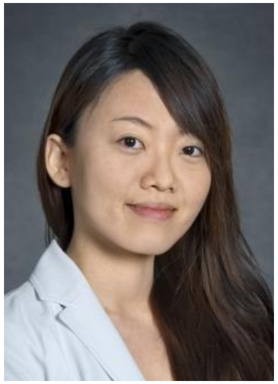
# Overcoming Challenges

## Demand Response and Peak Load Reductions

**Heather Langford**
*U.S. Green Building Council*



**Ella Sung**
*Lawrence Berkeley National Laboratory*

**Peter Sopher**
*Environmental Defense Fund*

U.S. GREEN BUILDING COUNCIL
LEED
USGBC

# Leadership in **Energy** and Environmental Design

## A leading-edge system for certifying the greenest performing buildings in the world

# 150

## total countries and territories with

# LEED® PROJECTS

# 213,900

PROJECTS ARE CURRENTLY PARTICIPATING IN LEED®, COMPRISING MORE THAN

**11.1 BILLION SQ. FT.**

OF CONSTRUCTION SPACE

# 1.7 MILLION

square feet certifies to LEED®

**EACH DAY**

ORGANIZATIONAL SILVER GOLD PLATINUM

# 12,800

## USGBC MEMBERS

are organizations, corporations and institutions that make up a vibrant and diverse community

# 198,500

LEED® credentials have been earned by building professionals across all areas of practice

LEED GREEN ASSOCIATE

LEED AP ID+C

LEED AP HOMES

LEED AP O+M

LEED AP ND

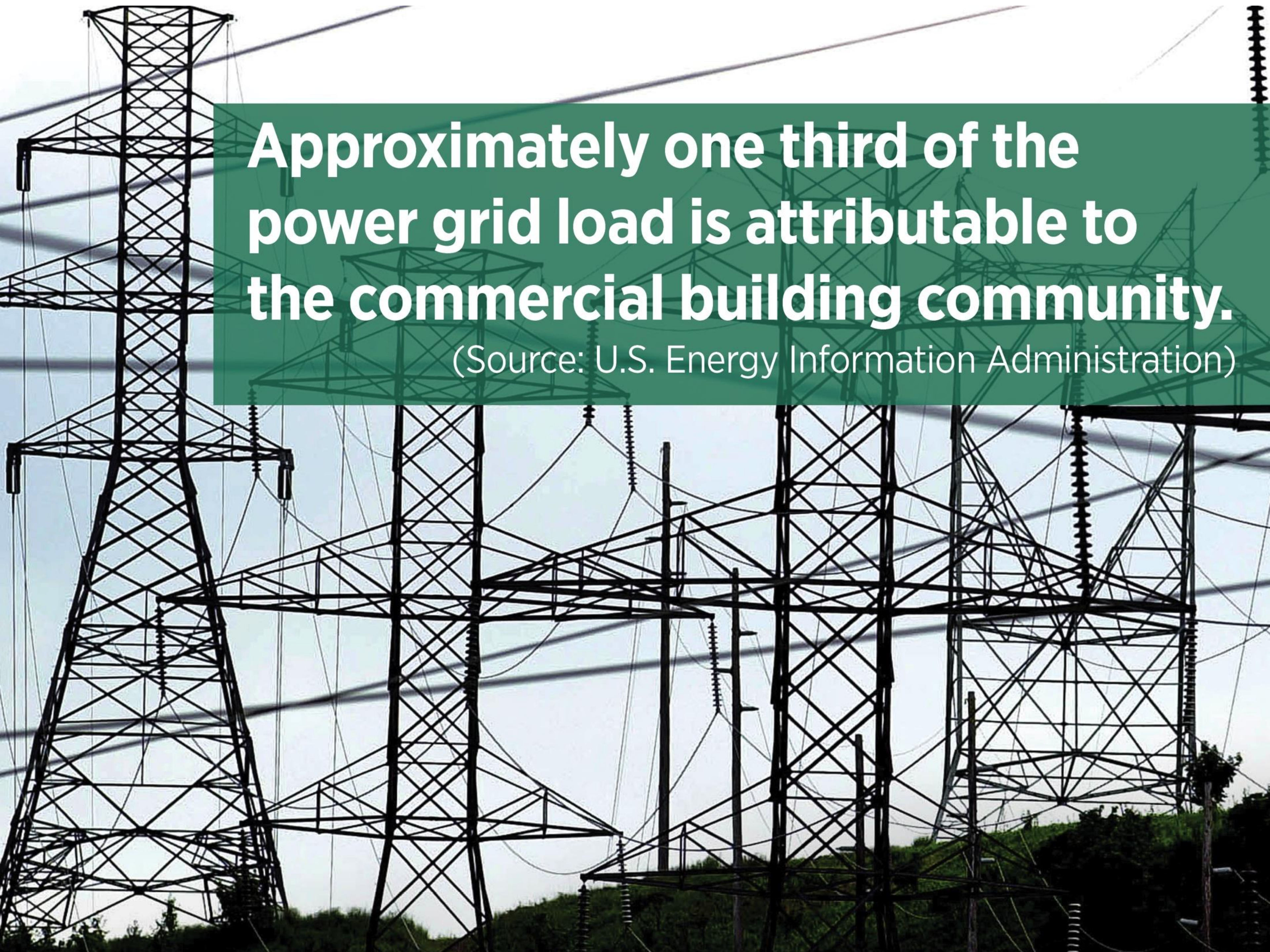
LEED AP BD+C

# 23,000

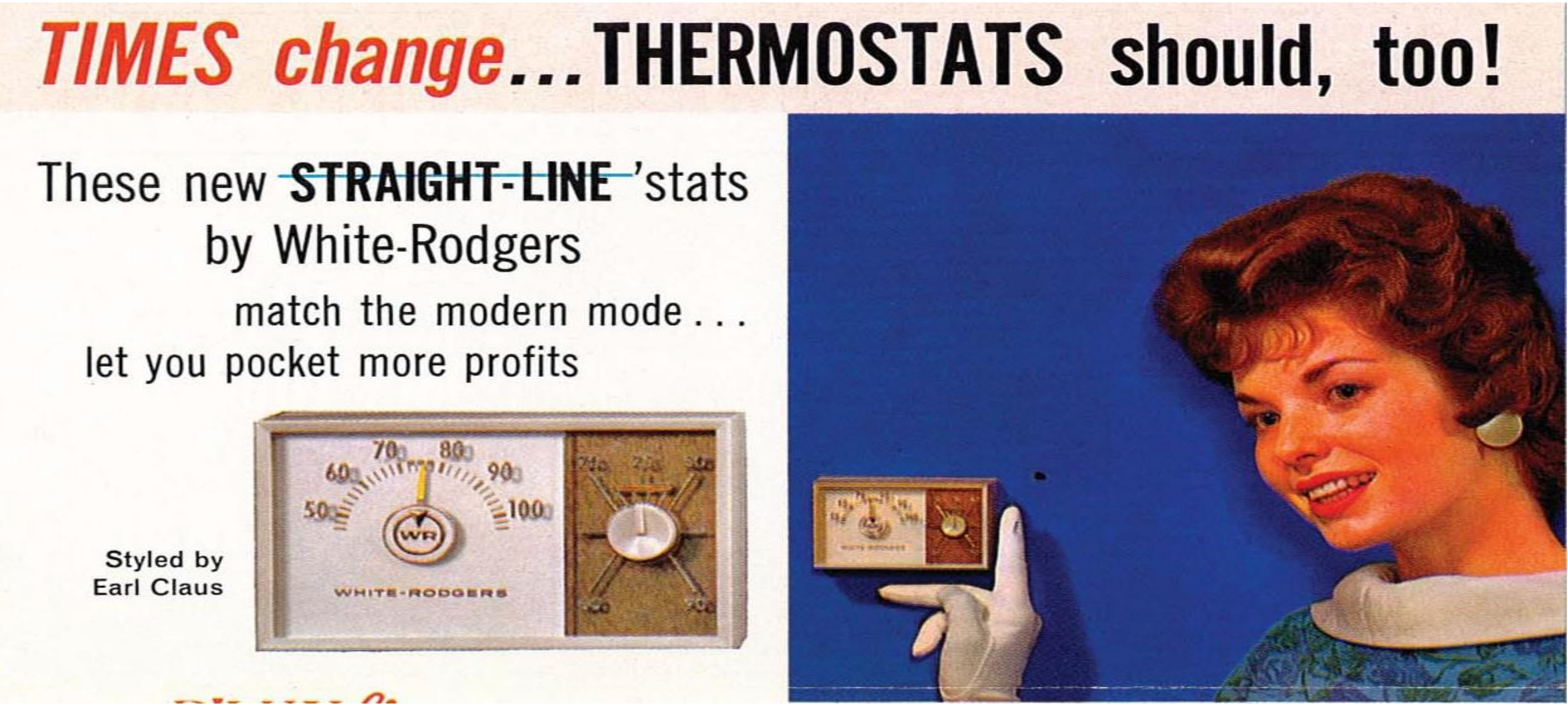
ATTENDED

**GREENBUILD 2013**

IN PHILADELPHIA

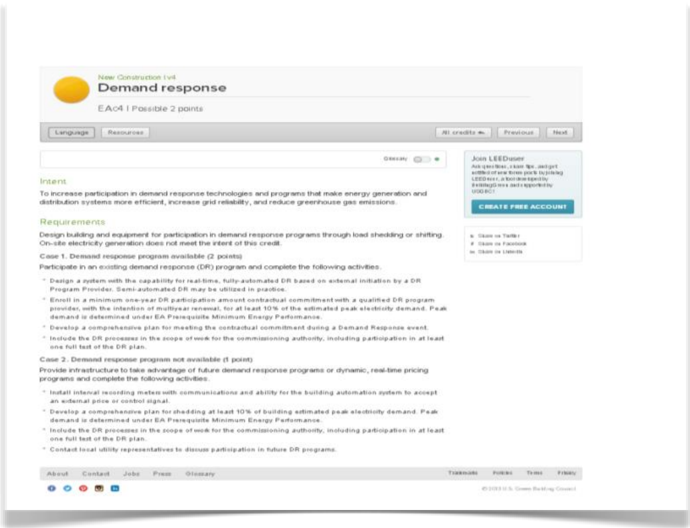

Approximately one third of the power grid load is attributable to the commercial building community.
(Source: U.S. Energy Information Administration)

