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U.S. DEPARTMENT OF ENERGY

Demand Side Energy Management

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Acknowledgements

- Many government agencies, utilities, contractors, researchers and others are investigating how best to implement demand side energy management for its multiple benefits, which include:
  - Reducing consumers' energy cost burden – particularly for the disadvantaged, low income households and businesses
  - Improving energy system reliability and resilience
  - Reducing the environmental impact of energy consumption
  - Improving energy security
  - And - *Supporting the cost-effective decarbonization of the energy sector*

- In particular I want to acknowledge the work of my colleagues at:
  - U.S. Department of Energy's Office of Energy Efficiency and Renewables and its Building Technologies Office - https://www.energy.gov/eere/office-energy-efficiency-renewable-energy
  - Lawrence Berkeley National Laboratory - https://energyanalysis.lbl.gov and https://buildings.lbl.gov

First Step of Energy Management – Use Energy Efficiently

Within the U.S. Economy it has been estimated that

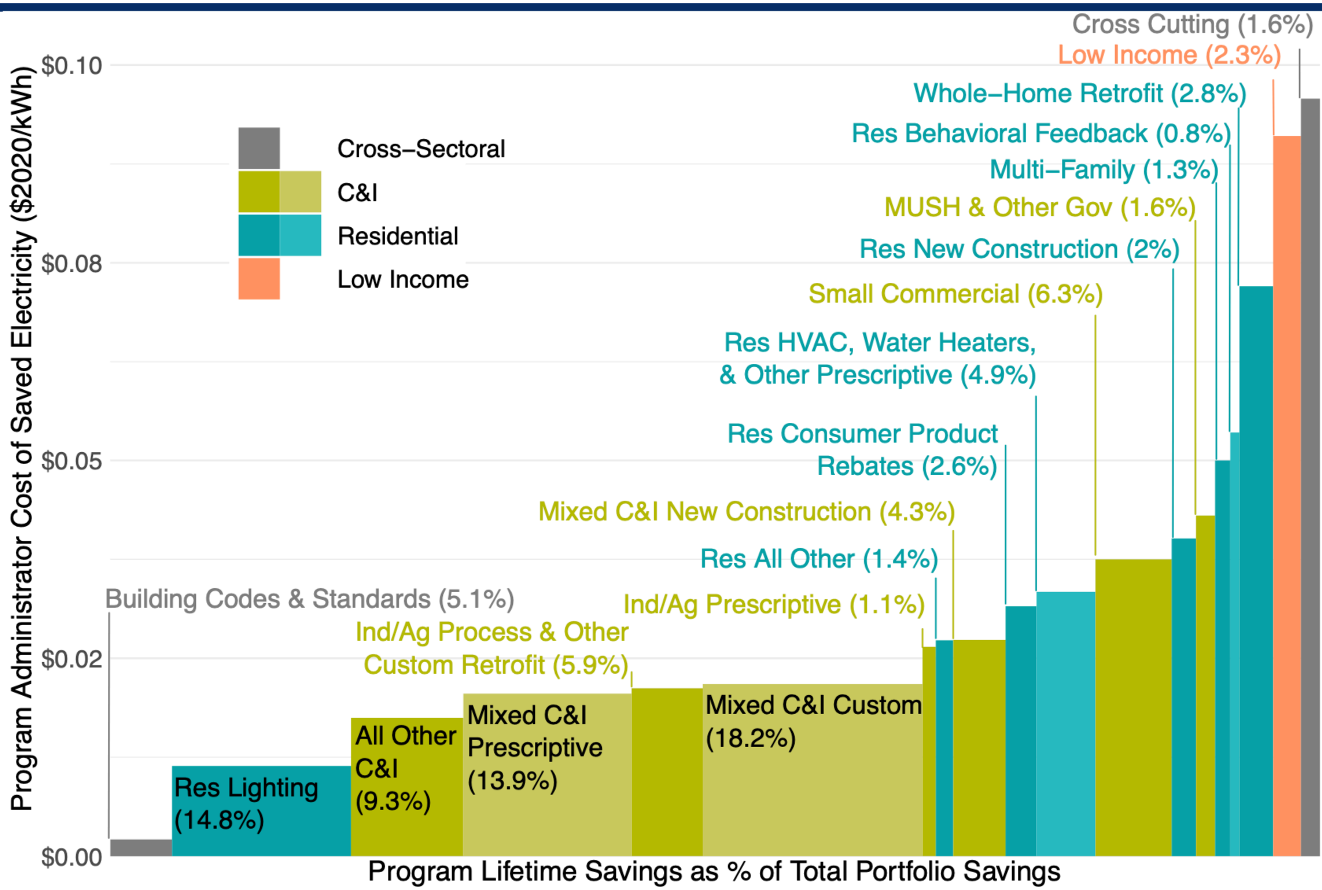
- There are over 2,000,000 energy efficiency jobs
- Without the energy efficiency investments made since 1980, energy consumption and emissions would have been 60% higher
- Appliance and equipment standards have helped deliver up to 80% in energy savings since 1980, often while improving size, capacity, and performance of such devices
- Energy efficiency is responsible for half the carbon dioxide emissions reductions in the power sector relative to 2005

