DEMAND RESPONSE MARKET OVERVIEW AND ROLE OF LIGHTING

2020 DOE LIGHTING R&D WORKSHOP

JANUARY 30, 2020

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TOPICS

- **Demand Response Definition**
- **Demand Response Market Overview and Role of Lighting**
- **Challenges and Opportunities**

DEMAND RESPONSE (DR) DEFINTION

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WHAT IS DEMAND RESPONSE (DR)?

- FERC/DOE definition

What? **Changes in electric usage by end-use customers from their normal consumption patterns…**

Why? … in response to changes in the **price of electricity** over time, or

… to **incentive payments** designed to induce lower electricity use

When? …at times of high wholesale market prices or

…when system reliability is jeopardized

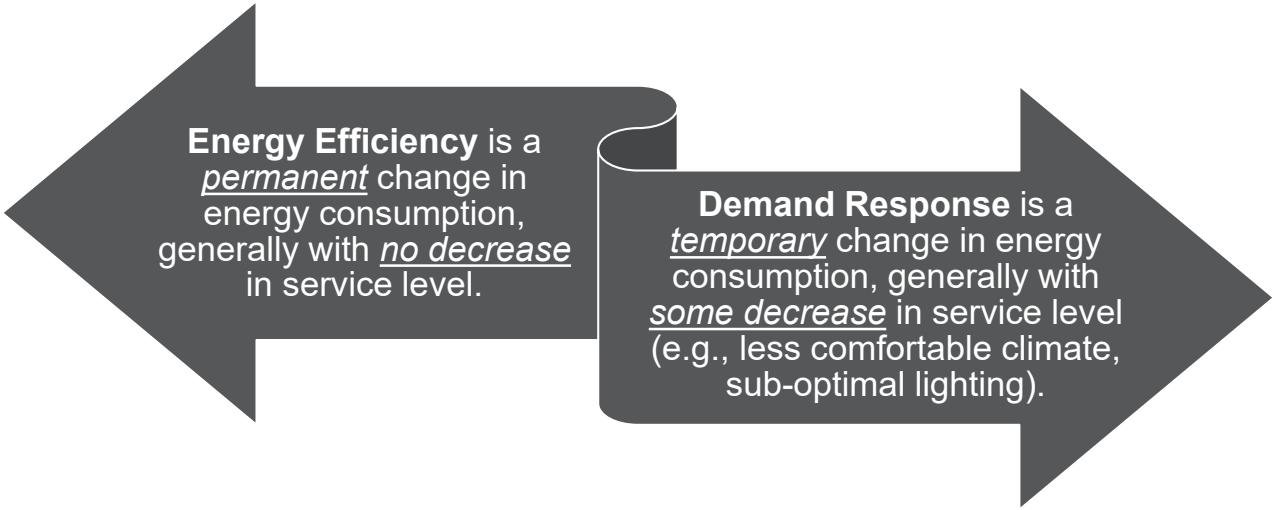
- By example:
  - Residential direct load control via paging of air conditioners
  - Monthly incentives to commercial customers for reducing load when requested
  - Pre-established high electricity prices in effect for participating customers when a utility declares the high-price period (critical peak pricing)
- What is **sometimes considered** DR?
  - Time of use rates
  - Permanent load shifting
  - Thermal energy storage

These program types are *not dispatchable*

Source: Peak Load Management Alliance (PLMA) DR to DER Evolution Training, 2019.

“SIMPLE” DR & EE DEFINITIONS

Both DR and EE reduce load, but



Source: Peak Load Management Alliance (PLMA) DR to DER Evolution Training, 2019.

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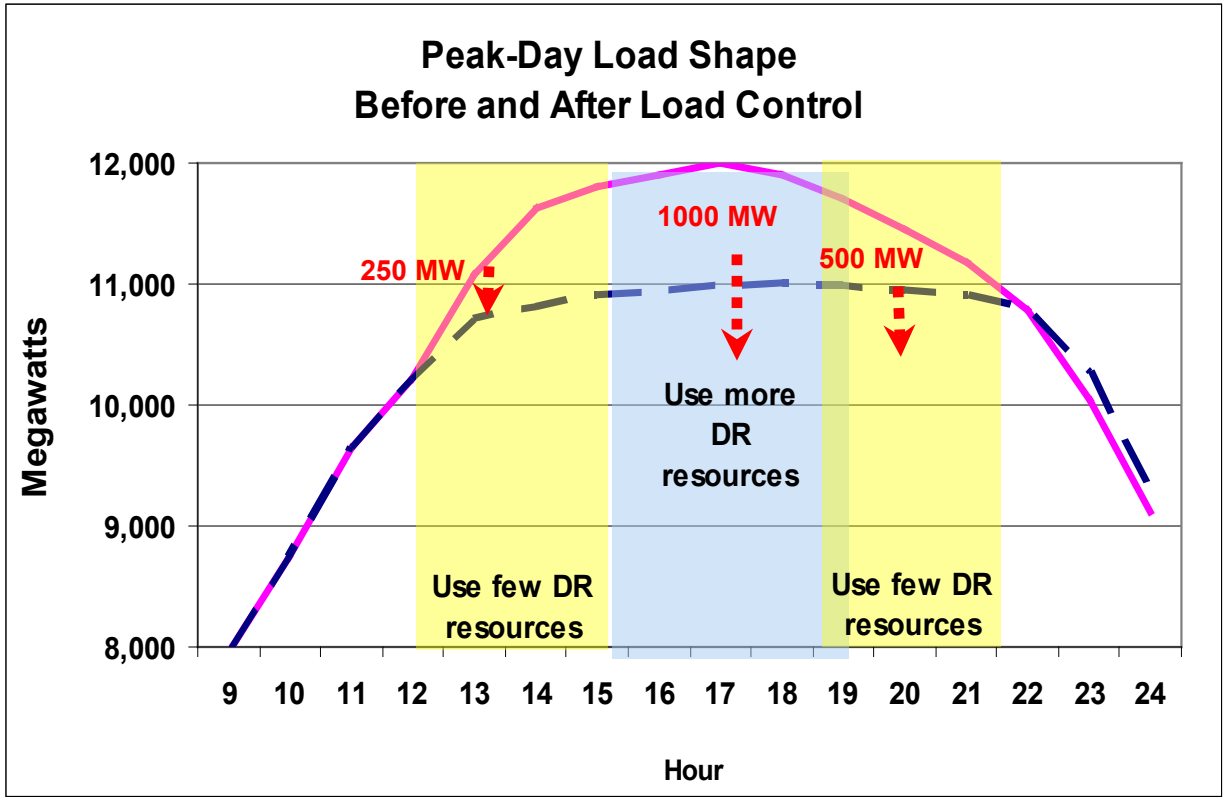
Call on DR when it is needed



Source: Navigant

Source: Peak Load Management Alliance (PLMA) DR to DER Evolution Training, 2019.

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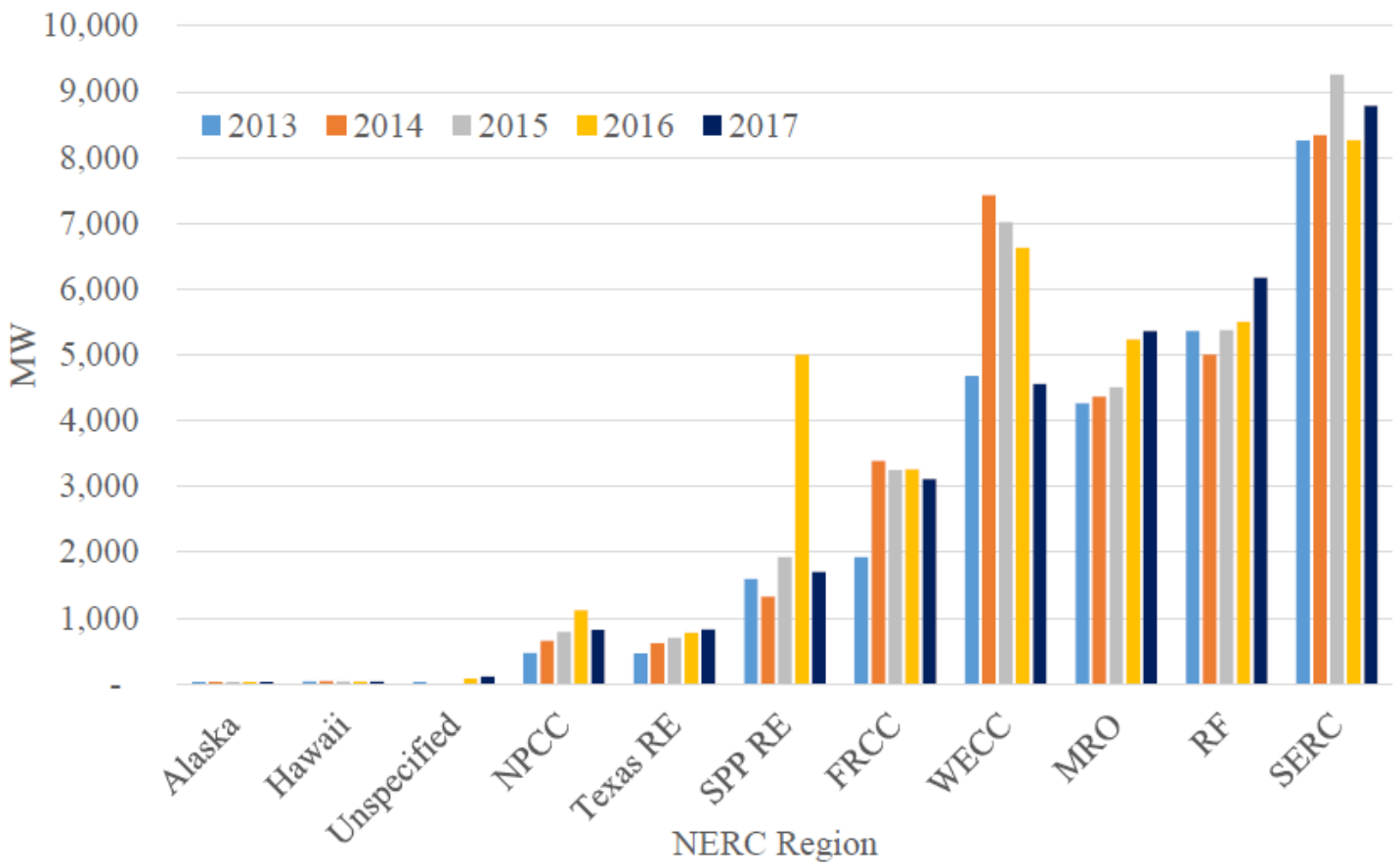
PEAK DEMAND SAVINGS FROM RETAIL DEMAND RESPONSE PROGRAMS