# Can LEED Buildings do even better…when called upon to do so?



# ADR for Peak Reduction


# Driving Market Transformation




## LEED v2009

→ Pilot Credit 8 for 1 point

## LEED v4

→ EA Credit for up to 3 points

# LEED Credit for Demand Response

- → Case 1: Demand Response Program Available
- → Case 2: Demand Response Program Not Yet Available
- → Case 3: Permanent Load Shedding (EB only)

# LEED Credit Requirements

→ Real-time, fully-automated demand response (ADR)

→ Minimum 1-year contractual commitment with intention of multi-year renewal

→ 2009 pilot credit: 10% or more of the estimated peak electricity demand **or** a minimum of 20 kW, whichever is greater

→ v4 credit: 10% or more of the estimated peak electricity demand

LEED O+M: Existing Buildings I v4

# Demand response

Possible 3 points

Language Guide Resources Forum

Glossary

## Intent

To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.

## Requirements

### Establishment

Evaluate building systems and equipment for participation in a demand response program. On-site electricity generation does not meet the intent of this credit.

LEED O+M: Existing Buildings | v4

# Demand response

Possible 3 points

**On-line Reference Guide**

Language | Guide | Resources | Forum | All credits | Previous | Next

**Free Preview!**

This web-based reference guide credit is being provided as a free preview. For more information on the web-based guide check out usgbc.org/guide. To purchase access to the full suite of guide content, go to the store.

- **Behind the Intent**
- Step-by-Step Guidance
- Required documentation
- Further explanation +
- Related credit tips
- Changes from LEED 2009

Glossary

## Behind the Intent

When temperatures rise or fall dramatically, use of air-conditioning or heating increases. The electricity grid must respond quickly, especially in urban areas and places where commercial buildings or industrial operations are clustered. Utilities work to keep the system operating in balance, reliably, and at reasonable cost.

Demand response (DR) strategies encourage electricity customers to reduce their usage during peak demand times, helping utilities optimize their supply-side energy generation and delivery systems. One strategy is tiered demand electricity pricing.

**Demand Response in Practice: How it Works**

# Challenges to Adoption

- → Limited number of energy-focused facility managers
- → Lack of familiarity with utility DR programs
- → Lack of specific knowledge around costs and benefits
- → Perception that demand response is disruptive
- → Concern over loss of control
- → Concerns over ongoing operational changes

# Demand Response Partnership Program

## Market Transformation

→ Drive adoption of demand response in commercial buildings and facilitate their participation in grid reliability and smart grid initiatives.

→ Inform the new LEED demand response credit.

→ Develop a stronger relationship between the energy and building communities.

# Program Goals

- → Generate and maintain interest in ADR
- → Reveal customer responsiveness and perceived barriers to adopting ADR
- → Quantify economic, environmental & grid benefits delivered by ADR
- → Serve as a foundation to bring together utilities, service providers and customers to continue the transformative journey of ADR at the company, state and national levels

# Who We Are

# Outreach

Targeted LEED registered and certified buildings

→ Emails, phone calls, in-person meetings

→ Webcasts, press releases

→ USGBC chapter resources

Outcomes

→ 572 buildings representing 275 million sq ft selected for initial outreach

→ 133 buildings (51 million sq ft) enrolled, evaluating enrollment, or are DR ready

# Research

- → Consumer energy use behavior and barriers to participation
- → Customer financial analysis and cost-effectiveness
- → System-wide impacts, including environmental and reliability impacts
- → Performance assessment and estimation in commercial buildings
- → Establishing baselines and peak load benchmarking
- → Education, best practices, and business cases for both the energy and building communities

# QUESTIONS?

**Heather Langford**
**Director, LEED**
**U.S. Green Building Council**
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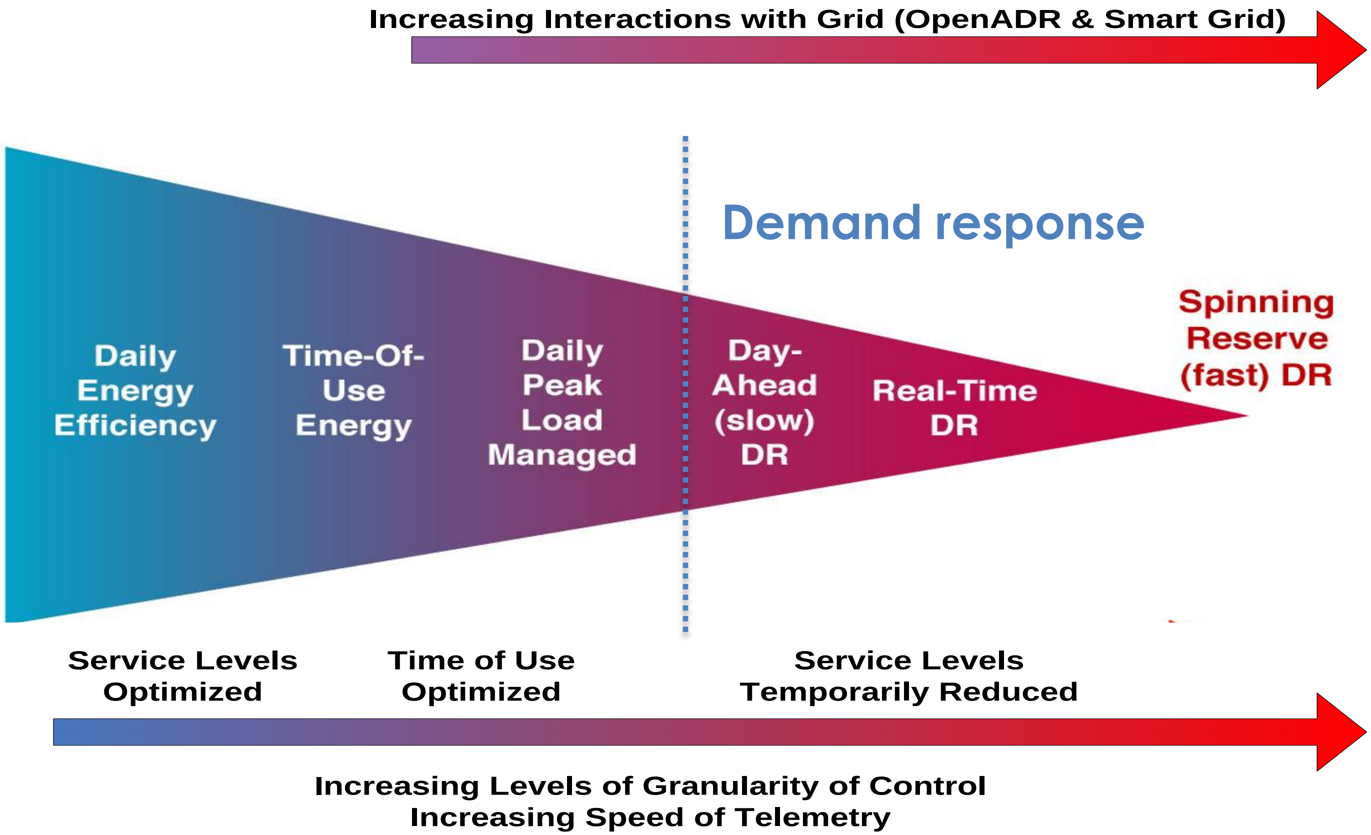
# Quantifying Benefits of DR Performance in Commercial Buildings