Source: Energy Efficiency Impact Report, 2020, https://energyefficiencyimpact.org/about/

And…Energy Efficiency Is Very Cost Effective

Composite cost curve for energy savings from electric efficiency programs (2010-2018)

The levelized program administrator cost for saving energy in the U.S. Economy for 2018 programs was 2.4¢/kWh.

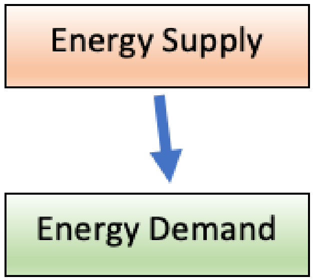


Source: **Still the One: Efficiency Remains a Cost-Effective Electricity Resource**
https://eta-publications.lbl.gov/sites/default/files/cose_cspd_analysis_2021_final_v2.pdf

Demand Side Energy Management – More Than Energy Efficiency

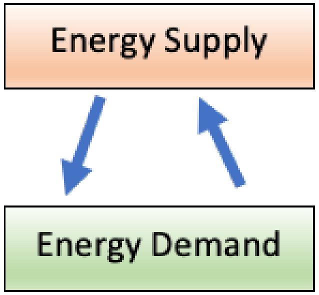
- Historically, conservation and energy efficiency have been used to primarily reduce the amount and cost of energy that consumers needed and thus the amount of energy provided by power plants, natural gas and fuel oil pipelines, biomass sources, etc.
  - Primary benefits include reduced fuel costs, reduced pollution and improved energy security
  - However, our energy supply system still followed the patterns of consumption

Historic



- With increased variable, renewable generation, the role of the demand side is changing and cost-effectively achieving a decarbonized energy system, particularly in the electricity sector, requires the consumption of energy to be coordinated with the supply side – i.e., *demand side energy management*
  - Primary benefits are same as efficiency but also focused on *improved grid reliability and resilience while reducing the amount and thus cost for generation, transmission and distribution infrastructure – reducing capacity costs*
  - And, now the demand can follow the patterns of generation via ***Demand Flexibility***

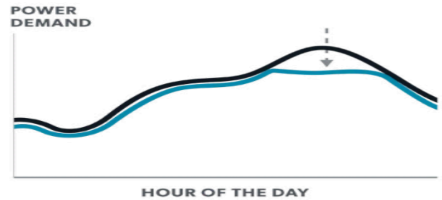
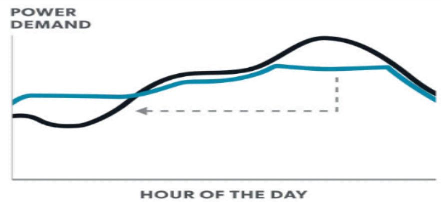
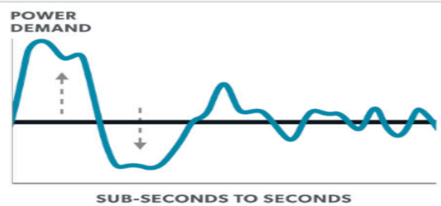
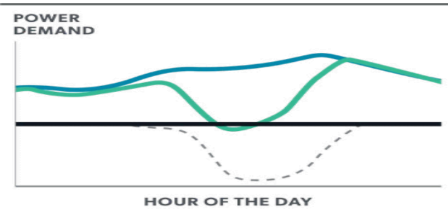
Future



