U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

What is the Value of Grid-interactive Efficient Buildings?

DOE Building Technologies Office 2018 Peer Review

May 1, 2018

Outline

- **Introduction**
  - David Nemtzow, Building Technologies Office
- **Presentations**
  - DER Valuation and Roles for GEB
    - Samir Succar, ICF
  - Valuing Grid-Interactive Efficient Buildings
    - Jan Brinch, NECP
  - GridOptimal Initiative
    - Eric Makela, New Buildings Institute
  - Time-Varying Value of Efficiency
    - Natalie Mims, LBNL
- **Panel Discussion**

DER VALUATION & ROLES FOR GEB

BTO Peer Review

May 1, 2018 – Arlington, VA

Samir Succar, Principal

ICF: WE MAKE BIG THINGS POSSIBLE

Energy

Health

5,000+
EMPLOYEES

Environment

Transportation

1 BILLION+
IN REVENUES

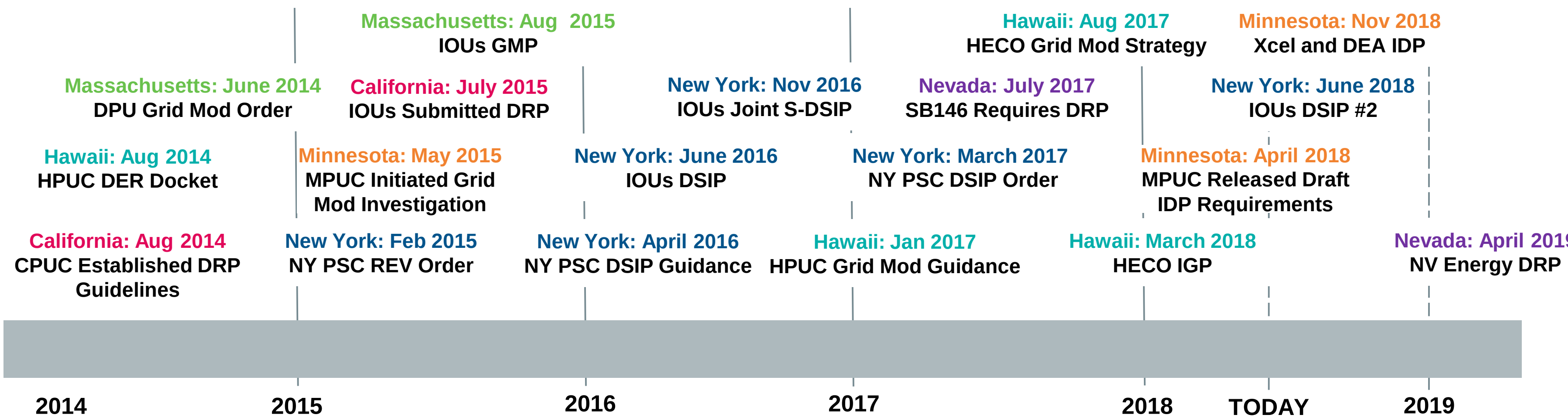
Global presence with more than 65 offices, headquartered in the Washington, DC area