**Ella Hae Y. Sung**
**Senior Researcher**
Lawrence Berkeley National Lab

# Research

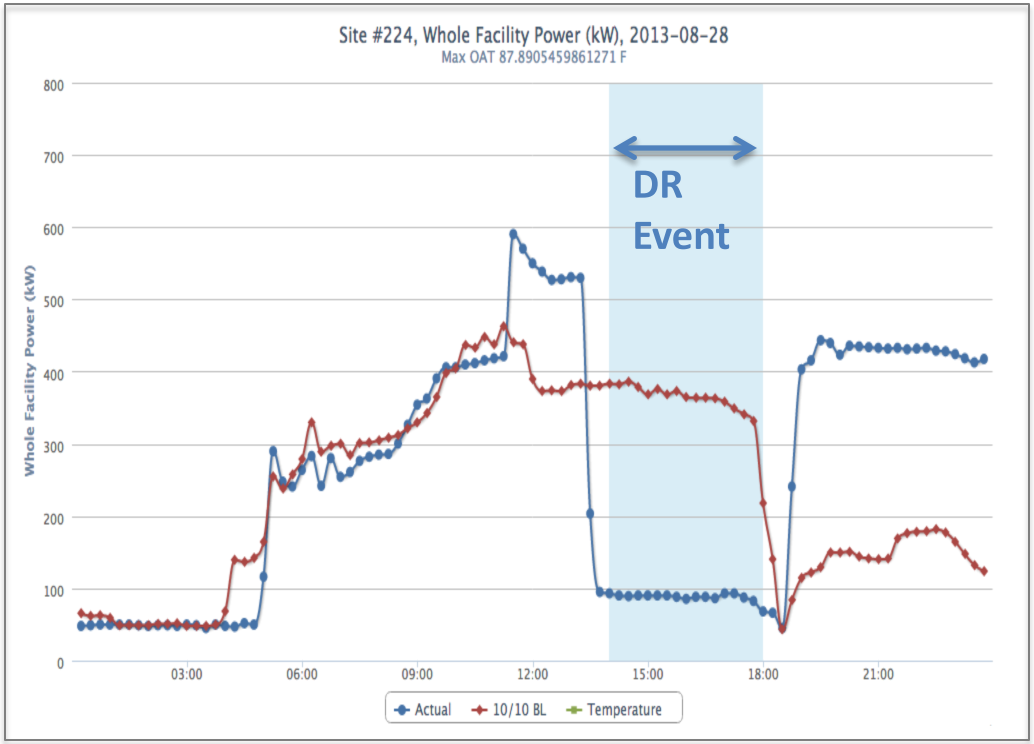
## How do we measure DR Performance?



# Research

## A DR event has three phases of curtailment

- Phase 1: Ramp Period
- Phase 2: The Sustained Response Period
- Phase 3: Recovery Period



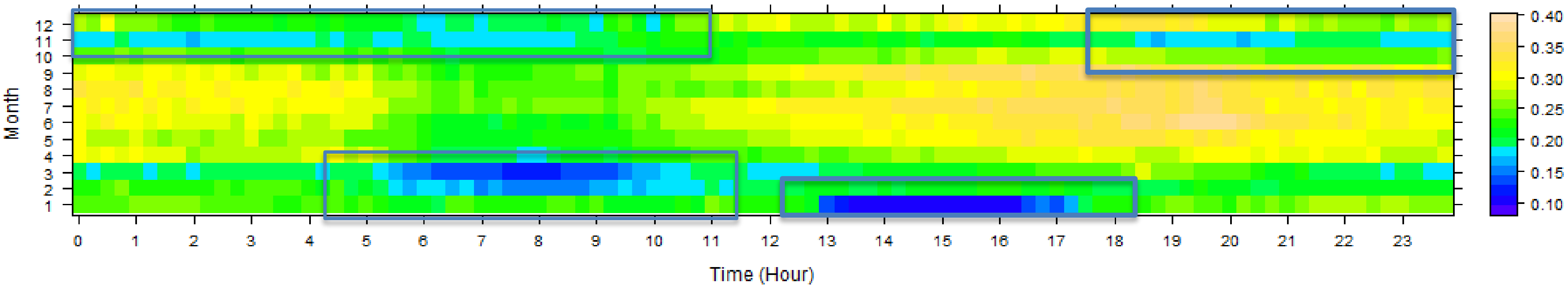
# Research

## Key Building Characteristics

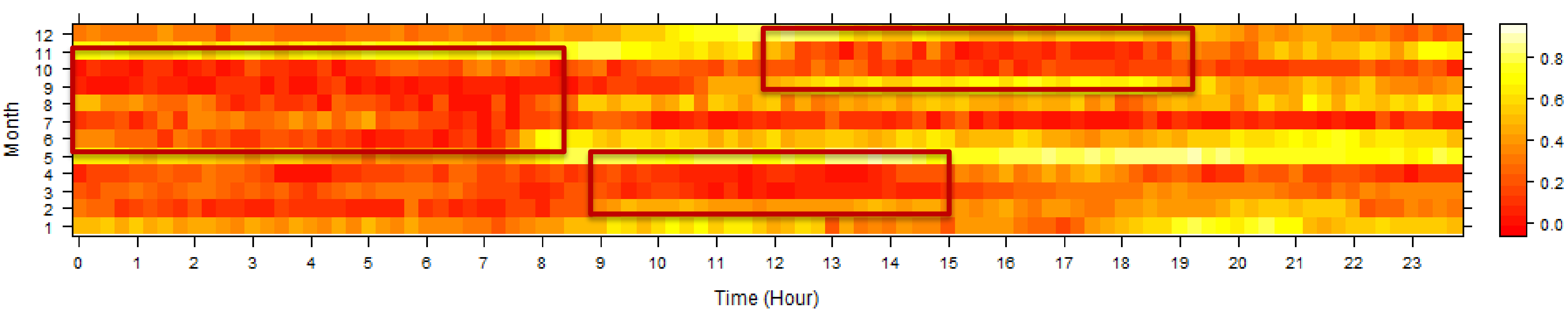
- Building systems
- Building size
- Building type (e.g., office, retail, cold storage, etc.)
- Occupancy schedule
- Load characterization – peak load time and magnitude
- Load variability
- Weather sensitivity

# Research

## Load Variability




## Weather Sensitivity



# Research

## What metrics are most useful to prioritize DR enablement of buildings?

- Response time
- Reliable load reductions
- Reduce load while maintaining comfort

Each of these is influenced by properties of building systems and occupancy.

# Research

## Demand Response Database

- Distinctions made according to
  - Building location
  - DR program
  - Building type
  - Building Size
  - DR strategies

- Analysis tool to identify load variability between days, weather sensitivity of loads, load ranges and load shed in response to DR events over time

- Choice of baseline development options

# Research

## What is Baseline?

- **10/10 Baseline**
  - Averages from similar 10 days
  - assumes that historic information is a good predictor of today's use

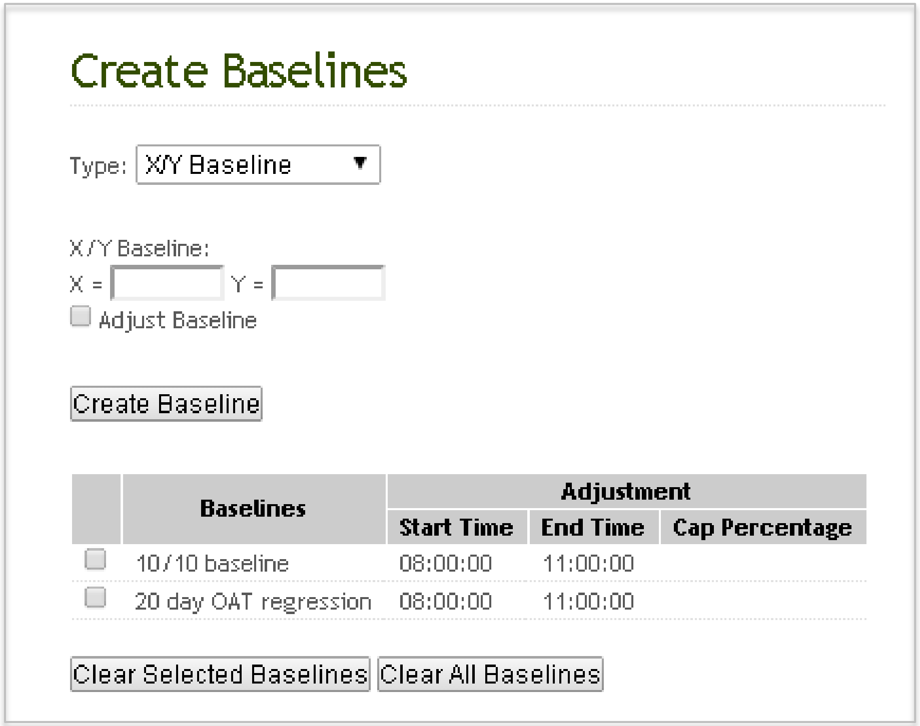
- **Adjustment Ratio* used in 10/10 Baseline**

$$\textbf{Adjustment Ratio} = \frac{\text{Average kWh usage of the first 3 of the 4 hours before the DR event}}{\text{Average kWh usage for the same 3 hours from the past 10 similar days (excluding event days, weekends, and holidays)}}$$

# Research

## Why Baseline Matters

- Compare similar days
- Baseline compensates for energy usage differences outside of DR events.



