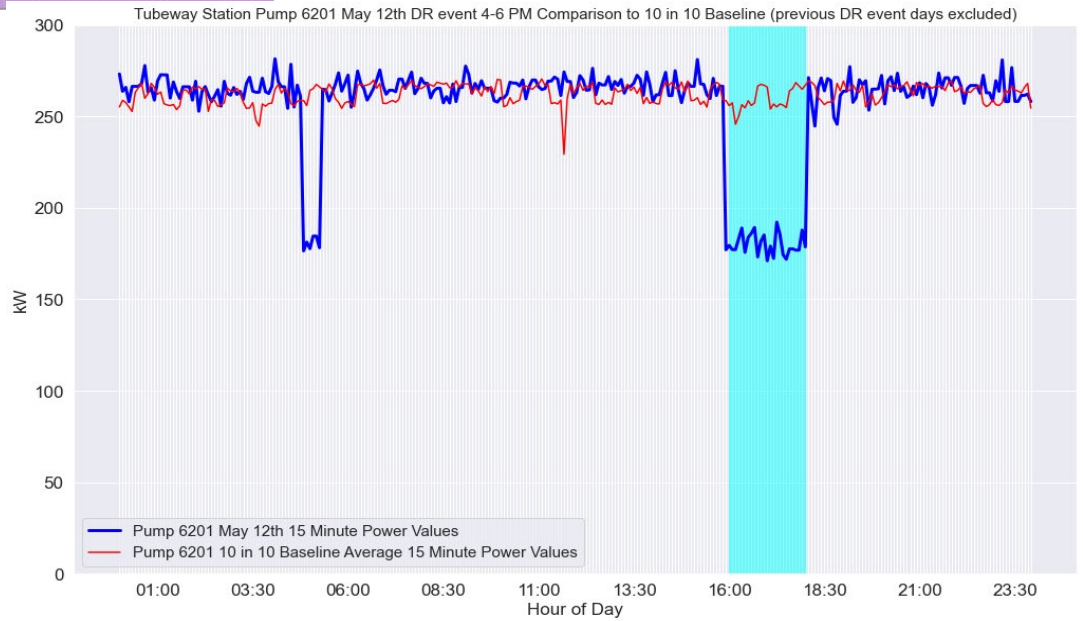
Decision Support Tools Developed for Operators to Take DR Actions







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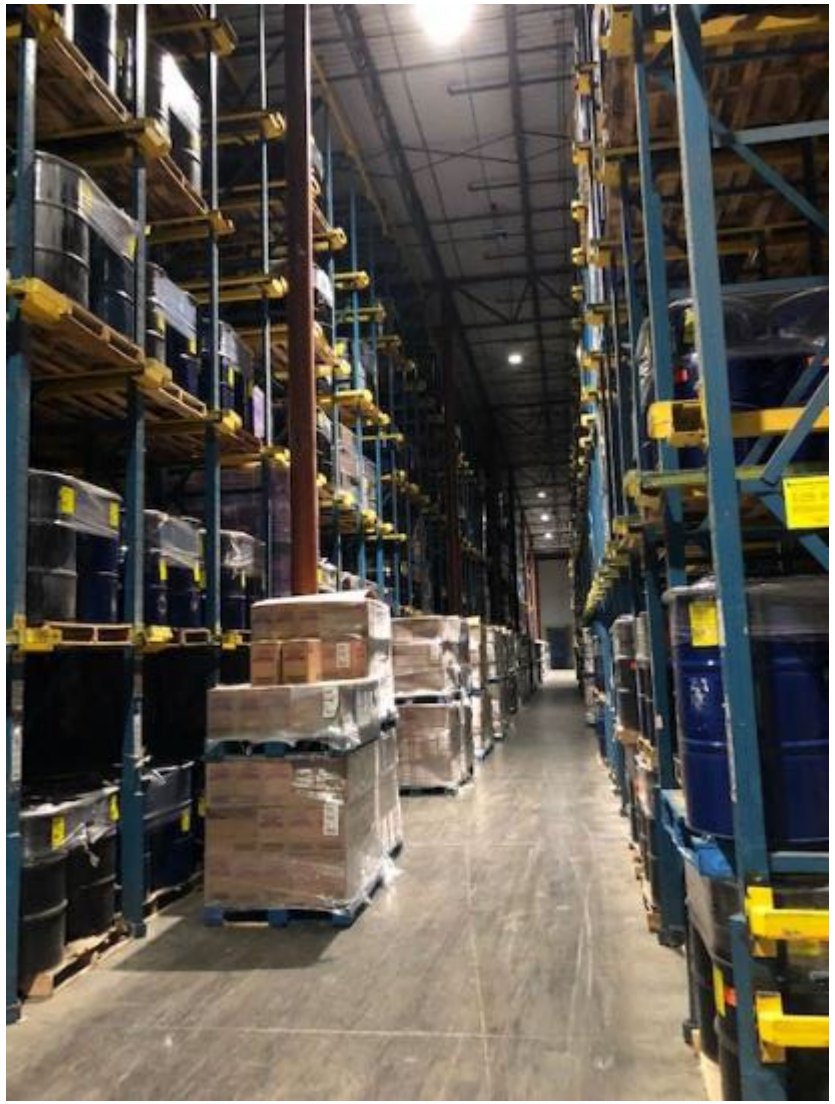
Flexible DR Opportunities in Refrigerated Warehouses