Source: "2019 Assessment of Demand Response and Advanced Metering"; Federal Energy Regulatory Commission Staff Report, December 2019

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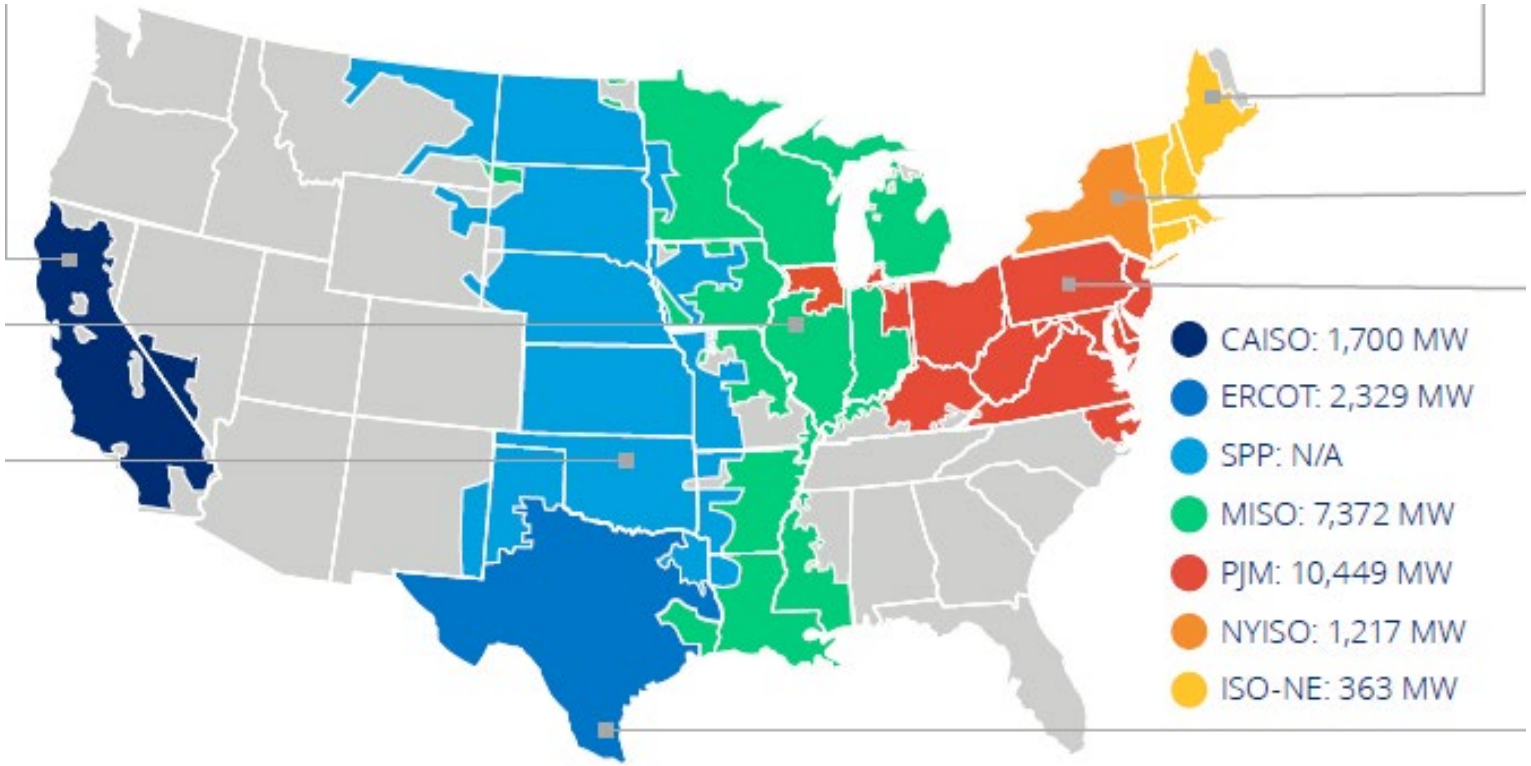
WHOLESALE MARKET DEMAND RESPONSE CAPACITY



Source: Navigant Research, 2019

Navigant's Methodology for ISO and RTO DR capacity

These numbers are based on publicly available data from the ISOs and RTOs and communication with ISO and RTO members. For PJM, NYISO, and ISO New England, the numbers shown are capacity market obligations. For MISO, ERCOT, and CAISO, they are a combination of the enrollment in the different DR programs that each RTO offers.

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COMMON APPLICATIONS OF DEMAND RESPONSE

Capacity Resource/ Emergency Response	• Curtailment when called by utility or grid operator for system stability • Common, proven application for reliability
Economic DR	• Curtailment called for high market prices or to avoid starting a new unit • Application for cost savings
Active Management / Grid Responsive	• Operator dispatch for short term relief/ operating reserves, balancing renewables • Automated response to grid conditions or price signals.

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Source: Peak Load Management Alliance (PLMA) DR to DER Evolution Training, 2019.

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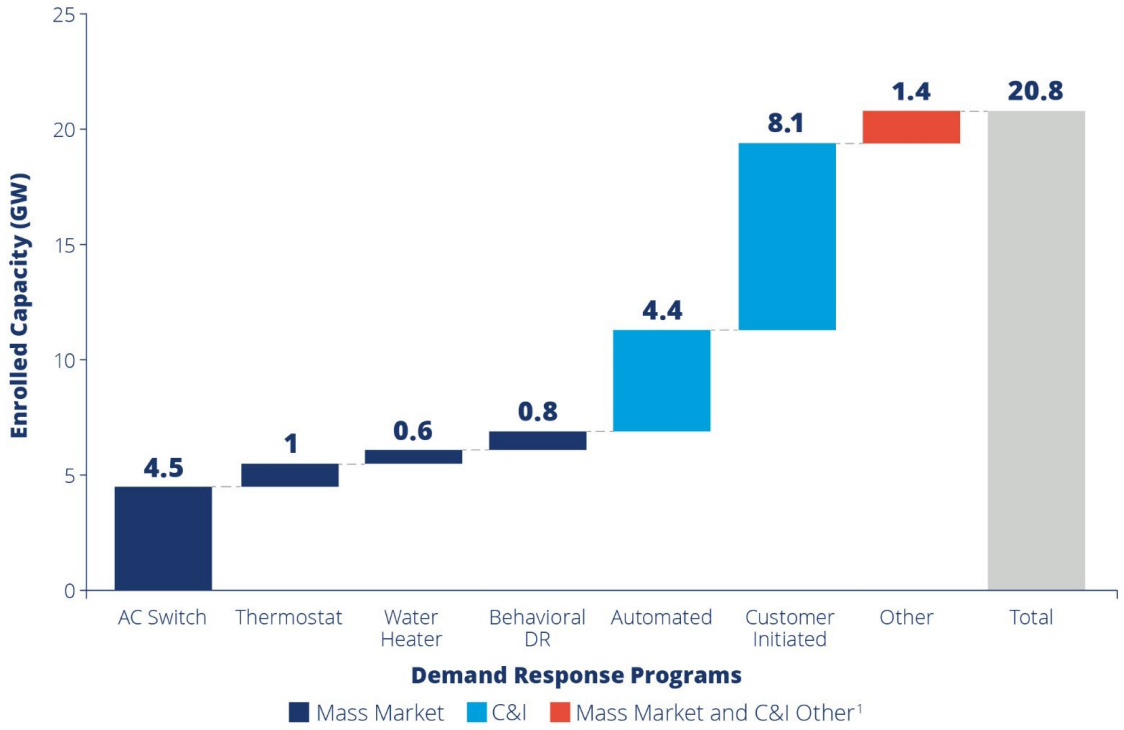
TYPES OF DR PROGRAMS



Source: Smart Electric Power Alliance, 2019. N=190 Utility Survey participants.