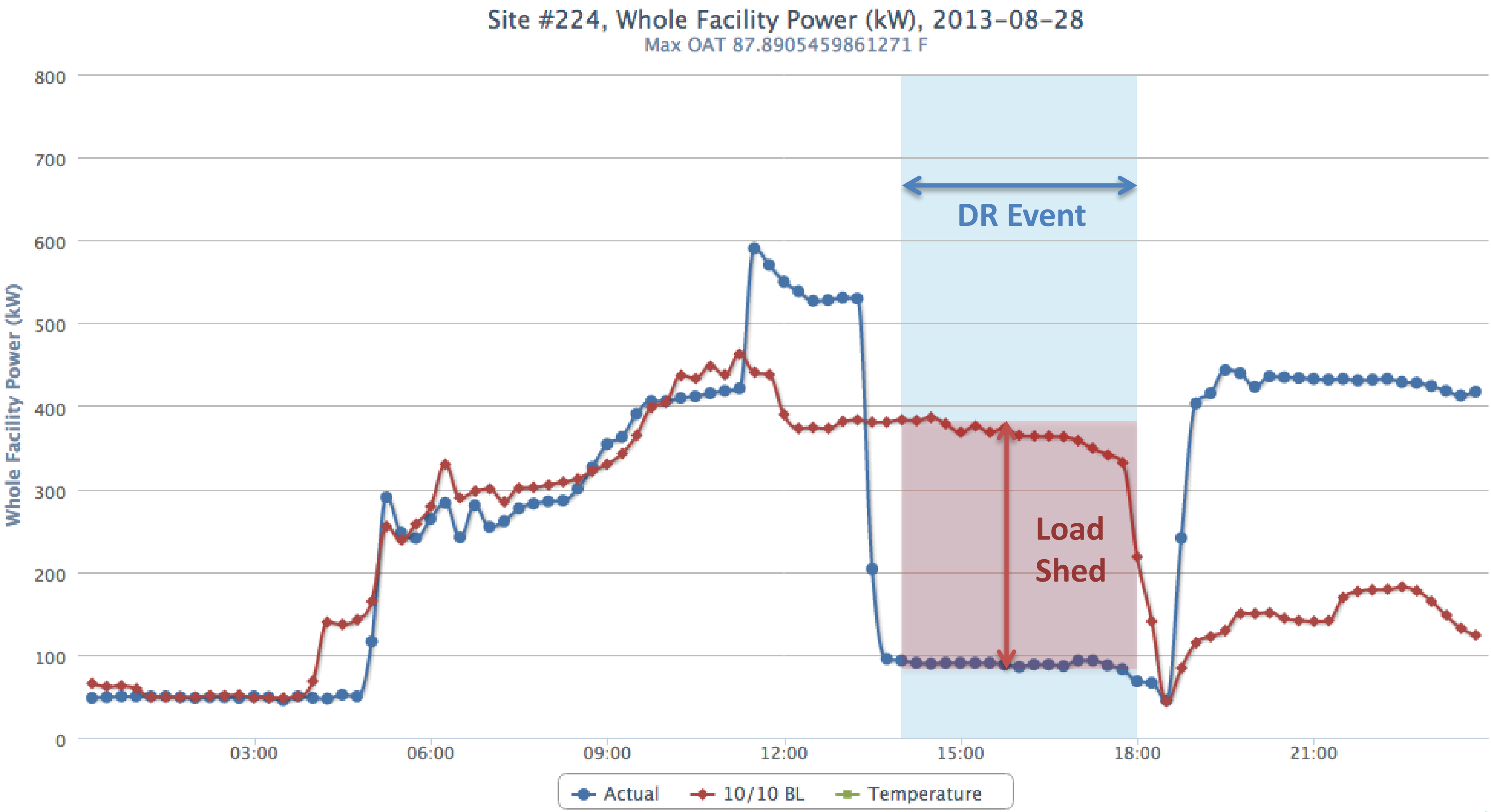
# Research

## DR Metrics for Load Characterization

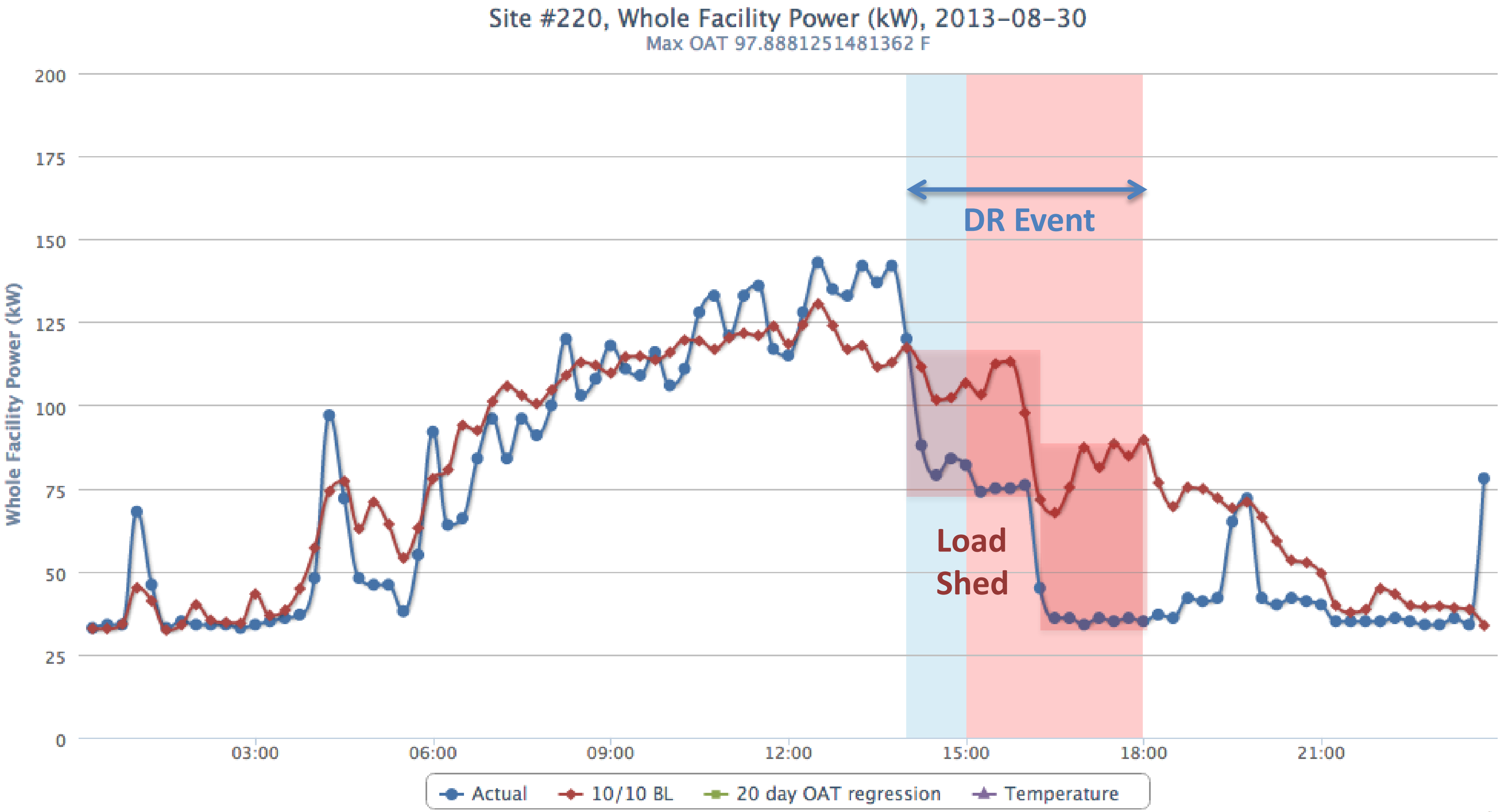
- Load shed (kW): historically most reported figure of merit but lacks context
- Peak load magnitude and timing: good to compare the timing of DR event across days

## Relevant Metrics

- Load shed per Floor Area (W/ sq. ft )
- Whole Facility Power % (WFP%)
- DR Enablement Costs ($/kW)*




| Baseline | Period | kW | | | W/ft² | | | WFP% | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Avg | Min | Max | Avg | Min | Max | Avg |
| 10/10 baseline | 14:00:00 - 15:00:00 | 278 | 297 | 289 | 0.65 | 0.69 | 0.68 | 75.5 | 76.9 | 76.2 |
| | 15:00:00 - 16:00:00 | 278 | 286 | 282 | 0.65 | 0.67 | 0.66 | 75.5 | 76.6 | 76.1 |
| | 16:00:00 - 17:00:00 | 265 | 277 | 273 | 0.62 | 0.65 | 0.64 | 74 | 76.2 | 75.4 |
| | 17:00:00 - 18:00:00 | 150 | 256 | 227 | 0.35 | 0.6 | 0.53 | 68.8 | 75.1 | 72.9 |
| | 14:00:00 - 18:00:00 | 150 | 297 | 268 | 0.35 | 0.69 | 0.63 | 68.8 | 76.9 | 75.2 |




| Baseline | Period | kW | | | W/ft$^2$ | | | WFP% | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Avg | Min | Max | Avg | Min | Max | Avg |
| 10/10 baseline | 14:00:00 - 15:00:00 | 18 | 25 | 22 | 0.33 | 0.44 | 0.4 | 17.9 | 23.1 | 21.1 |
| | 14:00:00 - 15:00:00 | 18 | 25 | 22 | 0.33 | 0.44 | 0.4 | 17.9 | 23.1 | 21.1 |
| | 15:00:00 - 16:00:00 | 22 | 38 | 32 | 0.39 | 0.68 | 0.57 | 22.3 | 33.7 | 29.4 |
| | 16:00:00 - 17:00:00 | 27 | 53 | 38 | 0.48 | 0.96 | 0.67 | 37.2 | 61.1 | 49.3 |
| | 17:00:00 - 18:00:00 | 45 | 55 | 50 | 0.81 | 0.98 | 0.9 | 55.7 | 60.9 | 58.6 |
| | 15:00:00 - 18:00:00 | 22 | 55 | 40 | 0.39 | 0.98 | 0.71 | 22.3 | 61.1 | 45.8 |

Thank you.