CEC EPC-16-026 Project (EPRI)

- Over 400 Refrigeration Plants in California
- Power Demand per Site – 250 kW to 4 MW
- Estimated DR Potential – 200 MW to 300 MW available
- Equipment Available for DR
  - Blast freezers: high capacity for fast cooling, reduces damage to food
  - Freezer rooms: for long-term storage of packaged foods: must ensure that temperature remains below a specific setpoint, typically 0°F
  - Additional equipment available for DR… (will be discussed)



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Flexible DR Tests at Lineage Logistics in Mira Loma, CA

- ~700,000 sq. ft. Refrigerated Warehouse
- Up to 4 MW Capacity
- ~$2.2 mm Power Bill
- SCE Service Territory
- Direct Access Customer
- TOU + Demand Rate

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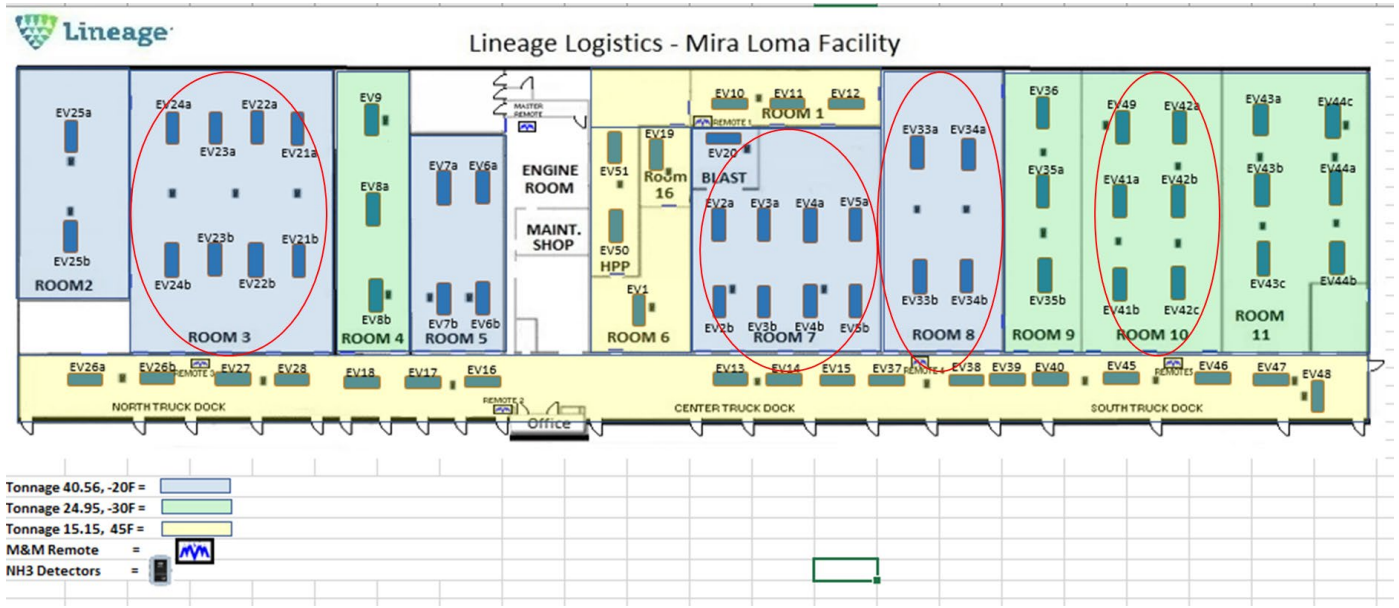
Flexible DR – Project Goal and Approach