190 utilities responded to SEPA's 2019 annual Utility Survey:

- **Enrolled DR capacity**: 20.8 GW
- **Dispatched DR capacity**: 12.3 GW

Source: "2019 Utility Demand Response Market Snapshot ", presented by Smart Electric Power Alliance (SEPA) at 40th PLMA Conference, November 2019.

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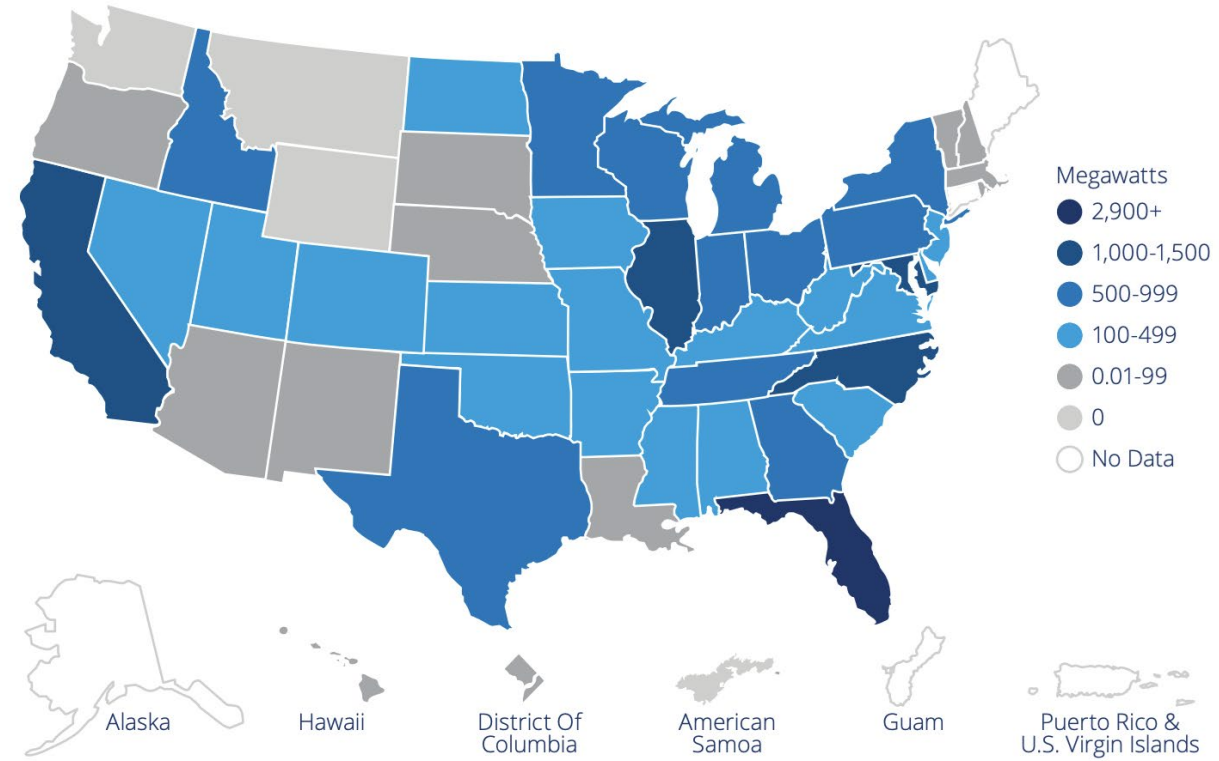
2018 DEMAND RESPONSE ENROLLED CAPACITY



Source: Smart Electric Power Alliance, 2019. N=190 Utility Survey participants.

Top States:

1. Florida - 2,911.4 MW
2. California - 1,335.4 MW
3. North Carolina - 1,319.8 MW
4. Maryland - 1,212.8 MW
5. Illinois - 1,146.5 MW

Source: "2019 Utility Demand Response Market Snapshot ", presented by Smart Electric Power Alliance (SEPA) at 40th PLMA Conference, November 2019.

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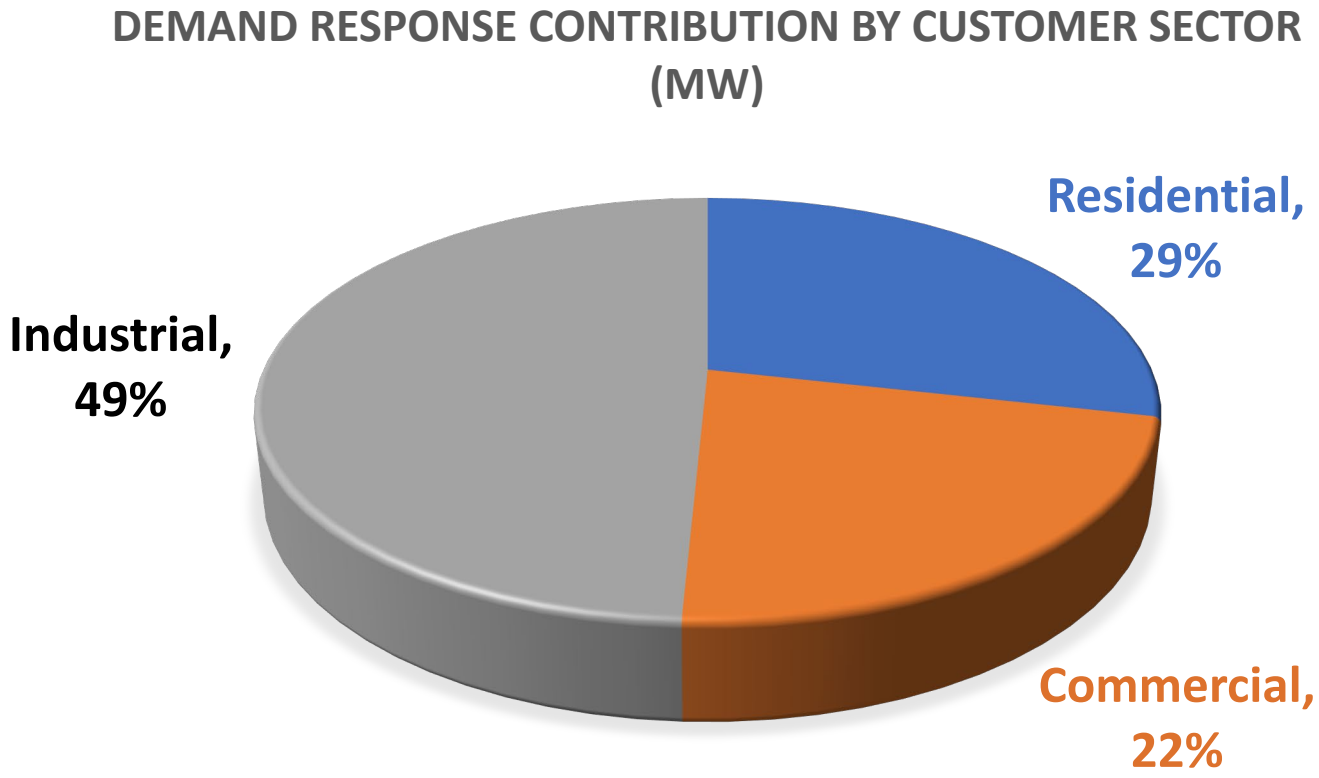
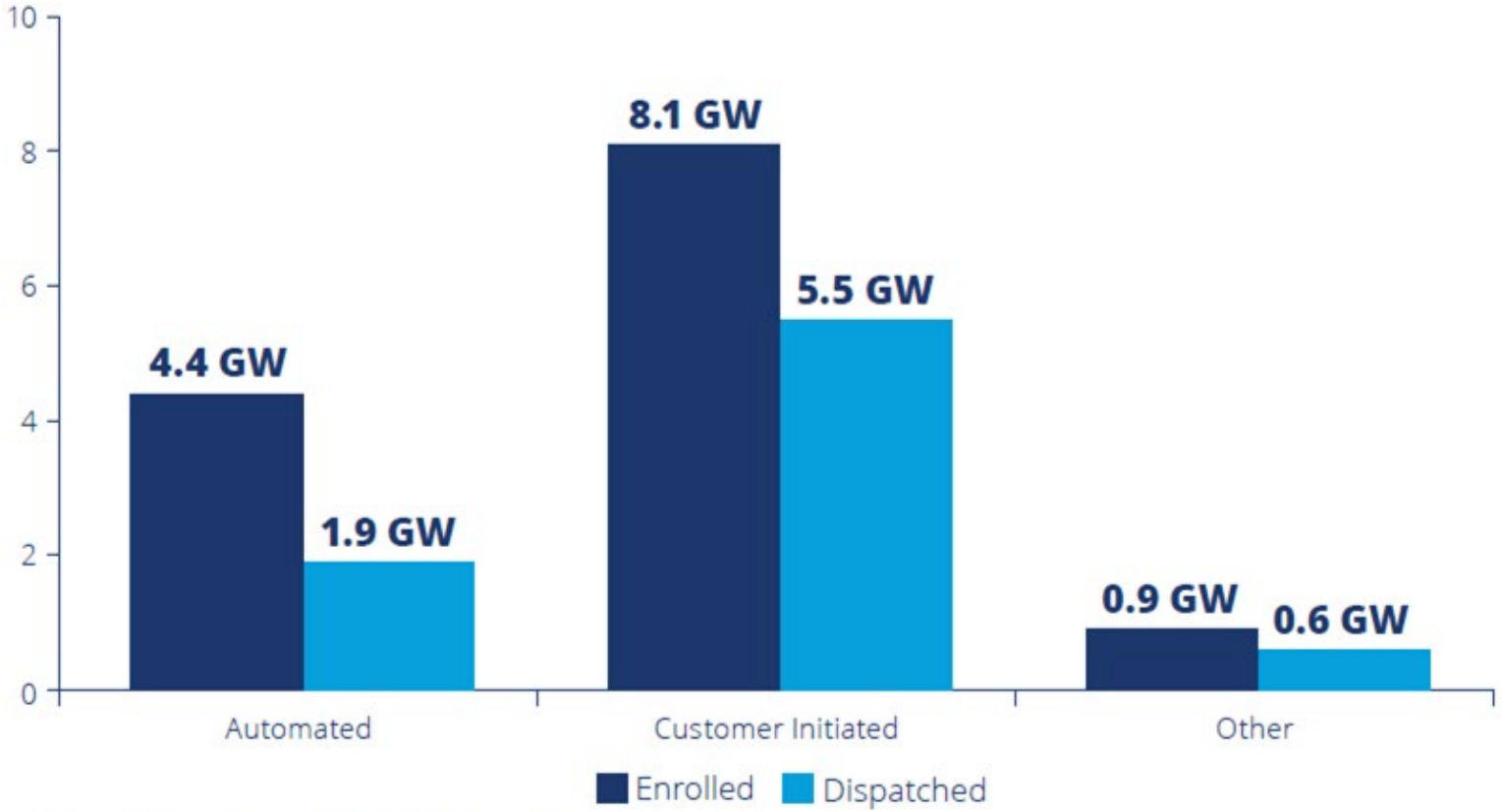
CONTRIBUTION IN DEMAND RESPONSE BY CUSTOMER SECTOR