Demand Flexibility	Capability to adjust energy consumption across different timescales

What Is Demand Side Energy Management – Demand Flexibility

Behind the Meter Resources

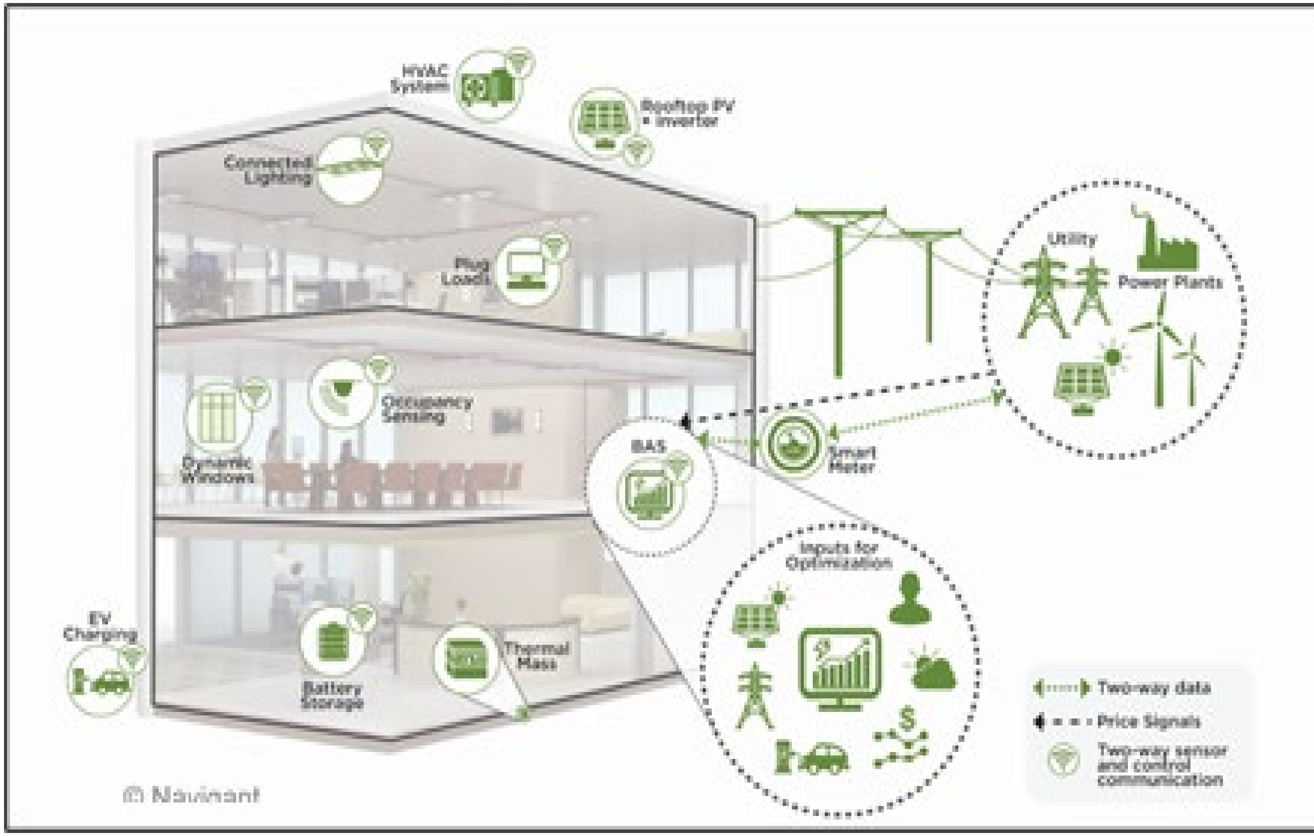
	LOAD IMPACT	EXAMPLE MEASURE	EXAMPLE BENEFIT
Efficiency		Building has an insulated, tight envelope and an efficient HVAC system to reduce heating/cooling energy needs	Reduced costs of burning fuel to satisfy energy demand, and reduced emissions associated with lower fuel use
Shed Load		Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort levels	Reduced investment in generation and transmission capacity due to lower peak demand
Shift Load		Connected water heaters pre-heat water during off-peak periods in response to grid signals	Reduced energy costs due to shifting consumption to cheaper hours of the day; avoided curtailment of renewables during off-peak periods
Modulate		Batteries and inverters autonomously modulate power draw to help maintain grid frequency or control system voltage	Reduced ancillary services costs, improved integration of variable generation resources (e.g., wind, solar)
Generate		Rooftop solar PV exports electricity to the grid	Reduced T&D losses due to on-site consumption; avoided need for grid-scale generation