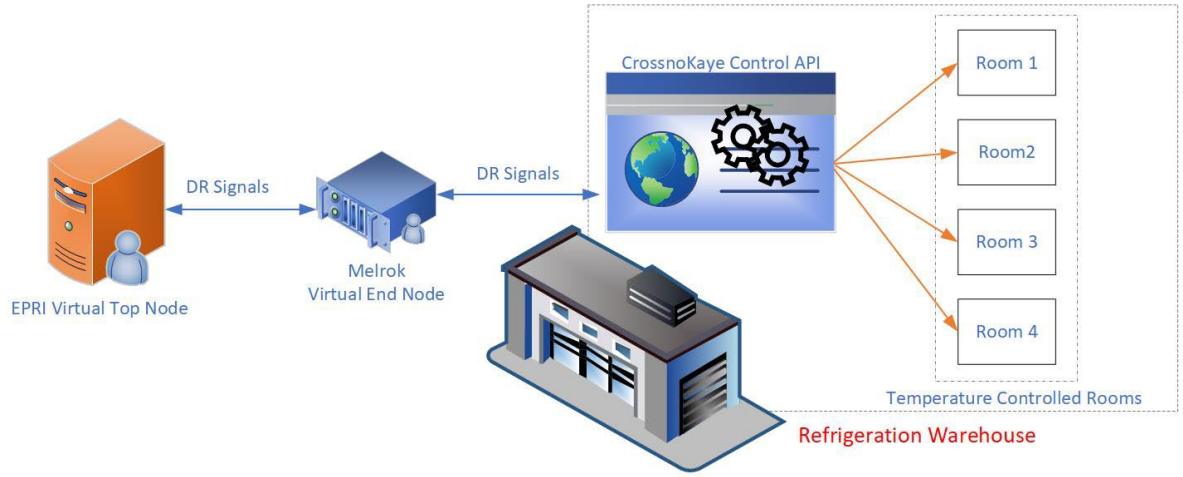
Goal

- Achieve 20% Demand adjustment – Up/Down

Approach

- Use frozen rooms as thermal batteries
- Control compressors that serve the frozen rooms
- Use OpenADR 2.0b to send DR signals and receive feedback
- Power up events – reduce temperature setpoint & adjust number of rooms to control magnitude of response
- Power down events – pre-cool frozen rooms prior to event, return temperature setpoint to original value at event





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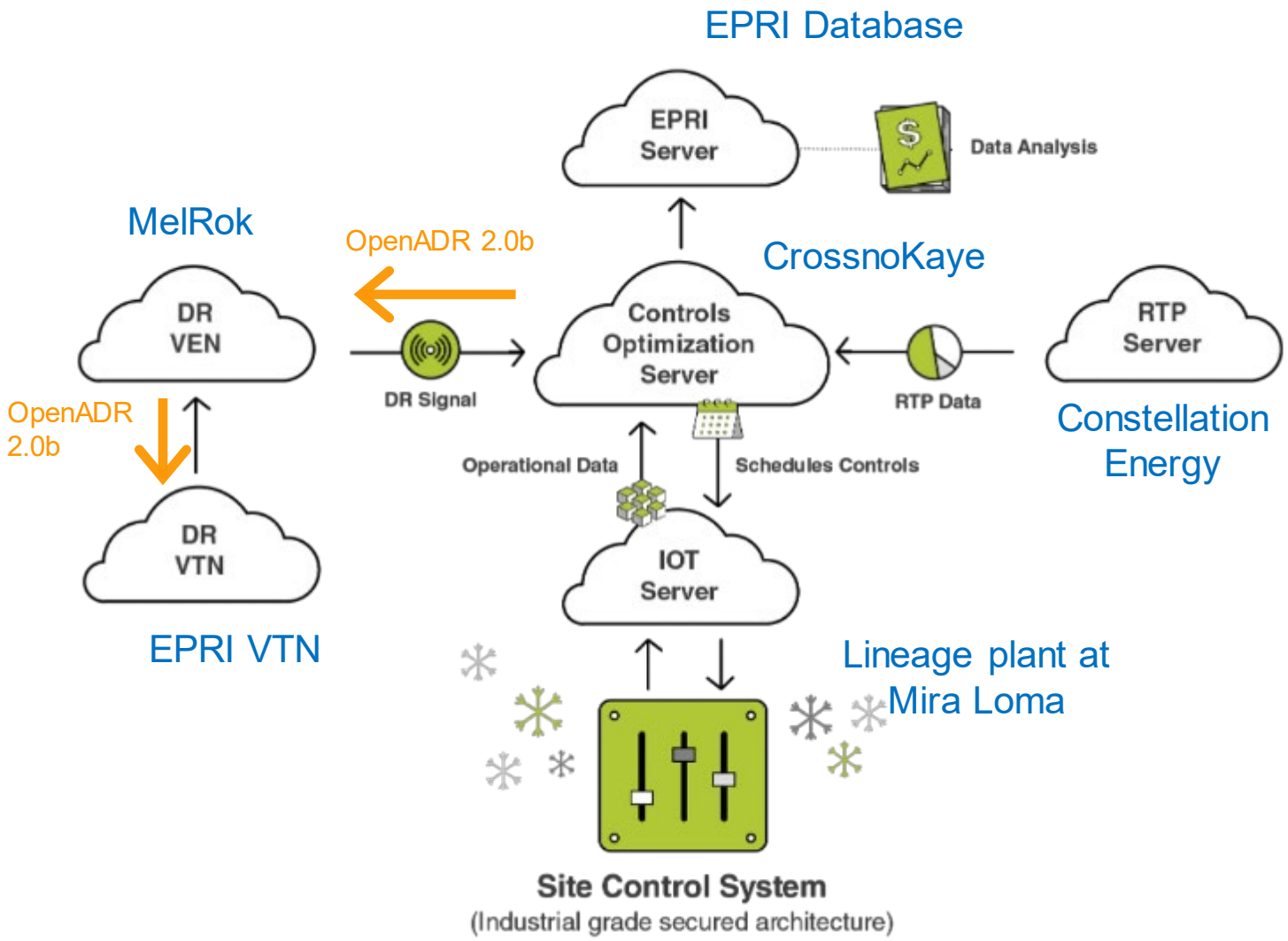
Flexible DR at Lineage – Communication Architecture