Source: Based on data in the "2019 Assessment of Demand Response and Advanced Metering"; Federal Energy Regulatory Commission Staff Report, December 2019"

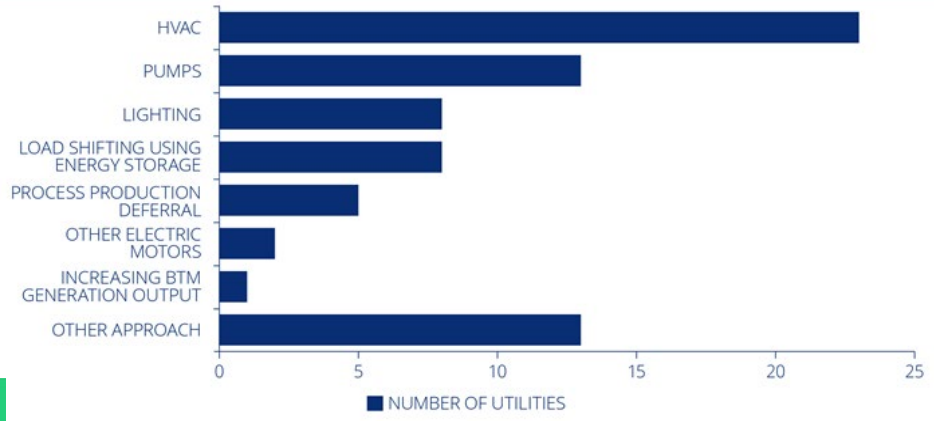
2018 COMMERCIAL AND INDUSTRIAL DR CAPACITY BY PROGRAM TYPE (GW)



Source: Smart Electric Power Alliance, 2019. N=190 Utility Survey participants.

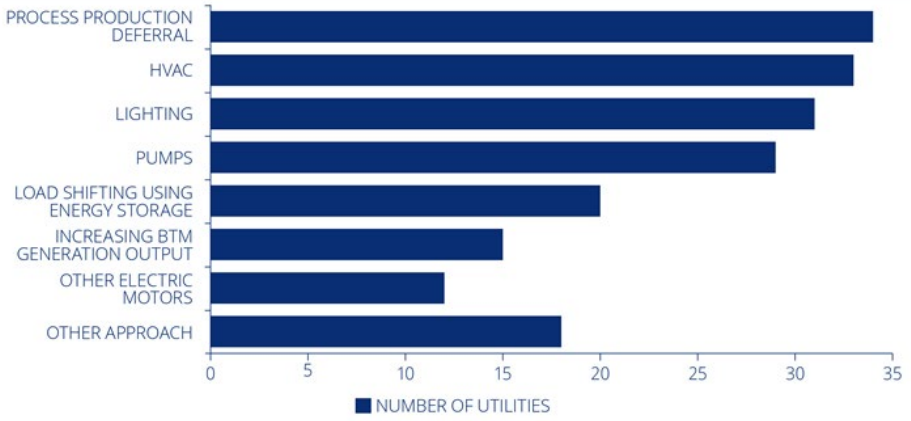
TYPES OF END-USES CONTROLLED IN C&I DR PROGRAMS

AUTOMATED DEMAND REDUCTION APPROACH BY PROGRAM TYPE



ource: Smart Electric Power Alliance, 2018. N=37. (Note that not all utilities that have automated programs responded to this survey uestion.)

CUSTOMER-INITIATED DEMAND REDUCTION APPROACH BY PROGRAM TYPE



Source: Smart Electric Power Alliance, 2018. N=55. (Note that not all utilities that have customer-initiated programs responded to this survey question.)

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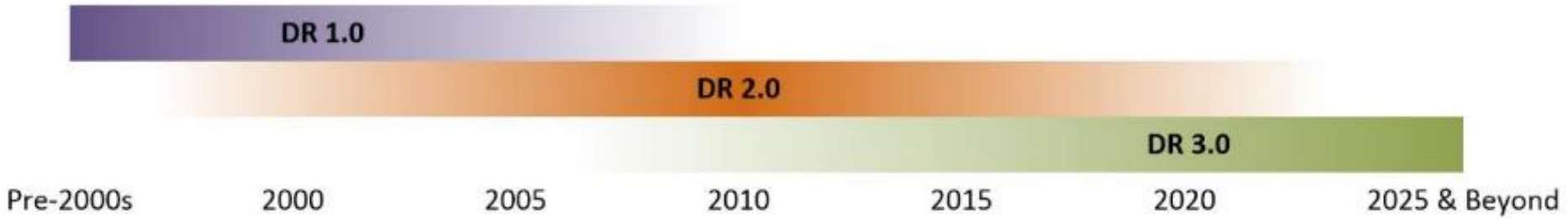
DEMAND RESPONSE EVOLUTION



- Largely manual control
- Interruptible tariffs for large C&I
- 1-way Direct Load Control for Residential
- Used for Capacity Planning & Emergencies

- Introduced To Wholesale Markets
- Increased automation
- Increased Precision
- Eventually Ancillary Services
- Behavioral/voluntary Options
- Smarter Equipment
- 2-way communications
- Some Near Real-Time Visibility

- Provide Multiple Grid Services
- Respond to Controls and/or Price Signals
- Distribution & Transmission Relief
- Introduction of Storage
- Migration to DER

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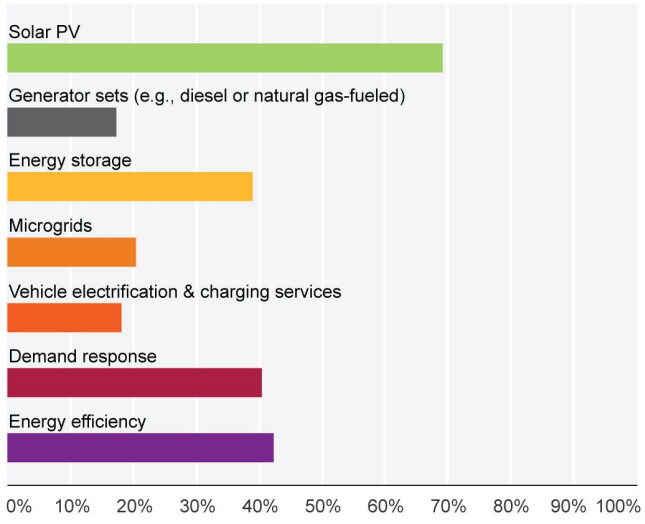
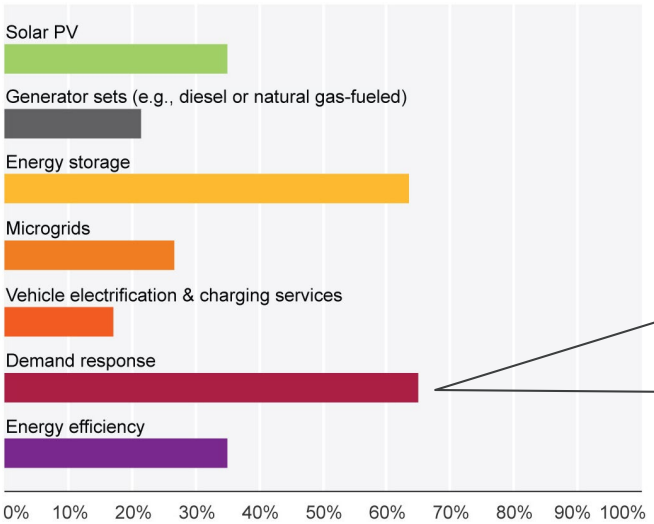
A RECENT SURVEY REVEALS DR AMONG THE MOST USEFUL DER FOR UTILITY OPERATIONS

Which will be the most **prevalent** DER **in terms of capacity** by 2025?