AMERICA'S BEST MANAGEMENT CONSULTING FIRMS 2016
– Forbes

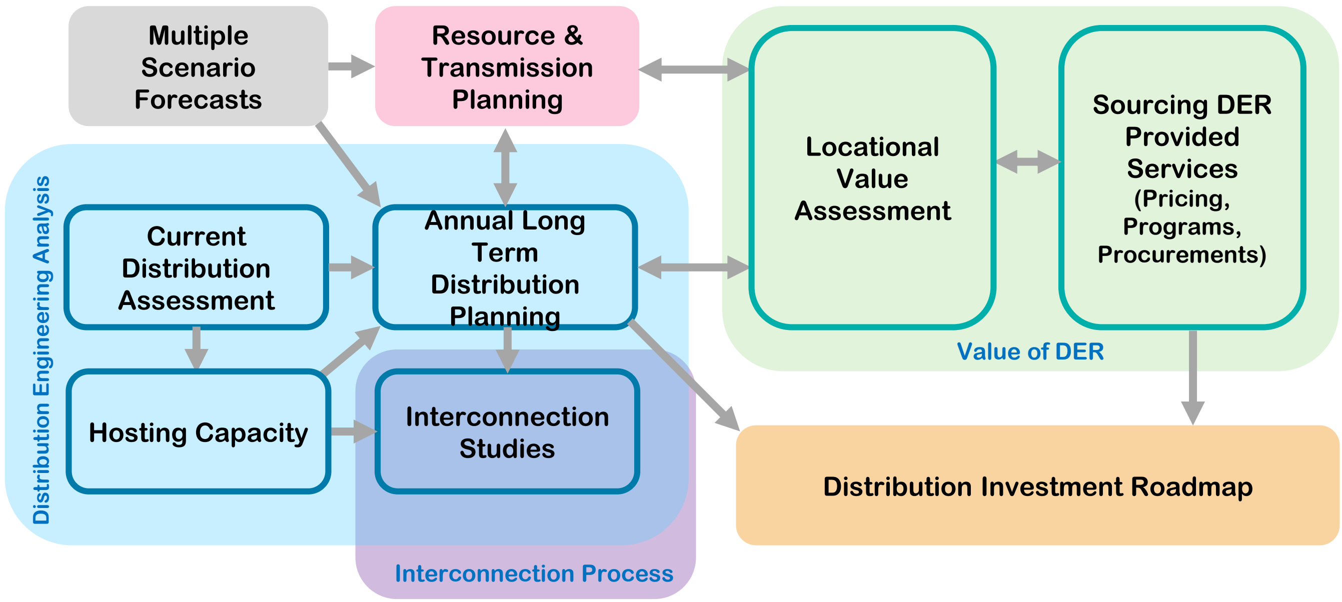
ICF: ENERGY PRACTICE

- **MULTISECTOR AND MULTIDISCIPLINARY**
  - Our depth and breadth fosters innovative, comprehensive, and integrated solutions for our clients
  - Transmission & Distribution Planning and IRP
- **LEADING EDGE ANALYTICS**
  - Foundational modeling and analytical capabilities that inform strategic decisions on customer engagement, generation and grid investments and DER valuation and sourcing
- **DELIVERY OF OVER 150 DSM PROGRAMS**
  - Expertise in the design, optimization and delivery of residential and C&I programs for 45 U.S. utilities
- **COMPREHENSIVE EXPERIENCE FOR COMPLEX "FUTURE UTILITY" ISSUES**
  - Insights from leading utility engagements in NY, CA, MN, AZ, MA, HI, Canada & Australia