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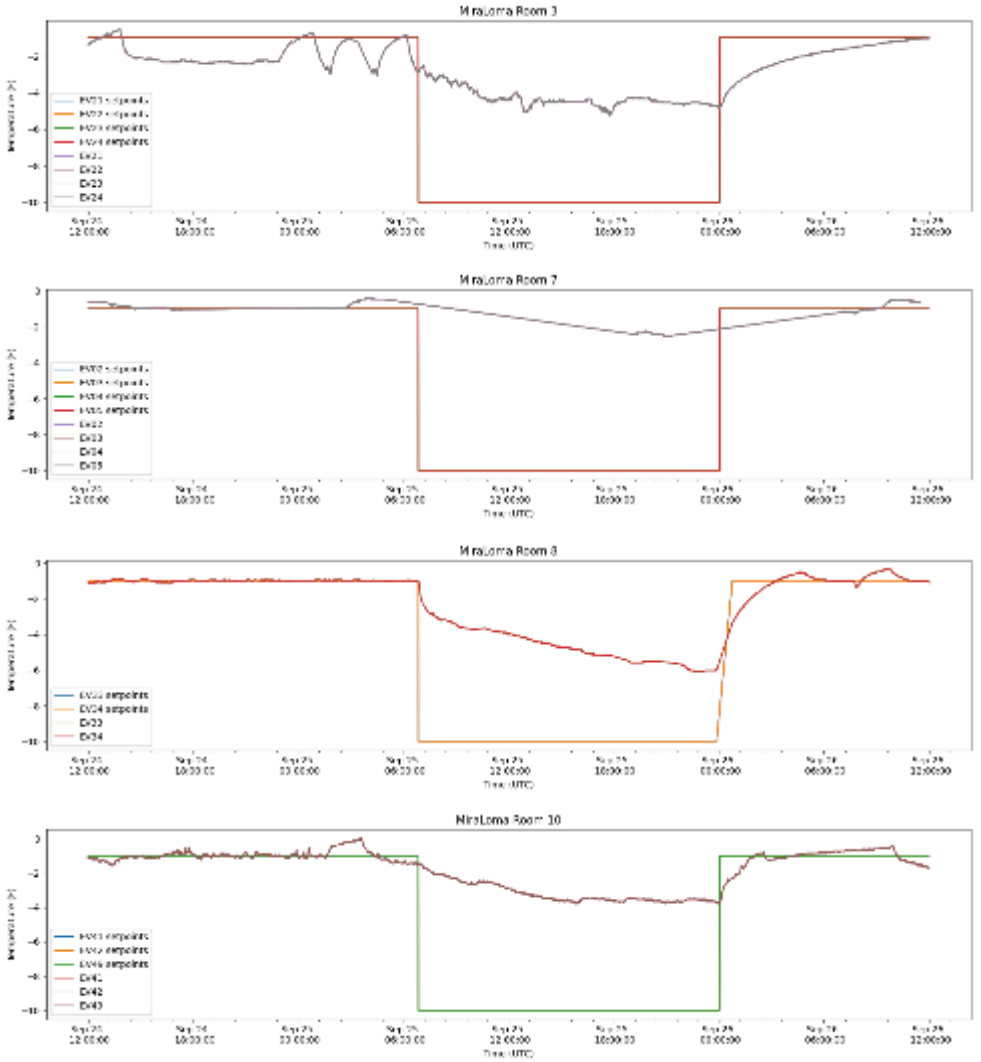