Solar is expected to be the most prevalent DER

Which DER will be the **most useful to utility operations** by 2025?



DR is expected to be the most useful DER

Source: Navigant Consulting, Inc. Public Utilities Fortnightly. July 2017. State & Future of the Power Industry. https://www.Navigant.com/new/corporate-news/2017/state-and-future-of-power-industry-2

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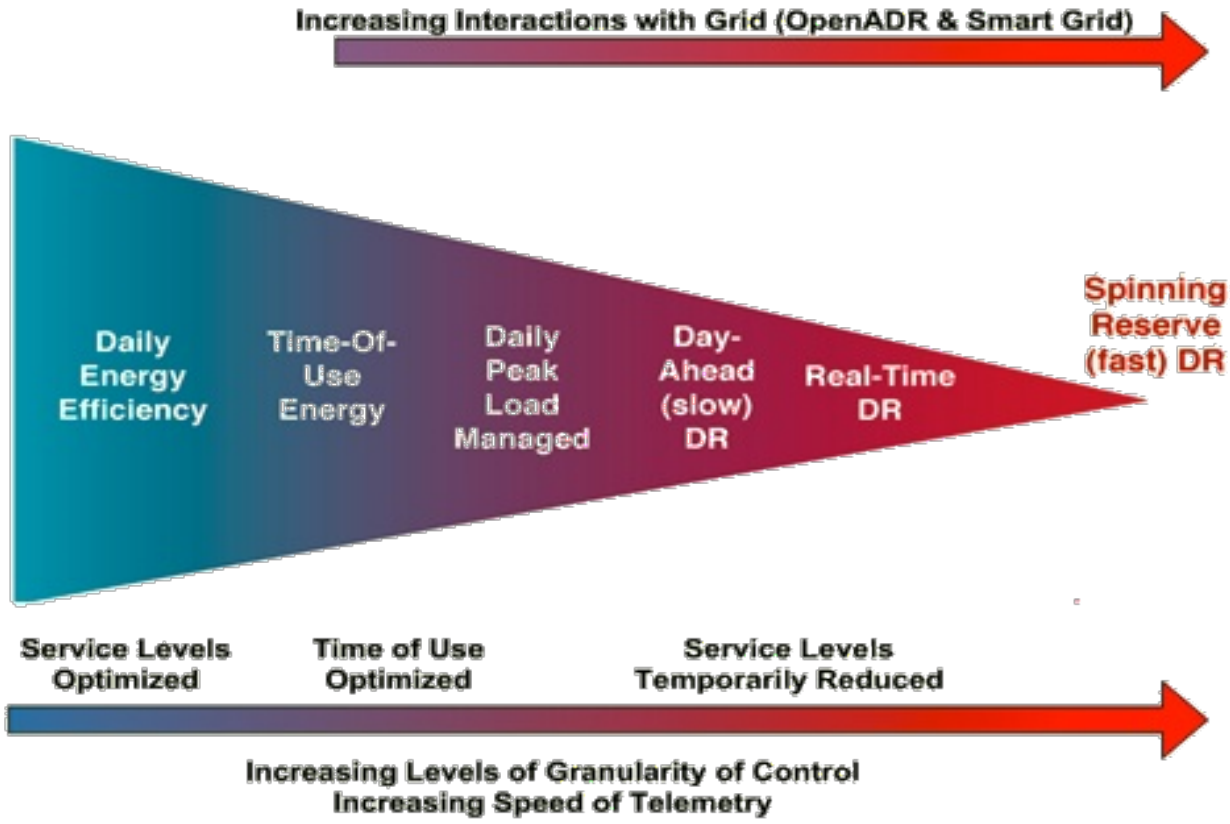
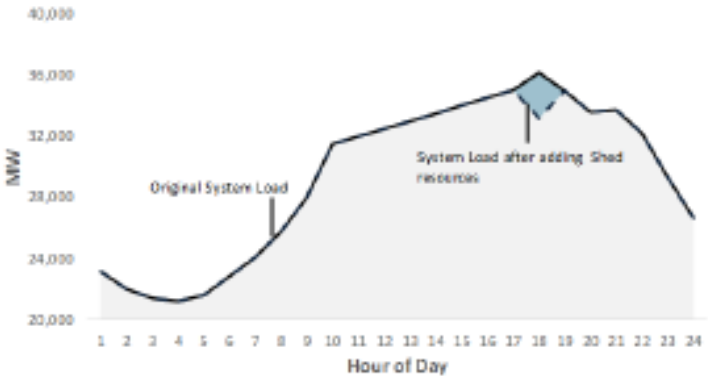
LINKING ENERGY EFFICIENCY AND DEMAND RESPONSE

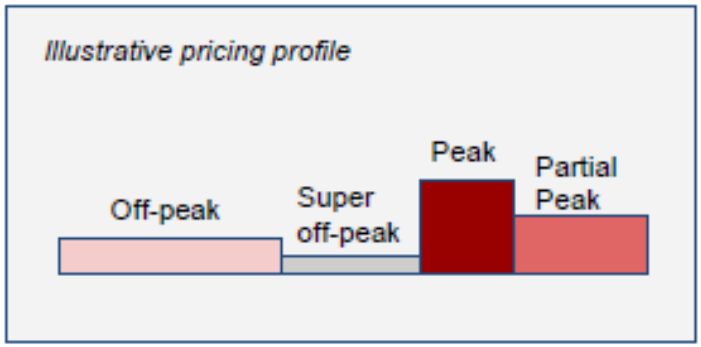


DEMAND RESPONSE SERVICE TYPES

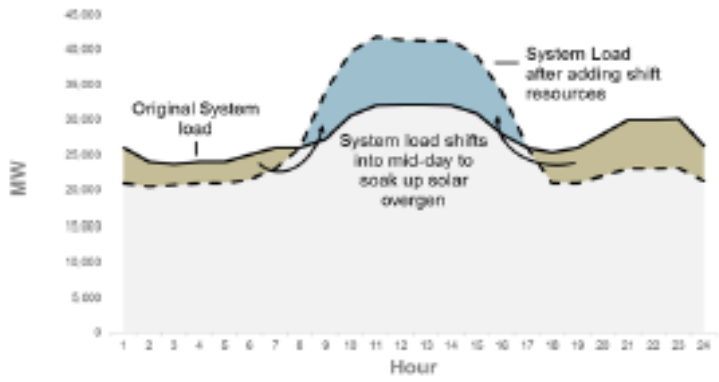
Shed Service Type: Peak Shed DR



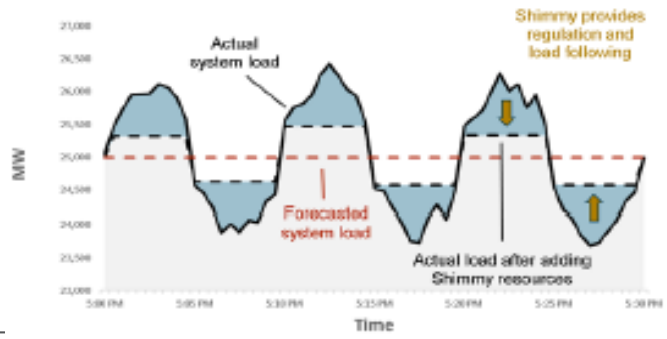
Shape Service Type as modeled: Accomplishes Shed & Shift with prices & behavioral DR.