Source: A National Roadmap for Grid-Interactive Efficient Building, U.S. Department of Energy, May 2021, https://eta-publications.lbl.gov/sites/default/files/a_national_roadmap_for_gebs_-_final_20210517.pdf

Demand Flexibility via Grid-interactive Efficient Buildings (and Industry)

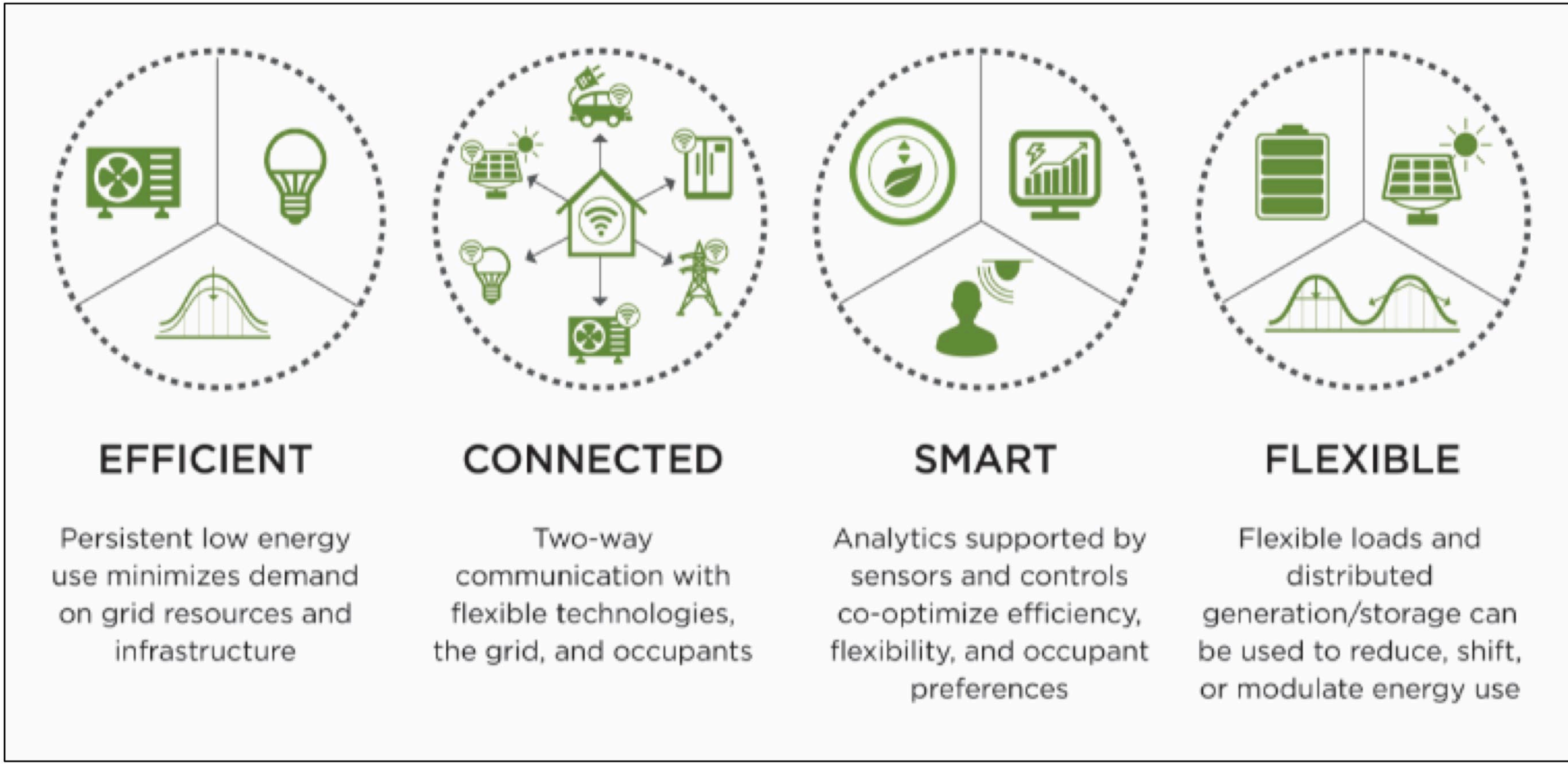
Grid-interactive Efficient Building (GEB)	An energy-efficient building that uses smart technologies and on-site DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences in a continuous and integrated way