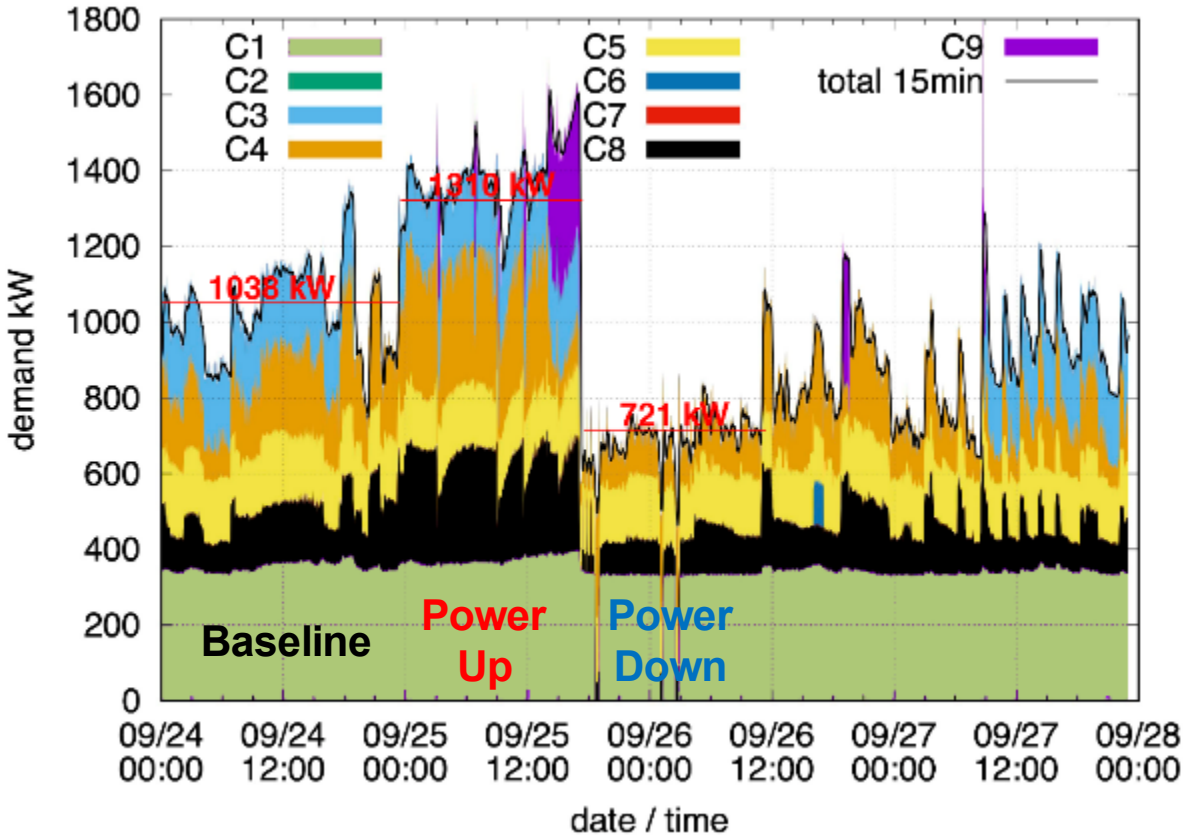
Flexible DR – Results