Shift Service Type: Shifting load from hour to hour to alleviate curtailment/ overgeneration

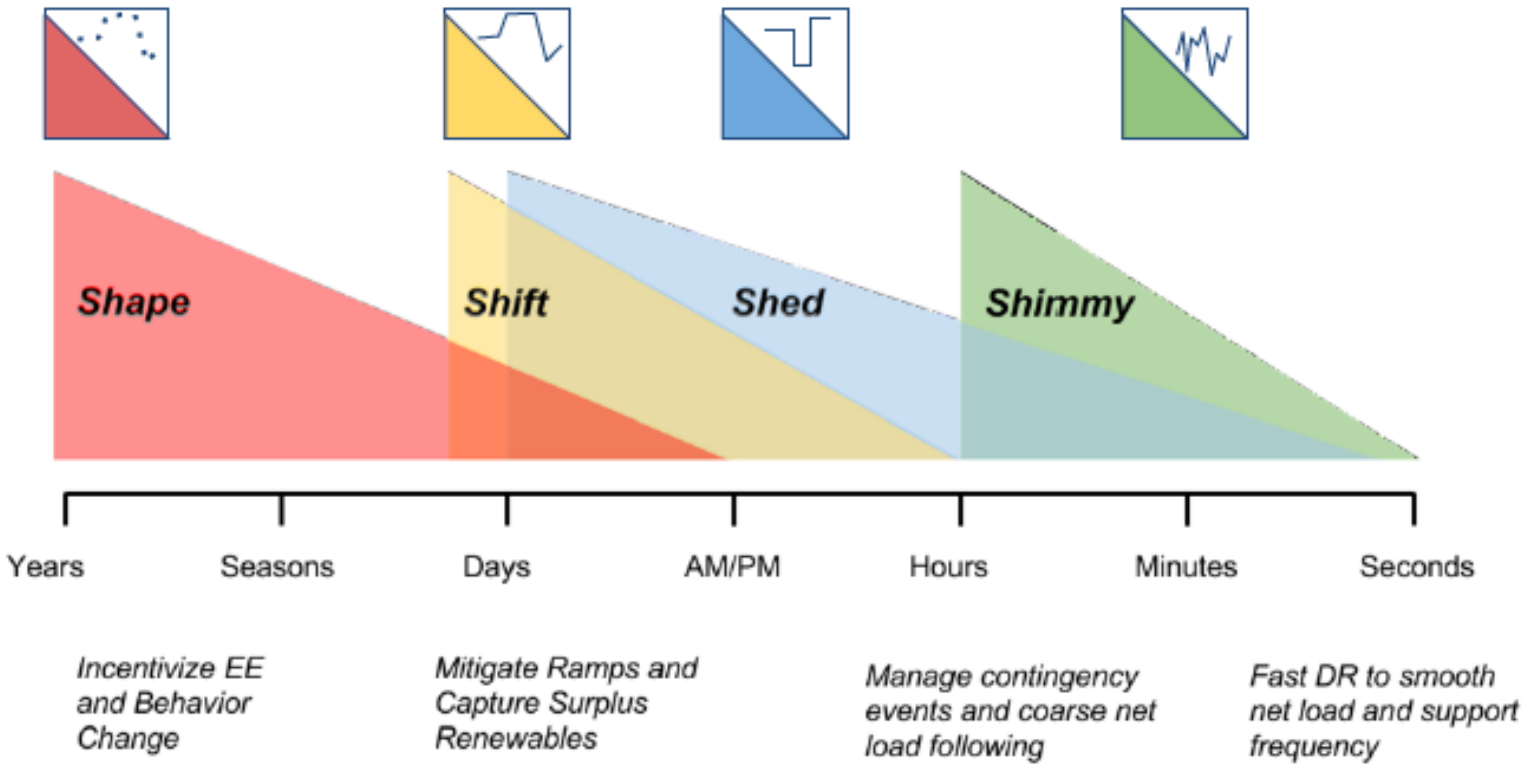


Shimmy Service Type: Load Following & Regulation DR



Source: 2025 California Demand Response Potential Study, Final Study Results; LBNL, 2017

TIME SCALES FOR DR SERVICES



Source: 2025 California Demand Response Potential Study, Final Study Results, LBNL , 2017.

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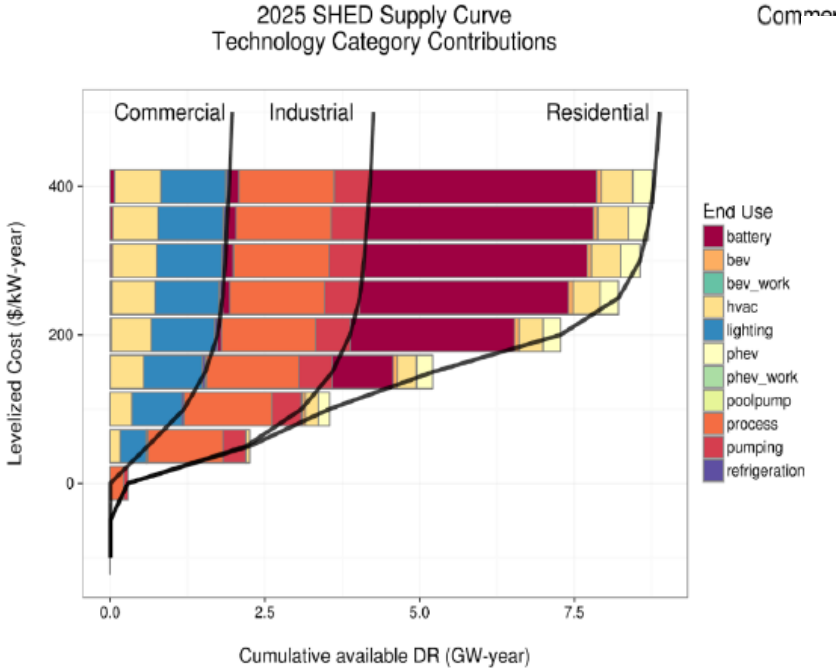
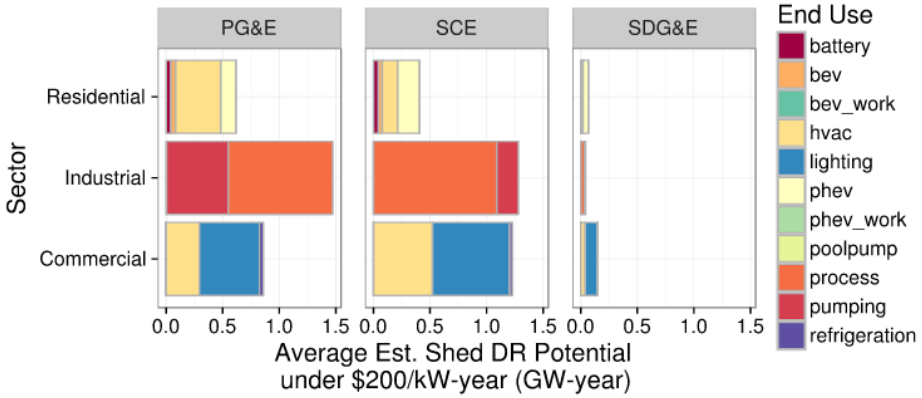
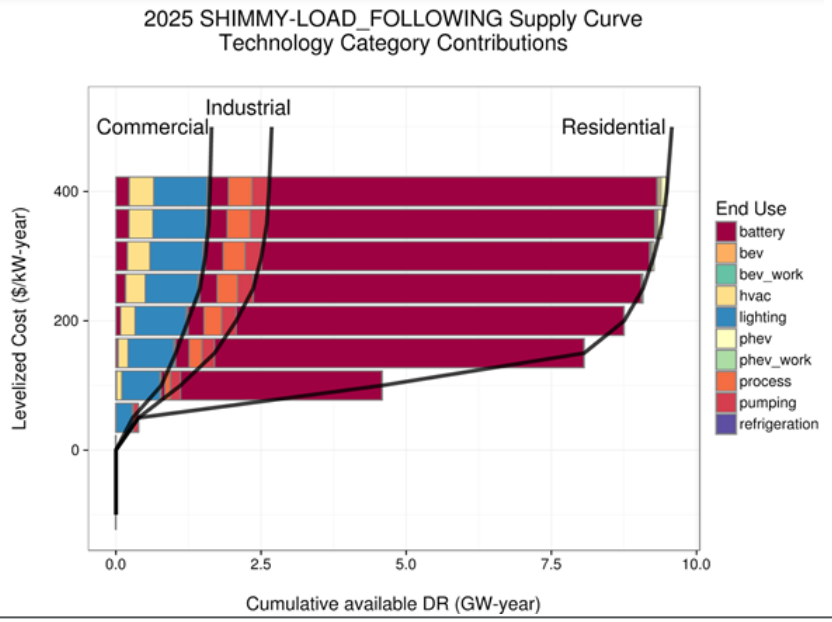
LIGHTING SHOWS SIGNIFICANT CONTRIBUTION IN DR POTENTIAL ESTIMATES







Source: 2025 California Demand Response Potential Study, Final Study Results, LBNL, 2017.

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AUTOMATED DEMAND RESPONSE & OPENADR

What is Automated DR?

- Automated Demand Response (Auto-DR) consists of fully automated signaling from a utility, Independent System Operator (ISO), Regional Transmission Operator (RTO) or other appropriate entity to provide automated connectivity to customer end-use control systems, devices and strategies.

What is OpenADR™?

- Open Automated Demand Response (OpenADR) is an open and interoperable information exchange model and emerging Smart Grid standard. OpenADR standardizes the message format used for Auto-DR so that dynamic price and reliability signals can be delivered in a uniform and interoperable fashion among utilities, ISOs, and energy management and control systems. While previously deployed Auto-DR systems are automated, they are not standardized or interoperable.