- *DER* – A resource sited close to customers that can provide all or some of their immediate power needs and/or can be used by the utility system to either reduce demand or provide supply to satisfy the energy, capacity, or ancillary service needs of the grid
- *Smart technologies for energy management* - **Advanced controls,** sensors and analytics used to manage DERs. **GEBs are characterized by their use of these technologies.**



Source: https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

Characteristics of Demand Flexible Buildings and Facilities



From: A National Roadmap for Grid-Interactive Efficient Building, U.S. Department of Energy, May 2021, https://eta-publications.lbl.gov/sites/default/files/a_national_roadmap_for_gebs_-_final_20210517.pdf

Examples of Demand Flexibility Systems

- Controls: building energy management systems, industrial controls, stand-alone controls (e.g., thermostats) - control the energy use of lighting, refrigeration, motors (e.g., water pumping, ventilation fans), space and heating and cooling systems, water heaters, etc. - *Demand Response*
- Energy storage: batteries, thermal storage, etc.
- Generators: photovoltaic systems
- Managed electric vehicle charging – and vehicle to grid
- Combinations of the above

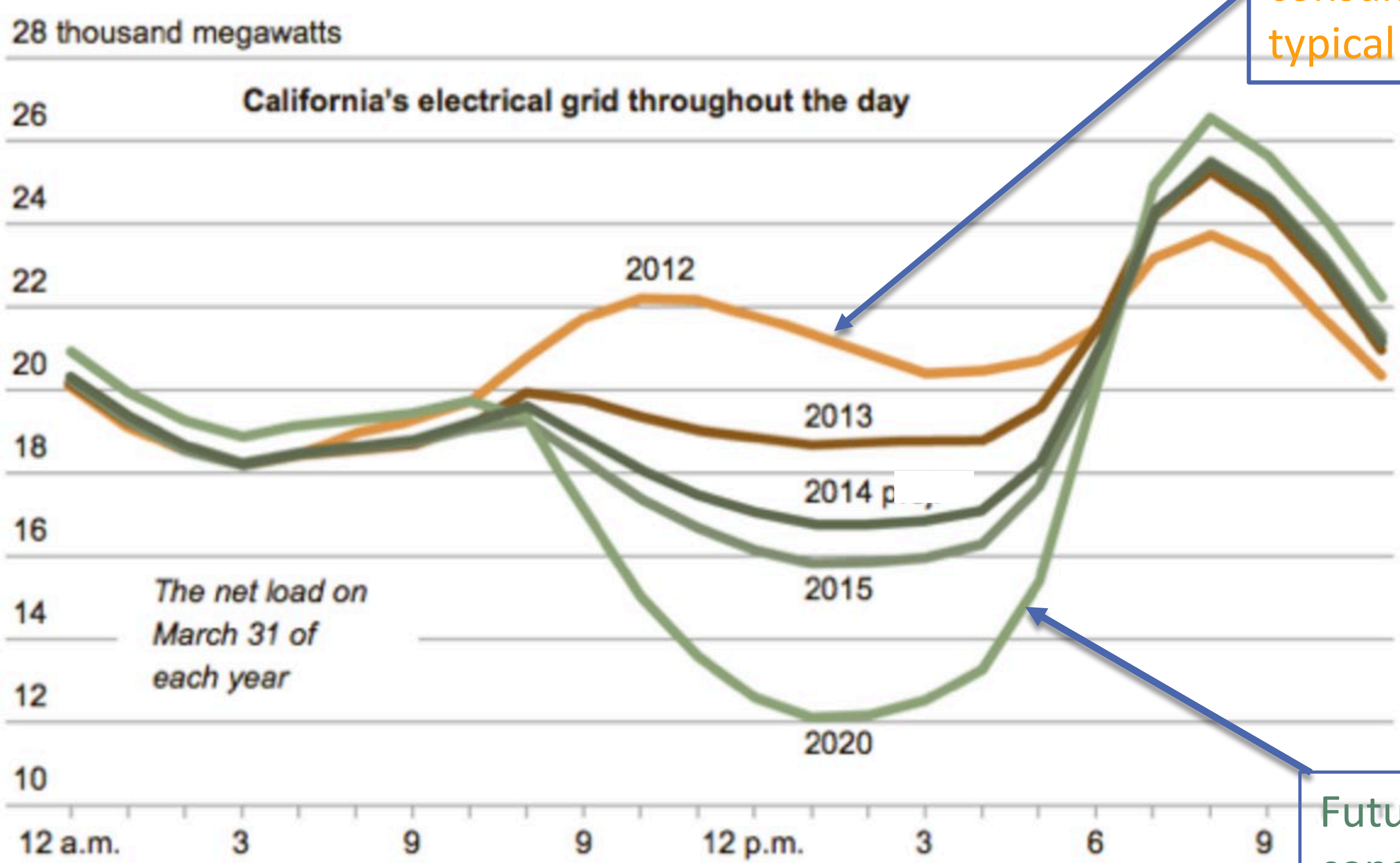
Why Demand Flexibility is Essential for Decarbonization

- Decarbonization efforts on the supply side (e.g., switching from coal to wind) are not enough – it requires coordinated resources on the supply and demand side
  - A challenge of renewable energy is how to integrate these variable resources into the grid
  - Variability causes periods of over and undersupply

- Thus, simply saving energy isn't enough – energy has to be saved **at the right times and right places**
- Demand flexibility focuses on time- and location-sensitive load shedding and shifting - using a diverse set of solutions including efficiency, electrification, demand response, storage and on-site generation.

See Active Efficiency Collaborative: https://activeefficiency.org

Demand Flexibility Supports Renewables Integration – the Duck Curve



Past: net electricity consumption during typical day

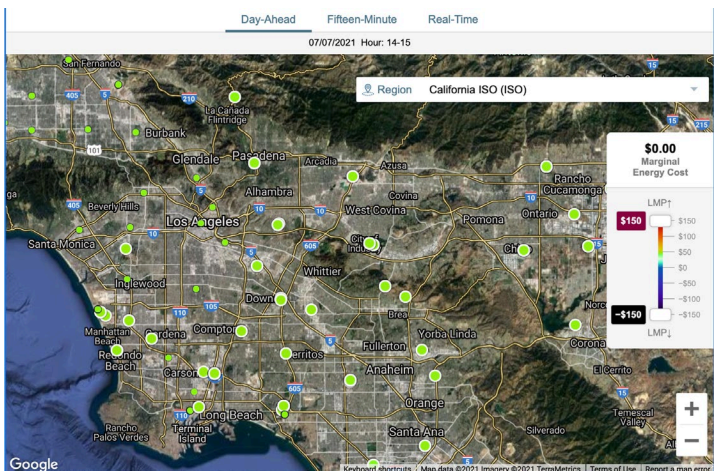
Future: net electricity consumption during times with significant solar generation