Baseline: 1038 kW

Up: +272 kW (+26.2%)

Dn: -317 kW (-30.5%)

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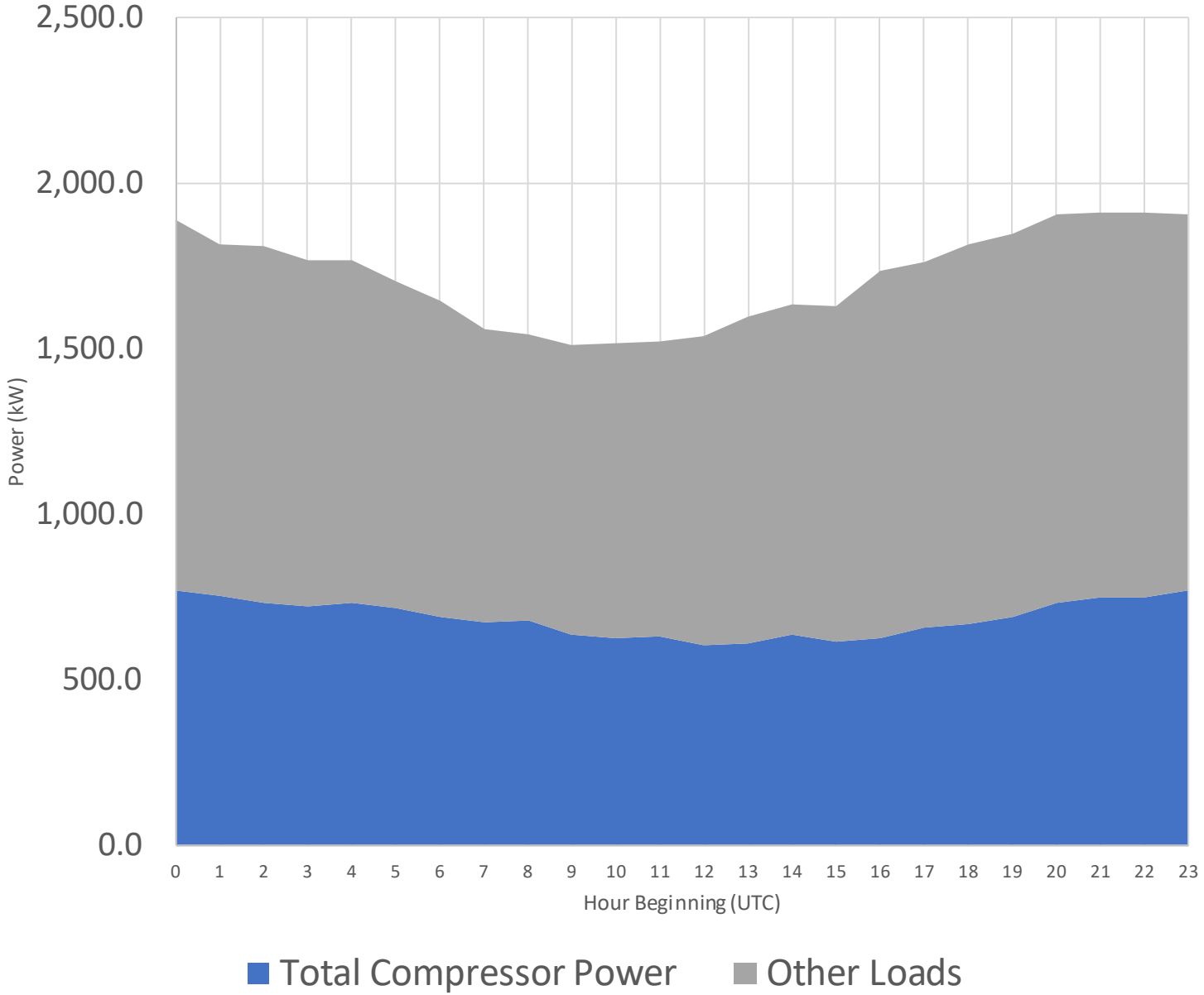
Load Shapes of Compressors & Other Loads