# Environmental Impacts

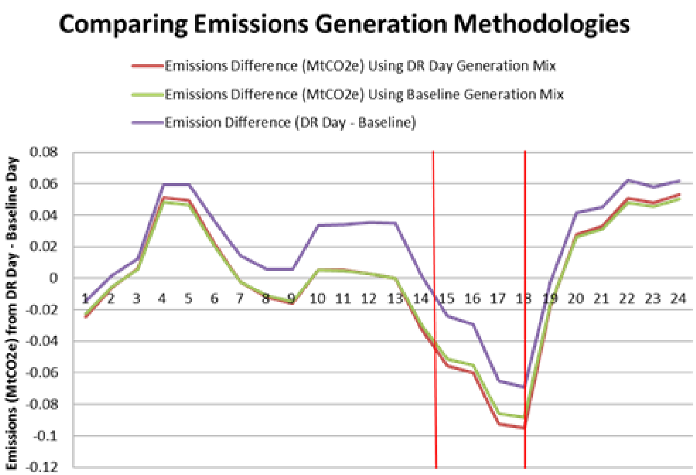
**Peter Sopher,**
Policy Analyst, Clean Energy
Environmental Defense Fund

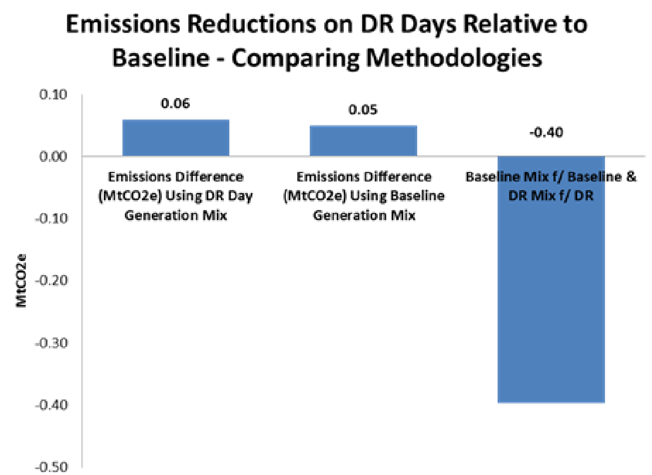
# Environmental Impact

## Key Takeaways:

→ **Our contribution:** An original approach to analyzing emissions impact of demand response using empirical data.

→ **Our results:** For each of our three scenarios, emissions during peak hours are lower during demand response event days than on corresponding baseline days.



# Environmental Impact

## Essential Data

- Hourly grid electricity generation mix, disaggregated by fuel source.
- Emissions factors for fossil fuel sources.
- Building-specific demand for DR event days and baselines.

| Table 2 – Essential Data | |
|---|---|
| Variable | Units of Measure |
| **Grid-Level Hourly Electricity Generation Disaggregated by Fuel Source, Summer '13** | **MWh** |
| Total | MWh |
| Thermal | MWh |
| Imports | MWh |
| Nuclear | MWh |
| Hydro (large-scale) | MWh |
| Renewables (aggregated) | MWh |
| Geothermal | MWh |
| Biomass | MWh |
| Biogas | MWh |
| Hydro (small-scale) | MWh |
| Wind | MWh |
| Solar PV | MWh |
| Solar Thermal | MWh |
| **Emissions Factors for Fossil Fuel Sources** | **(MtCO2e)/(kWh)** |
| Thermal | (MtCO2e)/(kWh) |
| Imports | (MtCO2e)/(kWh) |
| **Building-Specific Demand for DR Event Days and Baselines, Summer '13** | **KW** |
| **Generation Mix Emissions Efficiency (GMEE)** | **(kWh)/(MtCO2e)** |
| **Generation Mix Emissions Intensity (GMEI)** | **(Emissions)/(kWh)** |

# Environmental Impact

## SCE Buildings Data

| Table 1 – DR Event Location and Timing | | | | | | |
|---|---|---|---|---|---|---|
| DR Day | Site 220 | Site 224 | Site 227 | Site 232 | # of Events | Average Event Hours |
| June 28, 2013 | X | 4-6pm | 4-6pm | 4-6pm | 3 | 4-6pm |
| July 1, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| July 3, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| August 21, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| August 28, 2013 | 2-6pm | 2-6pm | X | X | 2 | 2-6pm |
| August 30, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Sept. 4, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Sept. 6, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Sept. 9, 2013 | X | 4-6pm | 4-6pm | 4-6pm | 3 | 4-6pm |
| Sept. 13, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Sept. 23, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Sept. 30, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| October 4, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| October 17, 2013 | 2-6pm | X | X | X | 1 | 2-6pm |
| Total # of Events | 12 | 3 | 2 | 2 | 19 | X |
| Average Event Hours | 2-6pm | 3:20-6pm | 4-6pm | 4-6pm | X | 2:38-6pm |

# Environmental Impact

## Methodology Summary

1. **Generation Mix Assessment:** Using CAISO's data, calculate average hourly generation, disaggregated by fuel source, for all DR days and corresponding baseline days.

2. **Load Impact Analysis:** Using building-level data, for each DR event, we subtract the baseline day load from the DR event day load to determine the hours for which DR event day load is higher or lower than baseline load.

# Environmental Impact

3. **Emissions Impact Analysis:** Based on these hourly DR event days versus baseline days' demand differences, we use three methods to calculate the emissions impact of DR days:

   a. We multiply hourly demand difference on DR event days relative to baseline days by the sum of each fuel's product when the emissions factor for a fuel is multiplied by that fuel's percentage of CAISO's generation mix using:

      a. The hourly generation mix for an average DR event day.
      b. The hourly generation mix for an average baseline day.
      c. DR event days use the DR day generation mix, while baseline days use the baseline day generation mix.