Source: OpenADR Alliance, https://www.openadr.org/

AUTOMATED DEMAND RESPONSE REQUIREMENTS IN BUILDING CODES

California Title 24 2016 Section 130.1(e)

Demand Responsive Controls—Lighting and Automation

- In buildings larger than 10,000 square feet, total lighting power shall be capable of being automatically reduced by a demand response signal by at least 15%.
- Lighting reduction shall be uniform.
- Non-habitable spaces do not count toward this requirement
- Spaces with less than 0.5 watts per square feet shall not count toward total power
- Demand response controls and equipment shall be capable of receiving and automatically responding to at least one standards-based messaging protocol.

OpenADR Requirements in City of Austin building codes (starting late 2016) for newly constructed buildings or facilities.

Excerpts from the code:

- " **C405.2.6 Demand response.** For all buildings having central control of a) lighting levels and/or b) the ability to turn on and off individual lamps, the controls shall have the capability to reduce lighting level in response to signals, based on OpenADR 2.0 or higher protocols, from a centralized contact or software point. Controls may be programmed to provide either an automatic or an operator adjustable degree of lighting reduction."

OPENADR CERTIFIED LIGHTING PRODUCTS EXAMPLES

Acuity Brands® | ECLYPSE™ Series

The ECLYPSE A1000™ manages and controls a network of Atrius™-Ready luminaires that are part of the Atrius Navigator Solution. This programmable device provides advanced functionality, such as customizable control logic, lighting groups configuration, Web-based design and visualization interface (ENVYSION embedded), logging, alarming, and scheduling.
https://www.acuitybrands.com/products/detail/768184/Atrius/ECLYPSE-A1000/IP-Building-Management-Interface-for-Atrius-Navigator…

Product Type: VEN (client) | OpenADR Profile: 2.0a

Enlighted Inc. | Enlighted Demand Response

Enlighted Inc. (www.enlightedinc.com) is the largest provider of advanced energy solutions for lighting, HVAC and big-data analytics growing at more than 2 million square feet per month. The Enlighted ADR2.0 solution for Lighting implements per-fixture, multi-tiered energy profiles to ensure appropriate dimming based on space…

Product Type: VEN (client) | OpenADR Profile: 2.0a

Exergy Controls | XRG-1000

Control of both interior and exterior lighting fixtures through advanced digital circuitry, sophisticated software and a web-based user interface allow Exergy Controls to enhance lighting system functionality while minimizing your facility's overall carbon footprint. Every system component works in concert to provide users with a…

Product Type: VEN (Client) | OpenADR Profile: 2.0a

Lunera Inc. | Lunera Ambient Compute Platform

Lunera Ambient Compute Platform is a cloud based platform offering multiple applications around Energy, HVAC, Asset Tracking, Indoor Navigation, etc. The platform leverages Lunera's lamps equipped with sensors and radios. Building owners can opt to receive OpenADR commands from their power utility to their lighting…

Product Type: VEN (client) | OpenADR Profile: 2.0b

Lutron | Quantum

Quantum is a lighting and shading control system that provides total light management by tying the most complete line of lighting controls, motorized window shades, digital LED drivers, and sensors together under one software umbrella. Quantum is ideal for new construction or retrofit applications and…

Product Type: VEN (client) | OpenADR Profile: 2.0a+b
View full profile

Lutron Electronics Co., Inc | Vive Hub

Vive by Lutron is a simple, scalable, wireless lighting control system that can be installed in a single space or throughout an entire campus. It's designed to meet today's energy codes, be used in new construction or retrofit situations, and meet your budgetary needs. And…

Product Type: VEN (client) | OpenADR Profile: 2.0b

OSRAM | ENCELIUM® EXTEND

The Award-Winning ENCELIUM® EXTEND Networked Light Management System is a flexible and powerful way to monitor, analyze and manage interior and exterior commercial lighting spaces. It is the only lighting control system that can gather data from a range of lighting devices to adjust lighting…

Product Type: VEN (client) | OpenADR Profile: 2.0b

RAB Lighting | Lightcloud

Lightcloud is the world's most advanced wireless lighting control system, offering sensor automation and scheduling, energy monitoring and demand response, and much more.

Product Type: VEN (client) | OpenADR Profile: 2.0b

Wattstopper Inc. | LMDR-VEN

The Wattstopper Digital Lighting Management (DLM) OpenADR 2.0 solution provides a cloud-based Virtual End Node (VEN) that is designed to securely manage the communication between the utilities Virtual Top Node (VTN) and the customer's Wattstopper lighting controls network while adding zero hardware cost to the…

Product Type: VEN (client) | OpenADR Profile: 2.0b

Source: OpenADR Alliance, https://www.openadr.org/

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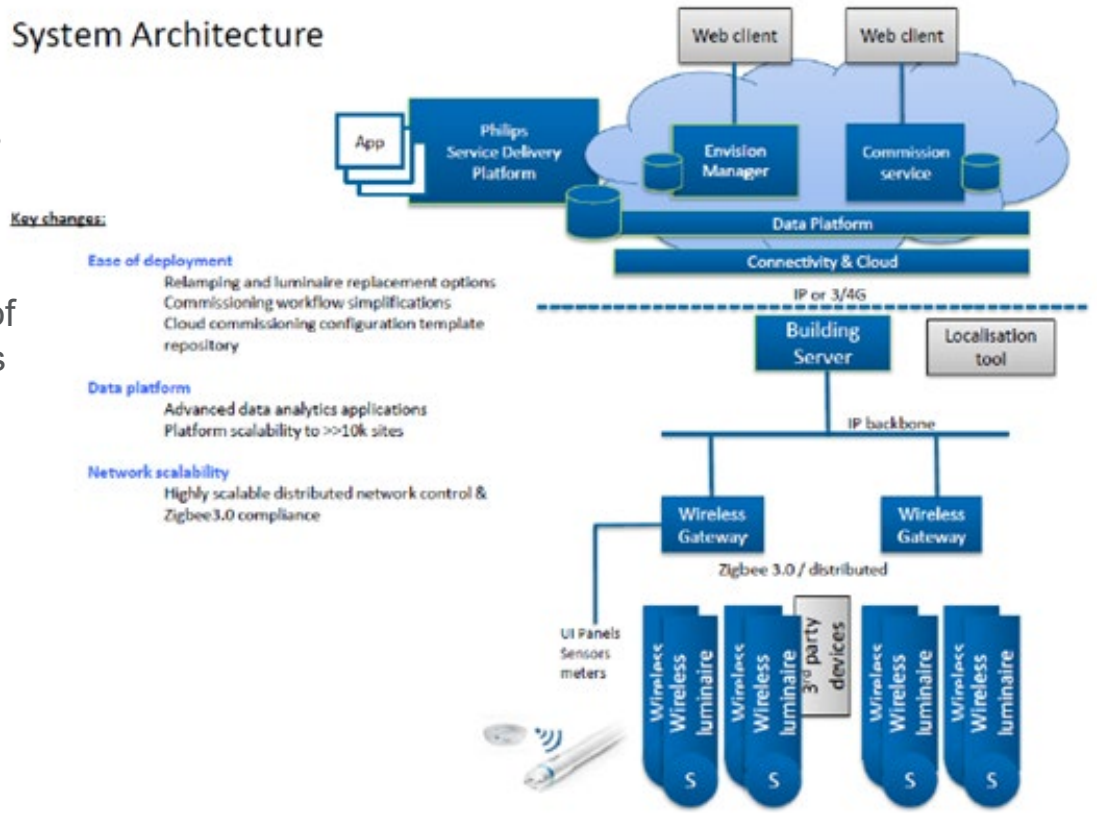
LIGHTING CONTROLS: DR OPPORTUNITIES

- Demand reductions using connected LED lighting system with embedded sensors and wireless controls integrated into the luminaire. successfully demonstrated.
- The luminaires connect to wireless access controls (WACs) that are connected to the EMS.
- As a prototype, the version of the solution used for this project allowed for grouping of fixtures by functional area. Newer versions allow for fixture by fixture control.
- The solution is scalable for any job size, from small to large.
- Integration into EMS or building management systems (BMS) can be achieved through the network gateways.
- SDG&E demonstration established demand reduction capabilities during DR events.