In California, 191 GWh of renewables were curtailed in April 2019

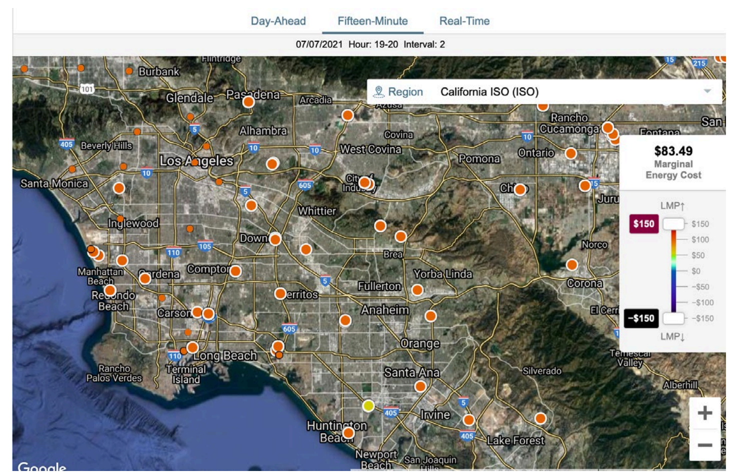
The Time and Location of Efficiency Impacts Matter

Green Dots ~50 USD/MWh   Red Dots ~ 100 USD/MWh

July 7th - from 2-3pm



July 7th - from 7-8pm



California Independent System Operator – Los Angeles, California Area

Summary of Demand Flexibility Benefits

- **Helps meet multiple economy-wide policy goals:**
  - **Supports decarbonization**
  - Other energy-related goals, e.g., resilience for critical infrastructure
- **Reduces stress on grid by addressing:**
  - Growth in peak demand
  - Infrastructure constraints for T&D
  - Impact of variable renewable generation
  - **Electrification of space and water heating, industrial processes and transportation**
- **For consumers** —improves building performance, increases asset value, and provide more control over energy use and costs
- **For society** — jobs, energy security, and environmental and public health benefits

Benefit	Utility System	Building Owners/Occupants
Reduced utility operation & maintenance costs	✓	-
Reduced generation capacity costs	✓	-
Reduced energy generation costs	✓	-
Reduced T&D costs	✓	-
Reduced T&D losses	✓	-
Reduced ancillary services costs	✓	-
Reduced environmental compliance costs	✓	-
Increased resilience	✓	✓
Increased DER integration	✓	✓
Improved power quality	-	✓
Reduced owner/occupant utility bills	-	✓
Increased owner/occupant satisfaction	-	✓
Increased owner/occupant flexibility and choice	-	✓

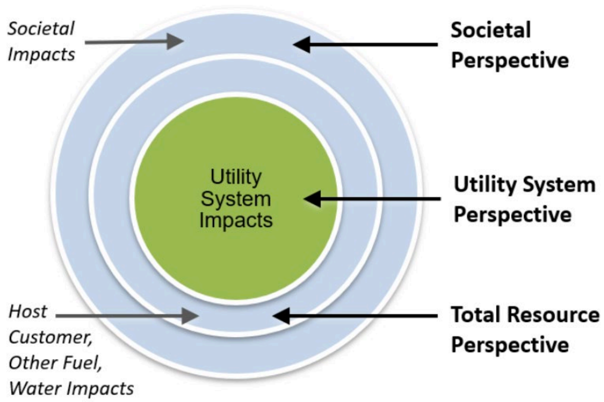
Source: State and Local Energy Efficiency Action Network. (2020). *Grid-Interactive Efficient Buildings: An Introduction for State and Local Governments.* https://eta-publications.lbl.gov/sites/default/files/bto-see-action-gebs-intro-20200415.pdf