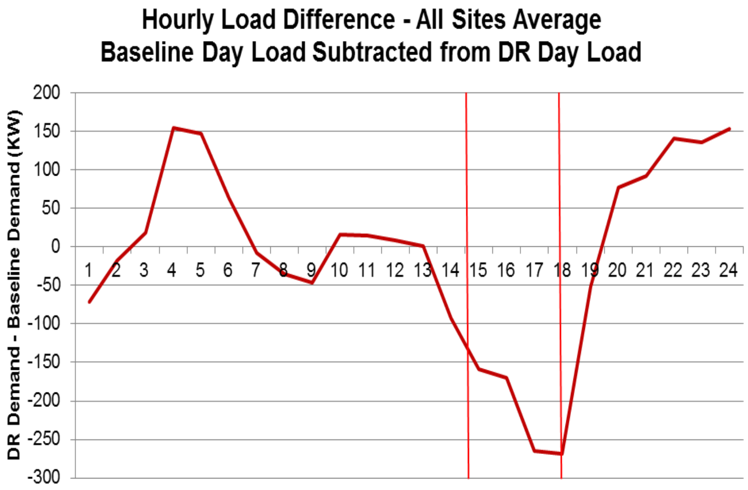
# Environmental Impact

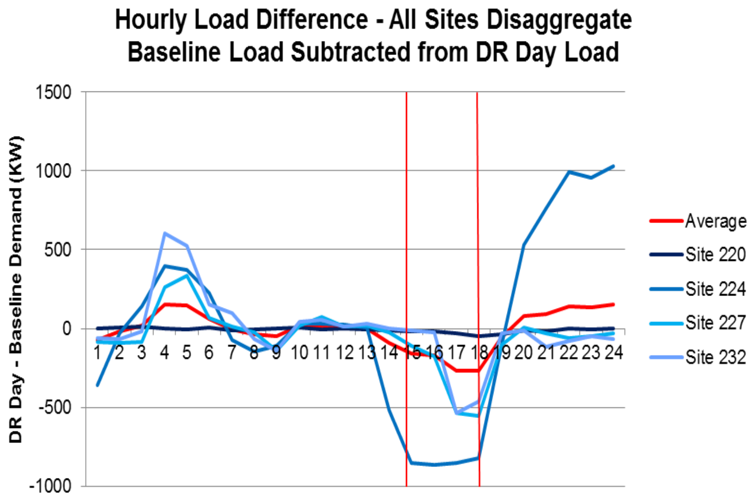
## Load Impact Summary

| Table 3: DR Event Load Statistics by Building, Month, and DR Event | | | | | |
|---|---|---|---|---|---|
| | | Demand Reduced on DR Days Relative to Baseline Days (KW) | Ave. Daily Baseline Load (KW) | % Demand Reduction on DR Days Relative to Baseline | DR Demand Lower than Baseline During Ave. DR Event Time |
| AVERAGE (All Events) | | 160 | 19,153 | 0.8 | Yes |
| Building | **220** | 195 | 7,212 | 2.7 | Yes |
| | **224** | (-775) | 22,464 | (-3.4) | Yes |
| | **227** | 1,288 | 53,468 | 2.4 | Yes |
| | **232** | 225 | 51,519 | 0.4 | Yes |
| Month | **June** | 2,724 | 42,641 | 6.4 | Yes |
| | **July** | (-1,718) | 5,513 | (-31.2) | No |
| | **August** | (-295) | 11,165 | (-2.6) | Yes |
| | **Sept.** | (-205) | 20,257 | (-1.0) | Yes |
| | **October** | 564 | 9,125 | 6.2 | Yes |
| DR Event Days | **28-Jun** | 2,724 | 42,641 | 6.4 | Yes |
| | **1-Jul** | (-2,080) | 5,390 | (-38.6) | No |
| | **3-Jul** | (-1,356) | 5,636 | (-24.1) | No |
| | **21-Aug** | (-472) | 6,845 | (-6.9) | Yes |
| | **28-Aug** | (-774) | 15,151 | (-5.1) | Yes |
| | **30-Aug** | 837 | 7,512 | 11.1 | Yes |
| | **4-Sep** | 414 | 7,593 | 5.5 | Yes |
| | **6-Sep** | 1,631 | 7,336 | 22.2 | Yes |
| | **9-Sep** | (-2,048) | 42,164 | (-4.9) | Yes |
| | **13-Sep** | 1,592 | 7,238 | 22.0 | Yes |
| | **23-Sep** | 820 | 6,912 | 11.9 | Yes |
| | **30-Sep** | 47 | 6,486 | 0.7 | Yes |
| | **4-Oct** | 1,259 | 6,114 | 20.6 | Yes |
| | **17-Oct** | (-132) | 12,135 | (-1.1) | Yes |

# Environmental Impact

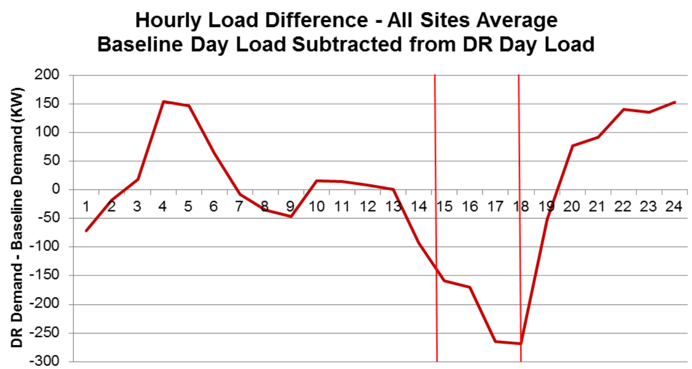
## Supplementary Load Impact Graphics

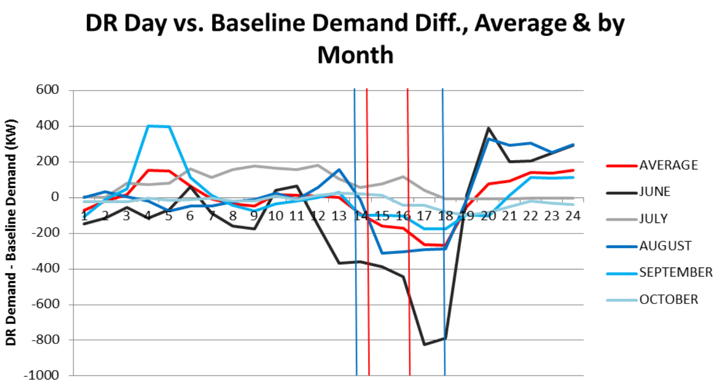


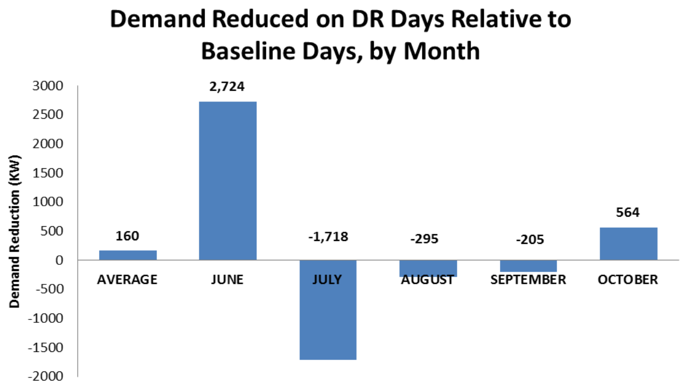



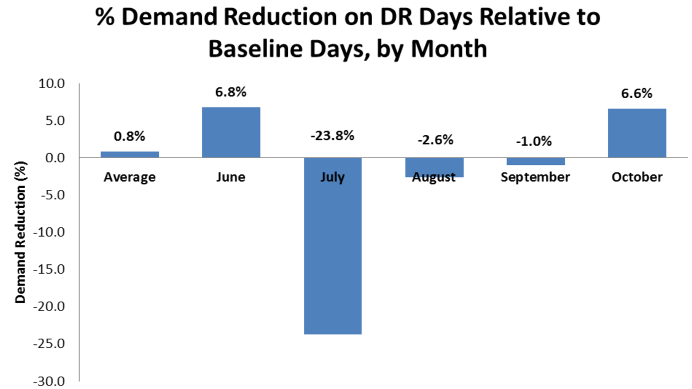
# Environmental Impact

## Supplementary Load Impact Graphics



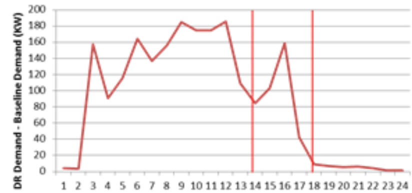



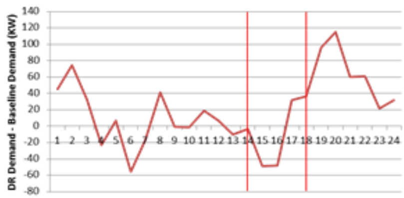
June 28 Average Hourly DR Day vs. Baseline Demand Difference


July 1 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)




July 3 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)

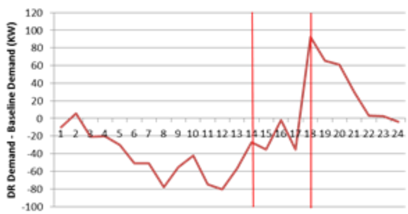

August 21 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)




August 28 Average Hourly DR Day vs. Baseline Demand Difference

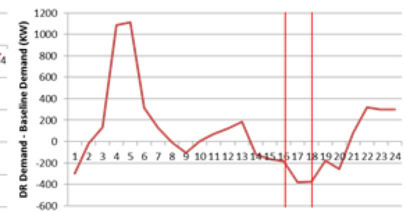

August 30 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)


September 4 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)




September 6 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)

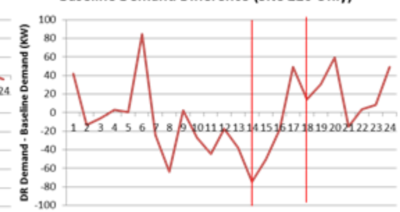

September 9 Average Hourly DR Day vs. Baseline Demand Difference



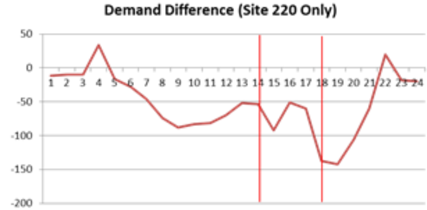

September 13 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)


September 23 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)

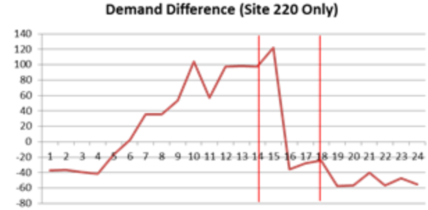

September 30 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)




October 4 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)



October 17 Average Hourly DR Day vs. Baseline Demand Difference (Site 220 Only)



# Environmental Impact

## Emissions Impact:

→ **3 methodologies used**

1. DR day generation mix used to assess emissions impact from both DR days and baseline days.

2. Baseline day generation mix used to assess emissions impact from both DR days and baseline days.

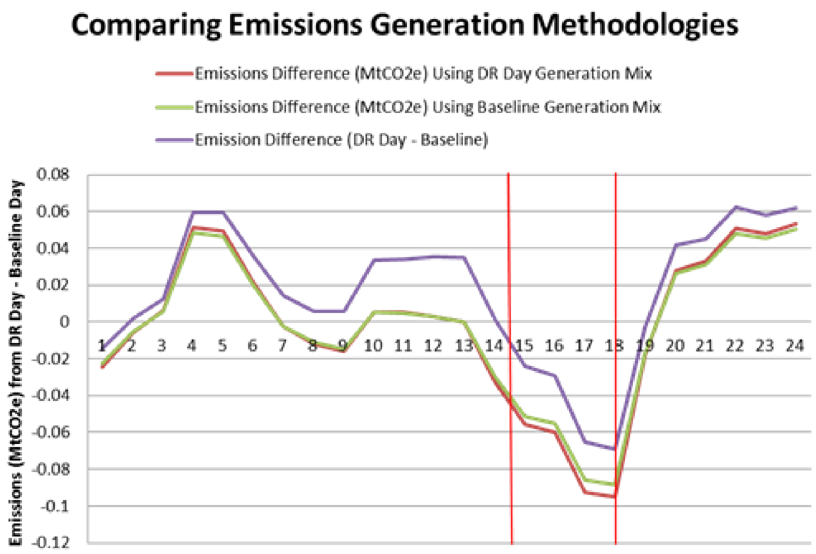
3. DR day generation mix used for DR days and baseline day generation mix used for baseline days.