Connected Lighting Points System Architecture



Source: San Diego Gas & Electric Emerging Technologies Program, *Wireless Lighting Controls Automated Demand Response,* August 2016

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DEPLOYMENT CHALLENGES AND OPPORTUNITIES

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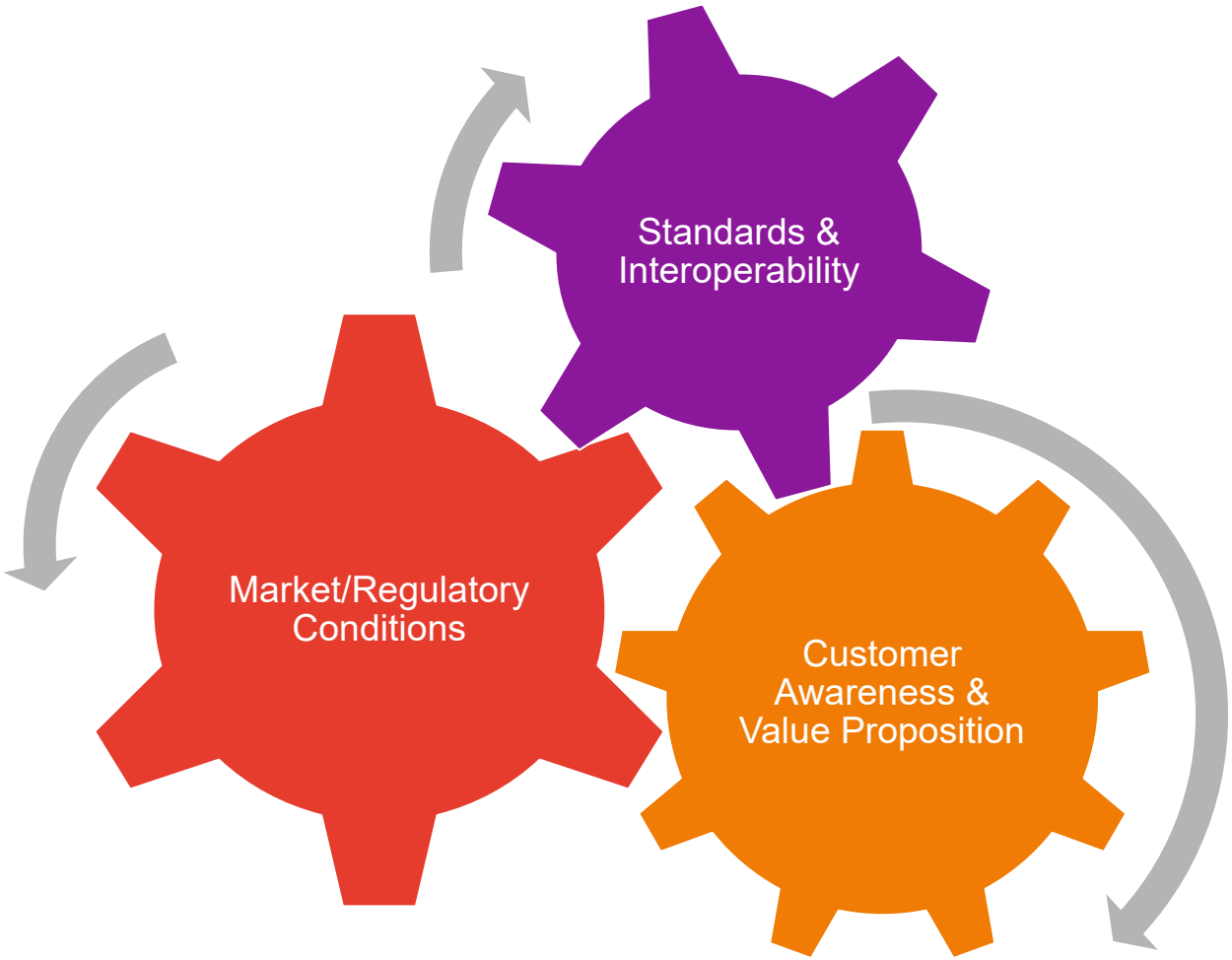
TECHNOLOGY DEPLOYMENT DRIVERS



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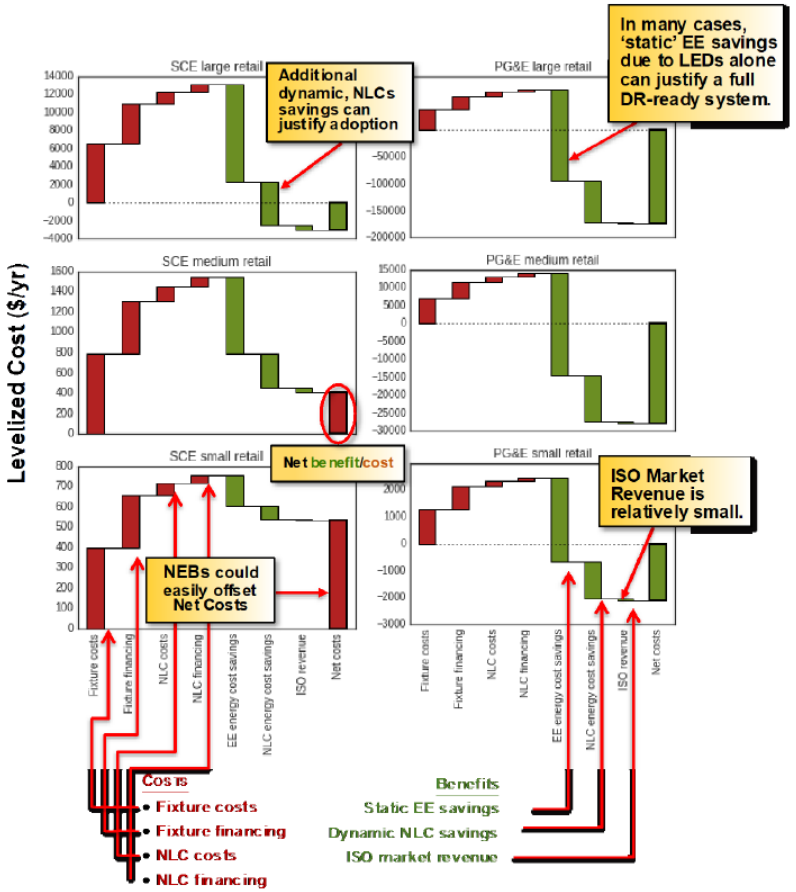
COSTS AND ENERGY BENEFITS FROM NETWORKED LIGHTING CONTROLS

- Energy-only cost-effectiveness of demand response-enabled lighting systems varies by building size and service territory.
- In Pacific Gas & Electric Company's service territory, where commercial retail electricity rates are relatively high (especially on peak), there is a net benefit across all building sizes and types.
- In contrast, in Southern California Edison's service territory where electricity rates are lower, the cost-effectiveness depends strongly on the building size, with a net benefit for large buildings only.
- The results for the San Diego Gas & Electric Company's service territory are somewhere between these two cases.
- Primary value proposition for demand response-enabled networked lighting controls comes from the site-level energy savings that are realized with or without demand response participation.

Source: "**The Value Proposition for Cost-Effective, Demand Responsive-Enabling, Nonresidential Lighting System Retrofits in California Buildings", CEC, April 2019.**

Figure ES-4: Levelized System Installation Annual Costs and Energy-Related Benefits in Southern California Edison and Pacific Gas & Electric Service Territories



Far Right Total: GREEN indicates Positive value; RED is Negative

Source: Lawrence Berkeley National Laboratory

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CUSTOMER VALUE PROPOSITION OF NETWORKED LIGHTING CONTROLS: QUANTIFICATION OF NON-ENERGY BENEFITS

- Recent study by the Lawrence Berkeley National Lab (sponsored by the California Energy Commission) developed a framework to capture the high customer values from Networked Lighting Controls (NLC) non-energy benefits to drive DR adoption.

Table 24: Benefits Value Intensity Category Summary

BVI Level	Organization Category	Definition	Example
1	**Energy (Ave. cost = $3/ft²)**	The lowest BVI category. Describes the energy benefits that may accompany a NEB.	Reduced energy consumption achieved by reducing unused space
2	**Building (Ave. cost = $30/ft²)**	Generalized "costs of rent" to capture all values a NEB can create on a building's operation	Avoided costs by not adding new space since current space is more efficiently used
3	**People (Ave. cost = $300/ft²)**	Captures a NEB's impact on people or activities they perform in a building	Employees can find spaces to work and conduct meetings. More efficient use of their time increases satisfaction with their space.
4	**Revenue (Ave. = $3,000/ft²*)**	The highest BVI category. Capturing additional revenue generated from business activities performed in the building as a result of a NEB.	Increased revenue generated by additional employees added to use the same workspace; increased revenue from using retail wayfinding to increase customer sales

*** Revenue represents a very rough estimate, since this metric requires significant exploration.**

Source: Lawrence Berkeley Laboratory

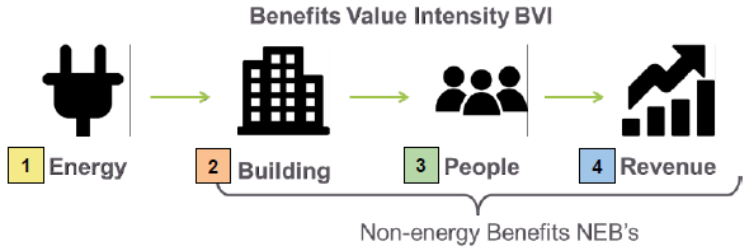

Table 27: Office Space Optimization Non-energy Benefits Quantified Results Summary

BVI	Energy	Building	People
Use Case Narrative	Reduced energy consumption and equivalent dollar value by reducing unused space	Avoided costs by not adding new space through more efficient current space use	Lowered overhead costs on employee-specific supplies, equipment and spaces
Savings ($/ft²)	0.16	10.54	26.4
Benefit Multiplier (normalized to energy)	1	67	167

Source: Lawrence Berkeley Laboratory

The study reviewed more than 130 networked lighting control case studies to quantify the non-energy benefits and develop a benefits value intensity model that captures the energy and non-energy benefits related to building, people and revenue

Source: "**The Value Proposition for Cost-Effective, Demand Responsive-Enabling, Nonresidential Lighting System Retrofits in California Buildings", CEC, April 2019.**

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