Assessing Potential & Assessing Performance

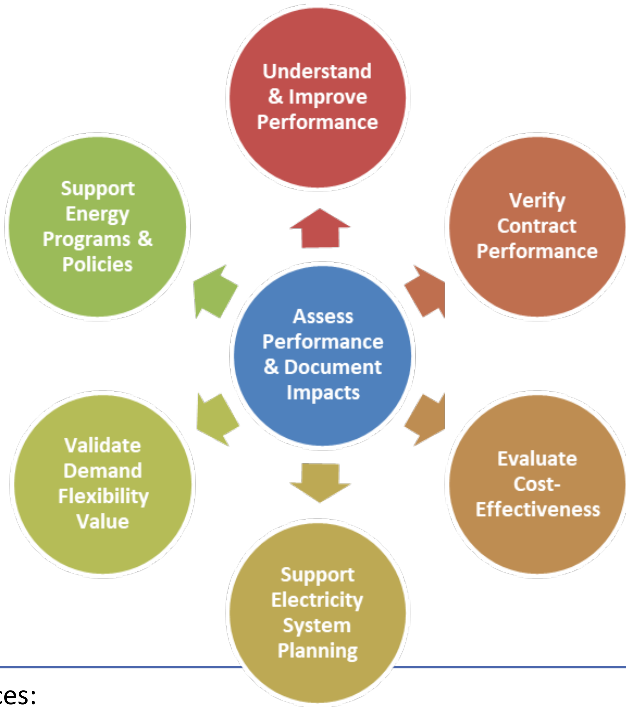
Potential Assessment

Comparing benefits and costs of alternative resource options to determine whether the benefits exceed the costs over the lifetime of the program or project. Options:

- Modeling:
  - Integrated Resource Planning
  - Benefit Cost Analyses
- Competitive bidding processes/auctions to compare with other resource options



Measurement and Verification



Resources:

- *Performance Assessments of Demand Flexibility from Grid-Interactive Efficient Buildings: Issues and Considerations.* https://emp.lbl.gov/publications/performance-assessments-demand
- *National Standard Practice Manual For Benefit-Cost Analysis of Distributed Energy Resources* *https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/*

The Potential and the Barriers

Potential – U.S. Economy Example

By 2030, according to one estimate, the United States will have nearly 200 gigawatts (GW) of cost-effective load flexibility potential, equal to 20% of estimated U.S. peak load - with savings for consumers from avoiding utility system costs estimated at $15 billion annually.

Hledik, R., A. Faruqui, T. Lee, and J. Higham. 2019. The Brattle Group. "The National Potential for Load Flexibility: Value and Market Potential Through 2030." https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf.

Barriers

- Front-end investment requirements
- Principal agent problem (property owner/tenant)
- Lack of information and understanding of benefits (and risks)
- Transaction costs
- Lack of knowledgeable contractors, suppliers, etc.
- Uncertainty in documenting benefits
- Lack of mechanisms for incenting consumers

Actions APEC Economies Can Take to Advance Demand Flexibility

- **Gather Information and Identify Opportunities**
  - Catalog opportunities
  - Prepare integrated resource plans with demand side options
  - Assess cost-effectiveness with full assessment of costs and benefits
  - Establish metrics and set goals
- **Early actions**
  - Work with regulators, utilities and grid operators to establish value (e.g., $/kWh) for demand management services provided by buildings and industry
  - Provide consumer education and workforce education and training
  - Lead by example - pilot projects/demonstrations – share results
  - Establish data collection and measurement verification standards
  - Improve utility metering infrastructure– improve access to real time data
  - Address data access, interoperability, cyber security and privacy through standards
- **Establish demand management programs for buildings and industrial facilities**
  - Time of use interruptible service energy tariffs
  - Financial incentives for energy users – utility and third-party aggregator programs
  - Low income consumer programs to support most-vulnerable and address equity
  - Establish building energy codes and appliance standards – demand flexibility ready buildings and equipment

Conclusion

The road to a decarbonized energy infrastructure requires demand side energy management, including demand flexibility, resources.

These resources can be plentiful and low-cost solutions, but to reach the scale needed to have widespread impact, it must be treated as a true resource and allowed equal access to markets like other energy resources.

Thank You

Contact

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