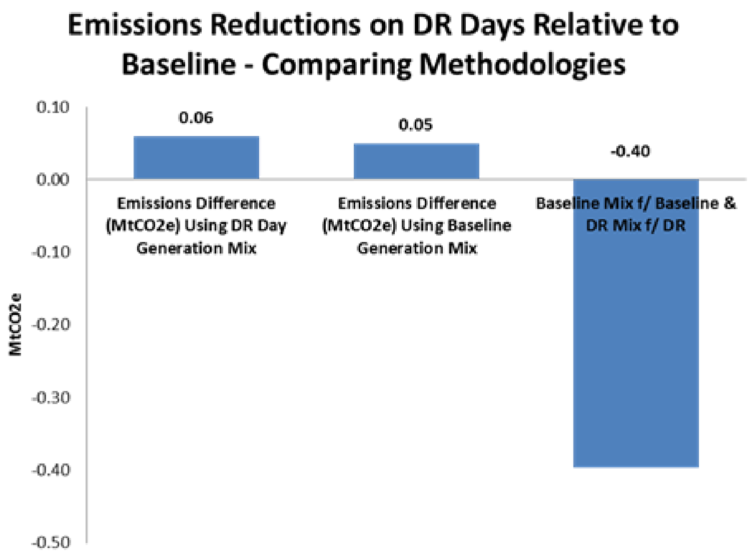
# Environmental Impact

## Results:

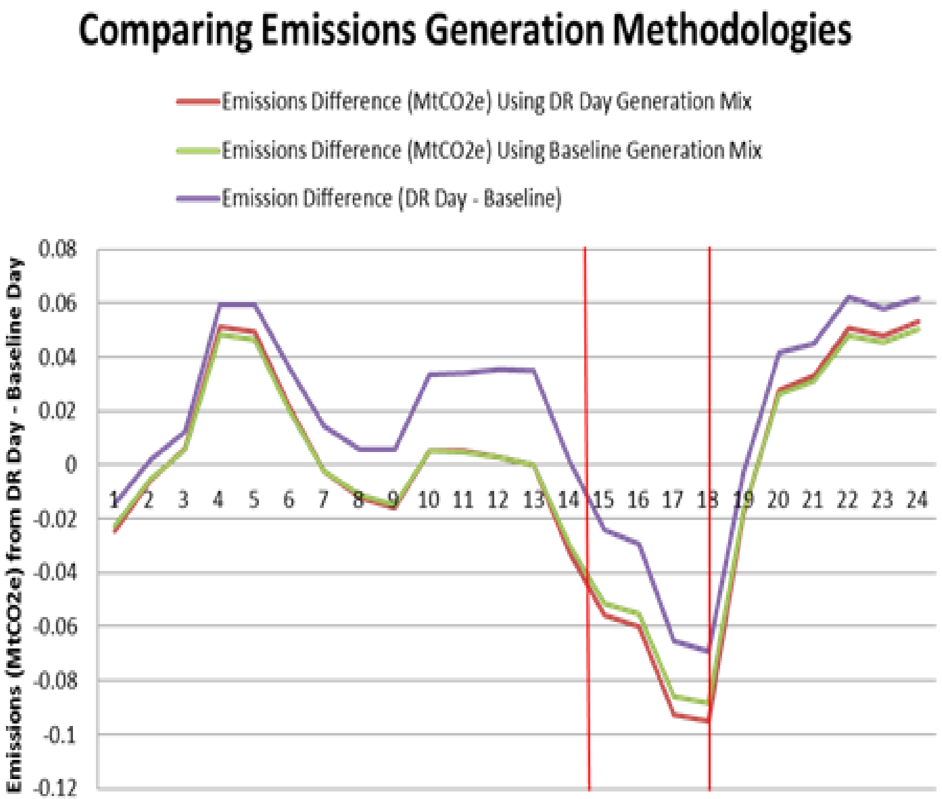
→ For all three methodologies, emissions are lower on DR days than on baseline days during peak hours.

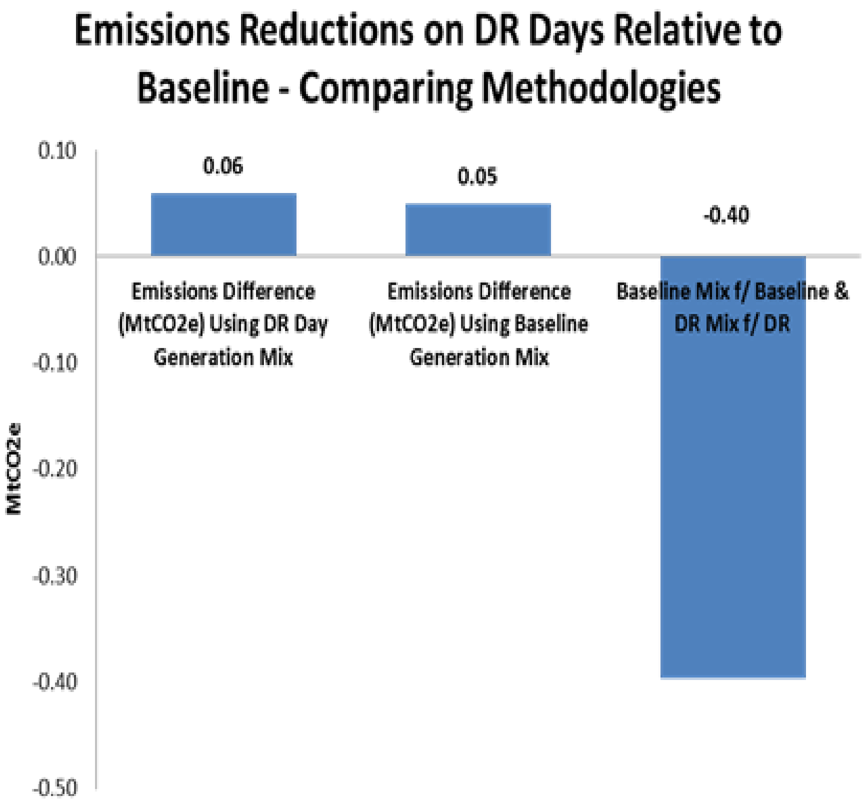
→ DR day emissions are lower on than baseline day emissions using methodologies (1) and (2), but higher using (3). Why?