Utility Planning is Evolving



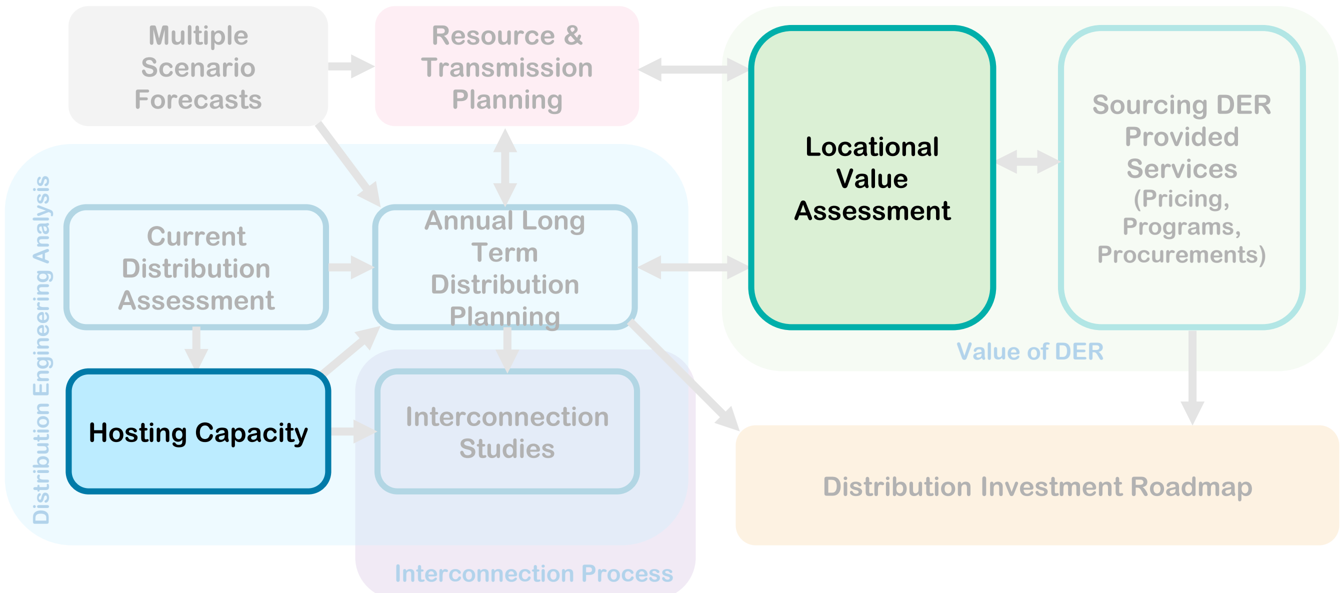
Integrated Distribution Planning



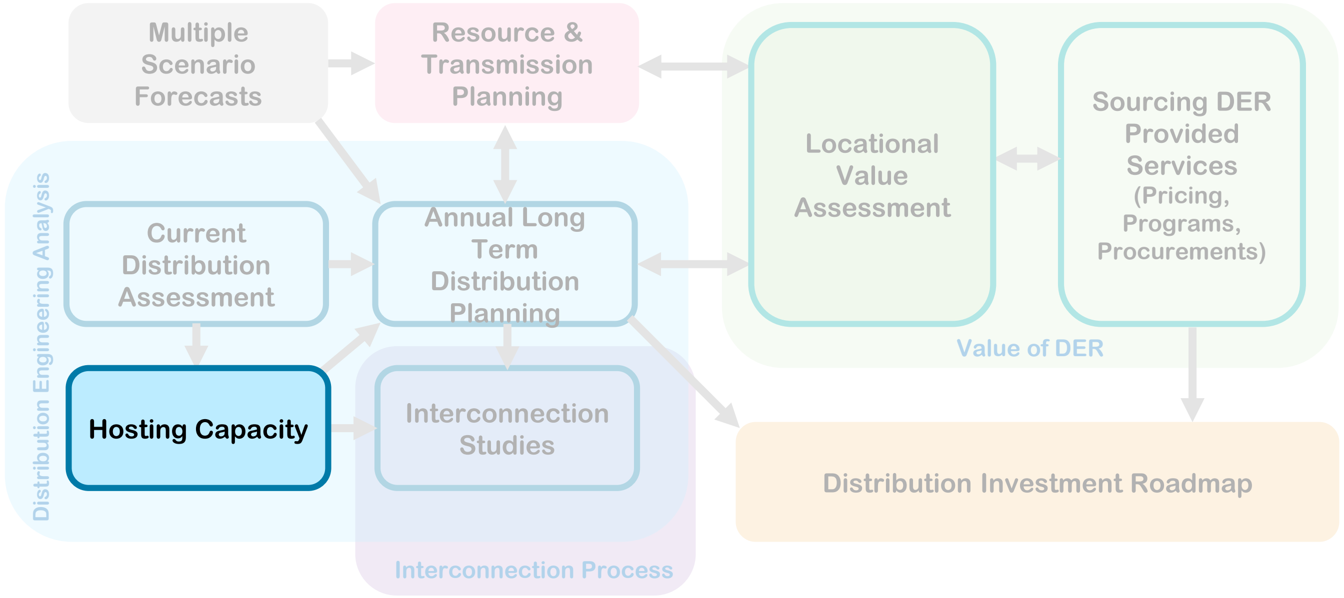
INTEGRATION

VALUATION

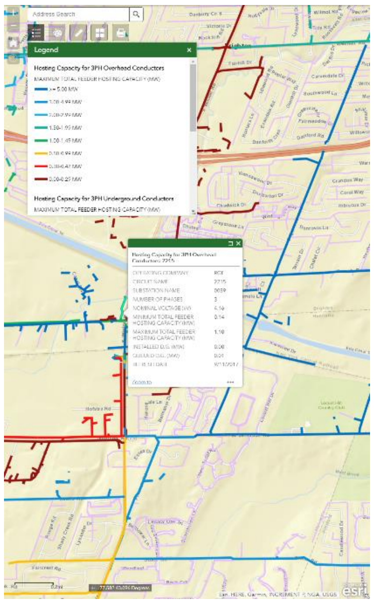
Focus: Hosting Capacity, Locational Value