Floor Heaters

Electric Forklifts

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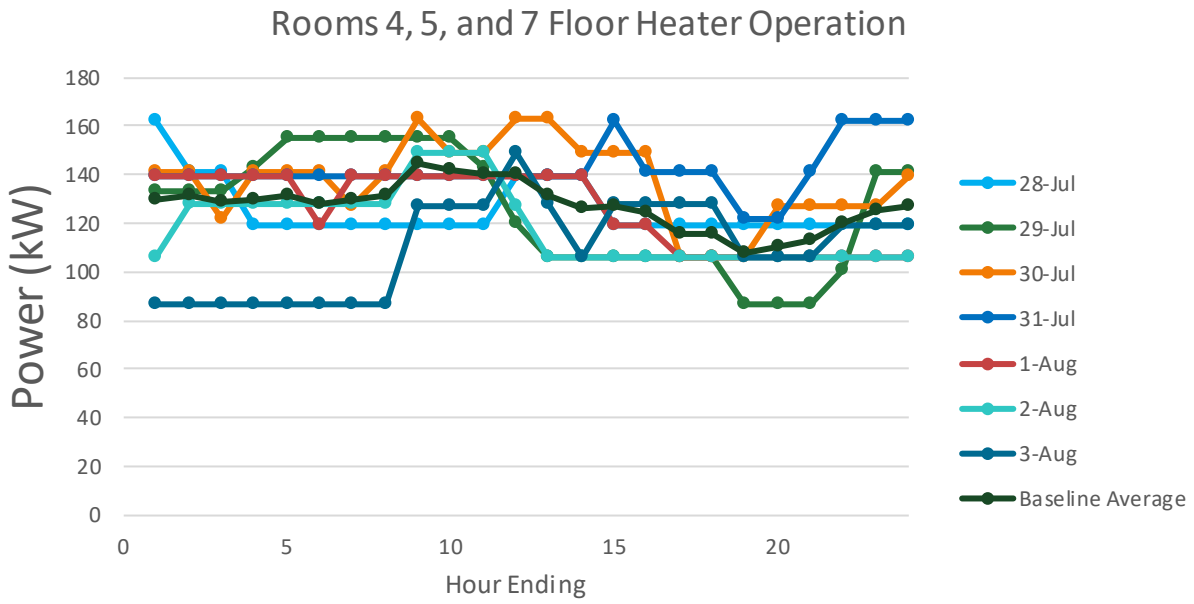
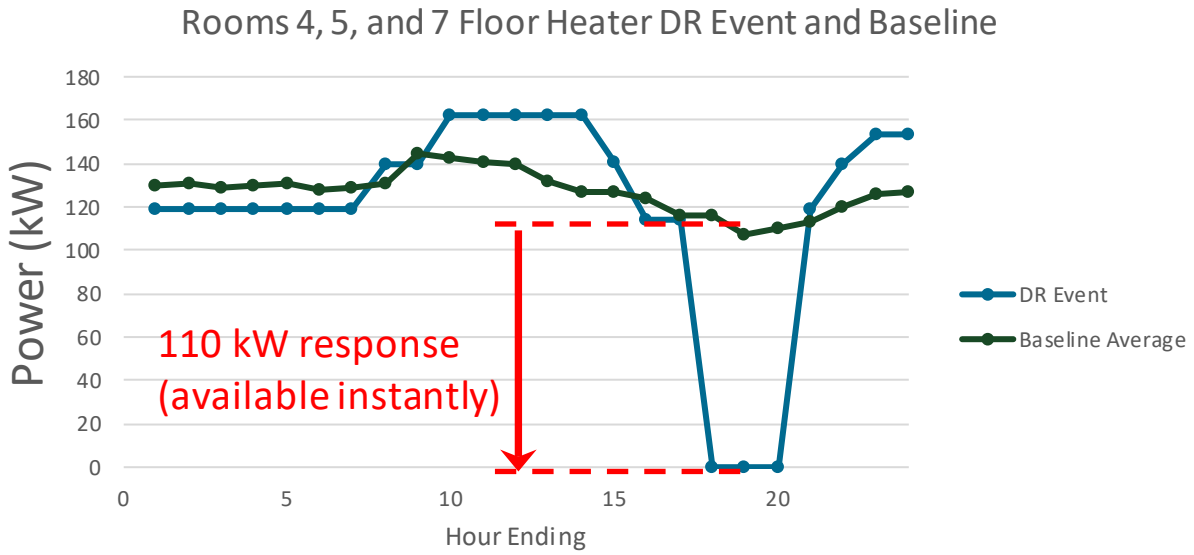
Other DR Resources: Floor Heaters and Forklifts

- Floor heaters (700 kW):
  - The thermal mass of the floor can be used as an additional storage device
  - DR with floor heaters is possible – and reacts instantly
- Electric forklifts (500 kW):
  - Forklift operations are currently being quantified by Lineage for future optimization
  - There is large potential for DR, but this is complex logistically and requires sophisticated tools