# Environmental Impact



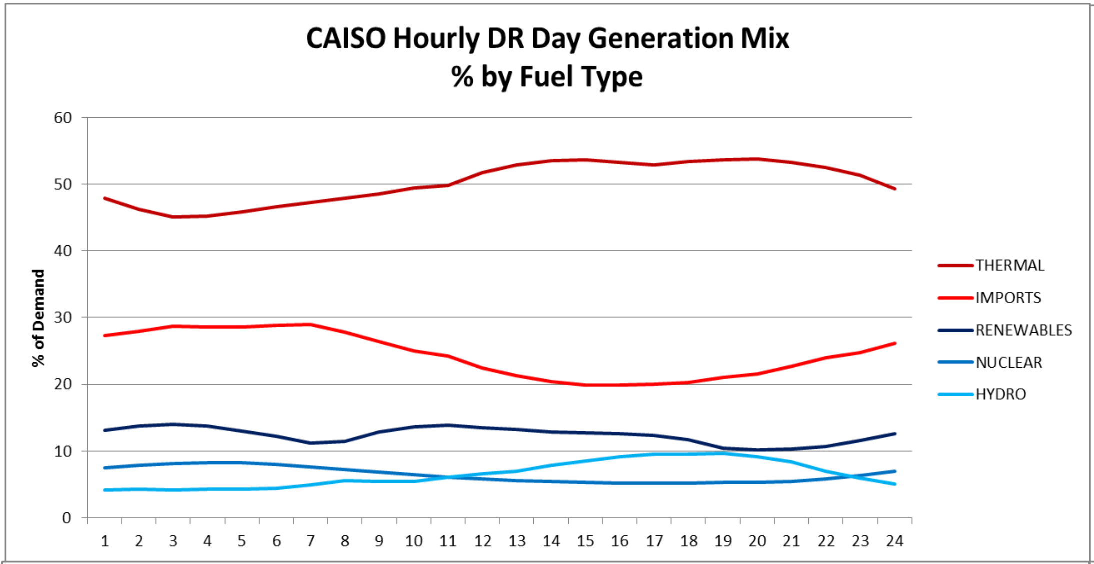



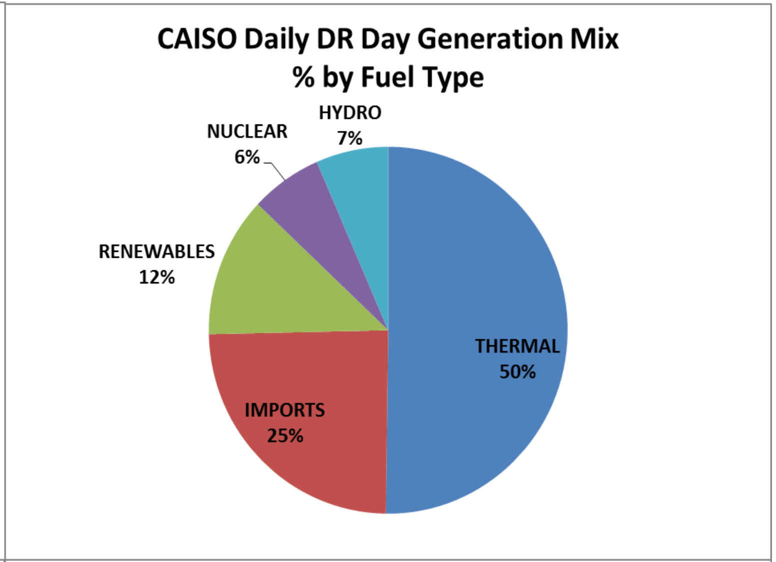
# Environmental Impact

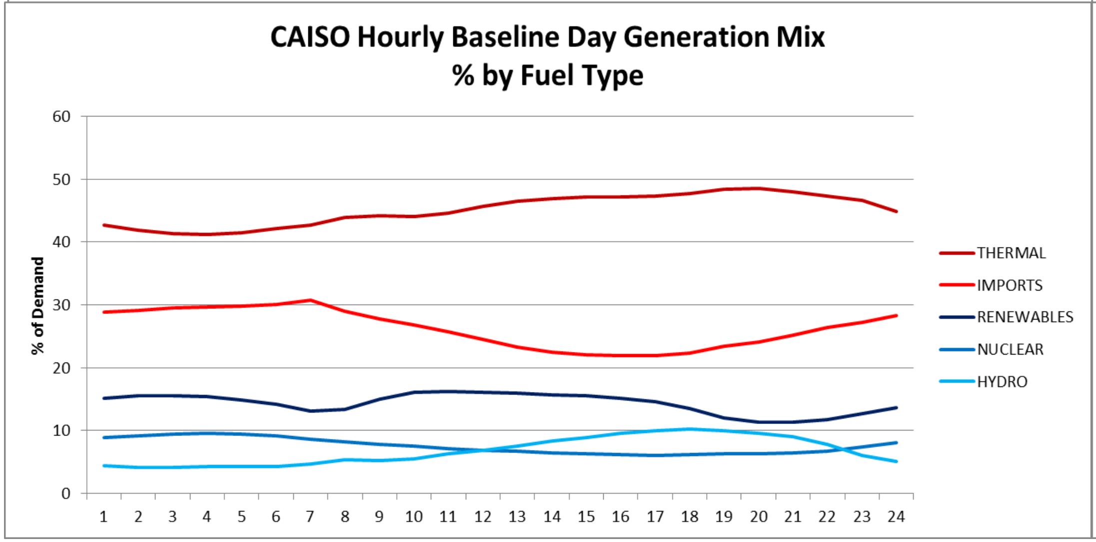
## Results Explained:

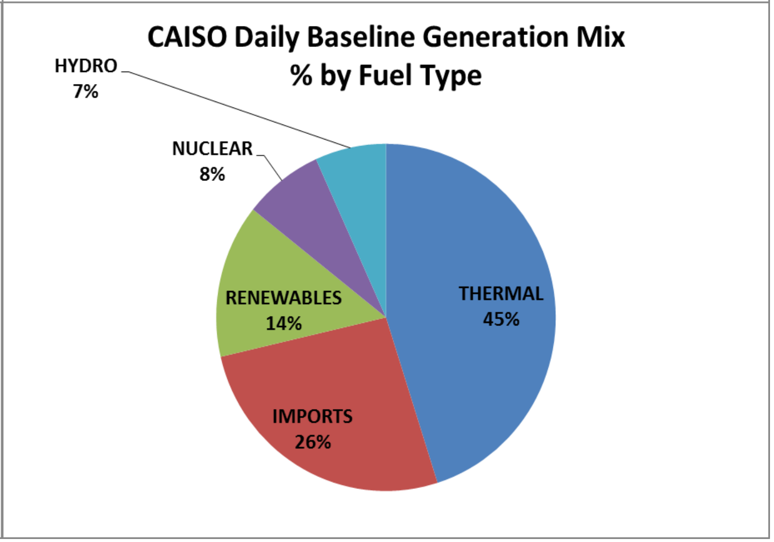
→ In our small sample, emissions intensive fuels comprised 75% of CAISO's daily generation mix on DR days versus 71% on baseline days.

# Environmental Impact



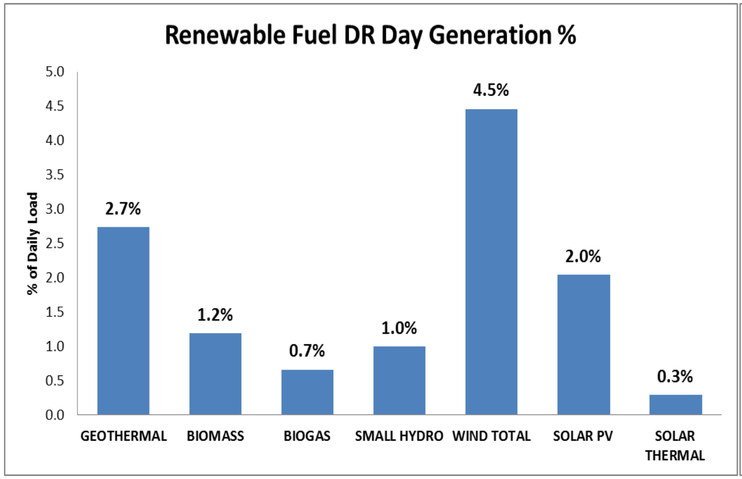



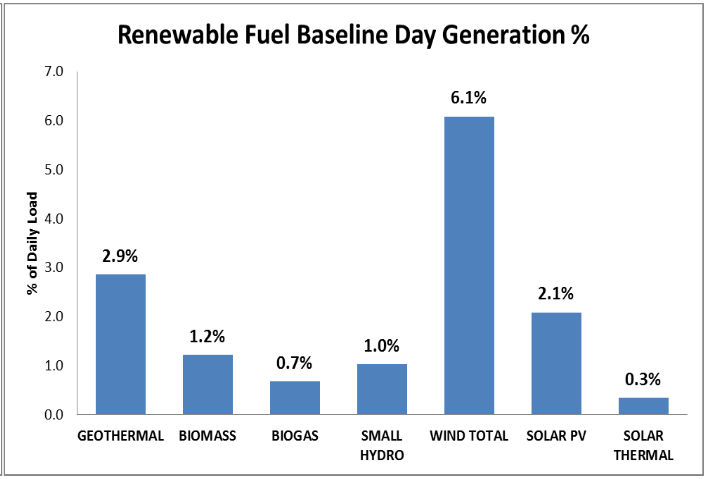



# Environmental Impact

## … Continued:

- → Renewables comprised 12% of the generation mix on DR days and 14% on baseline days.
  - → This RE dip on DR days is particularly pronounced for wind power, which drops from 6.1% of the generation mix on baseline days to 4.5% on DR event days.



# Environmental Impact

## Applied Grid Level Emissions Impact:

→ Assuming 100% of CAISO buildings participate in DR in a similar fashion to the SCE buildings analyzed in this study, grid demand on DR days would be 5.4% lower, equating to 40,925 MW of demand reduced and 14,227 MtCO2e of emissions reduced.

**Table 4 - Grid vs. Building Level DR Day Load Reductions**

| | CAISO | SCE Buildings in This Study |
|---|---|---|
| **DR Day Demand** | 753,138 MW | 18,993 KW |
| **Baseline Day Demand** | 718,269 MW | 19,153 KW |
| **DR Day - Baseline** | 34,869 MW | -160 KW |
| **% Change** | 4.63% | -0.84% |

**Table 5 - Applied Grid-Level Demand Reductions Assuming 100% DR Participation**

| | |
|---|---|
| DR Day Demand | 753,138 MW |
| Applied Grid Level Demand for DR Days, Assuming 100% of Buildings Participate | 712,214 MW |
| % Reduction | **5.4%** |
| Demand reduced | **40,925 MW** |
| Emissions Reduced (Using DR Day CAISO Generation Mix) | **14,227 MtCO2e** |

# THANK YOU

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