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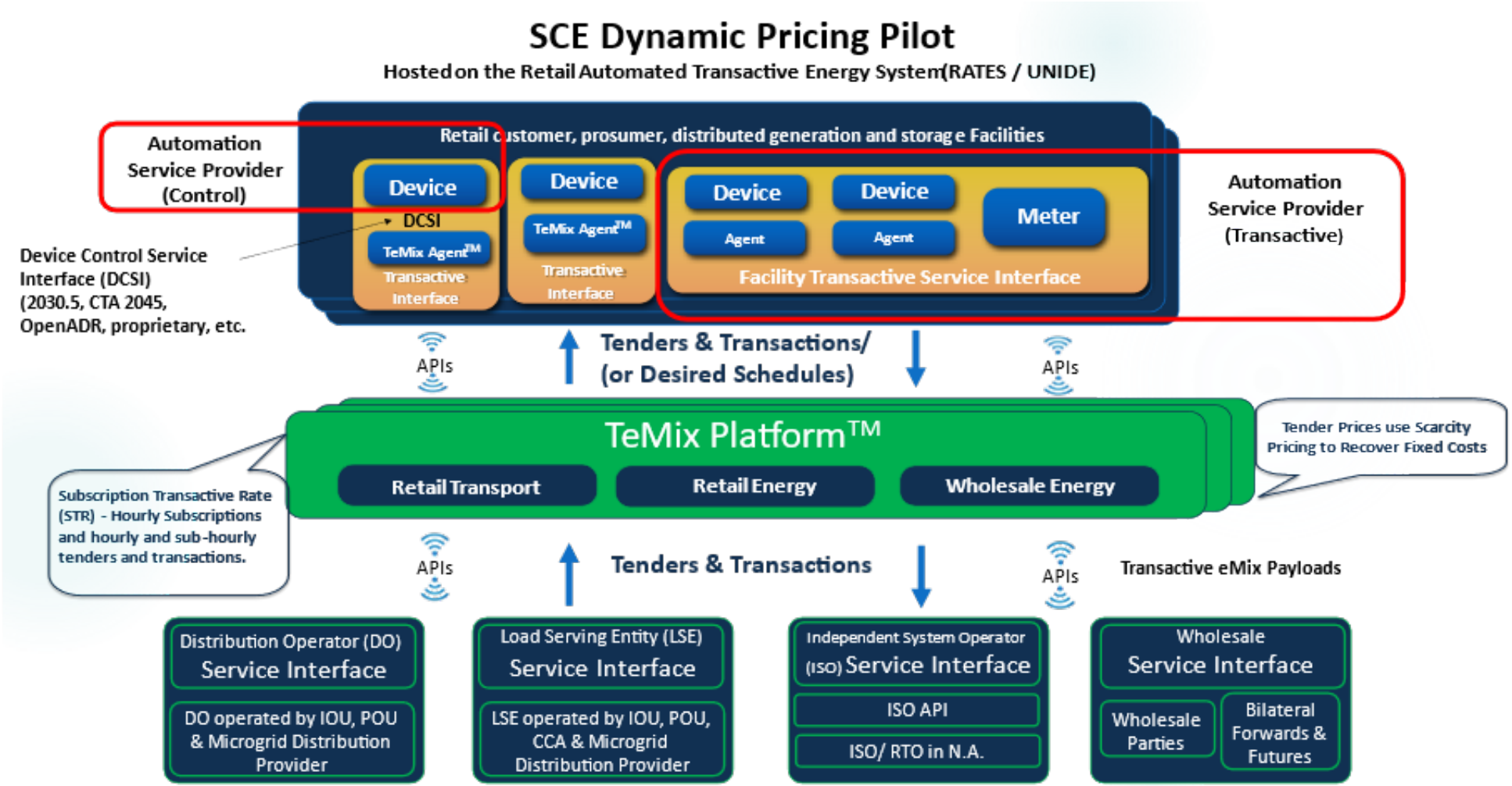
Next Phase – Dynamic Rate Pilot



New SCE Project with TeMix, UDI and EPRI

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Summary

- As the grid decarbonizes, loads need to become more flexible
- As industries decarbonize, electrification will increase
- Some industrial loads can operate flexibly
  - Ex: Food cold chain, water and wastewater treatment, agriculture, data centers etc.
  - Both power up and power down scenarios (Flexible DR)
- Opportunities for collaboration between utilities, energy service providers, end-use industrial customers and the government to enhance industrial load flexibility
  - Important to have domain knowledge when collaborating with industry
  - Dynamic rates may make a difference

Thank You for this Opportunity to Present!

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