Hosting Capacity: What & Why



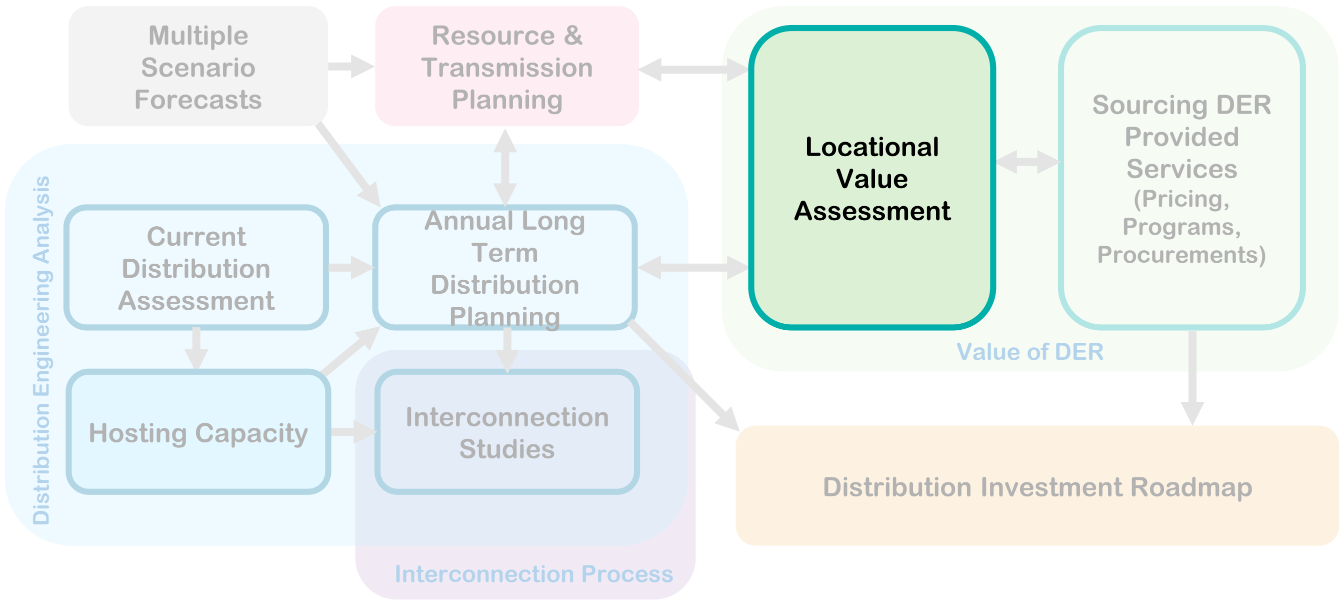
HOSTING CAPACITY: USE CASES



Source: NYSEG&RGE

Identify Lower Cost Areas	DER Deployme	DER Developm
Improve interconnectio n studies	Timely, robust screening	Enhanced Application Process
Proactive Identification of Upgrades	Reduce future barriers	Advancing Planning Analytics
Dynamic Hosting	Allow Aggregatio n Dispatch	Provision of DER

Locational Value: Components, Use Cases



Value Components

Choosing Value Components to Reflect Objectives, Priorities

VALUE CATEGORY	POSSIBLE BENEFITS, AVOIDED COSTS
Distribution	Distribution Capacity
	Distribution O&M
	Increased Hosting Capacity
	Voltage/Power Quality
	Reliability
	Resiliency
	Reduced Distribution Losses
Transmission	Transmission Capacity
	Reduced Transmission Losses
Generation	Resource Adequacy
	Renewable Integration (Flexibility)
	Energy
	Ancillary Services
Environmental / Society	GHG
	RPS Compliance
	Environmental Justice
	Criteria Air Pollutants
	Public Safety

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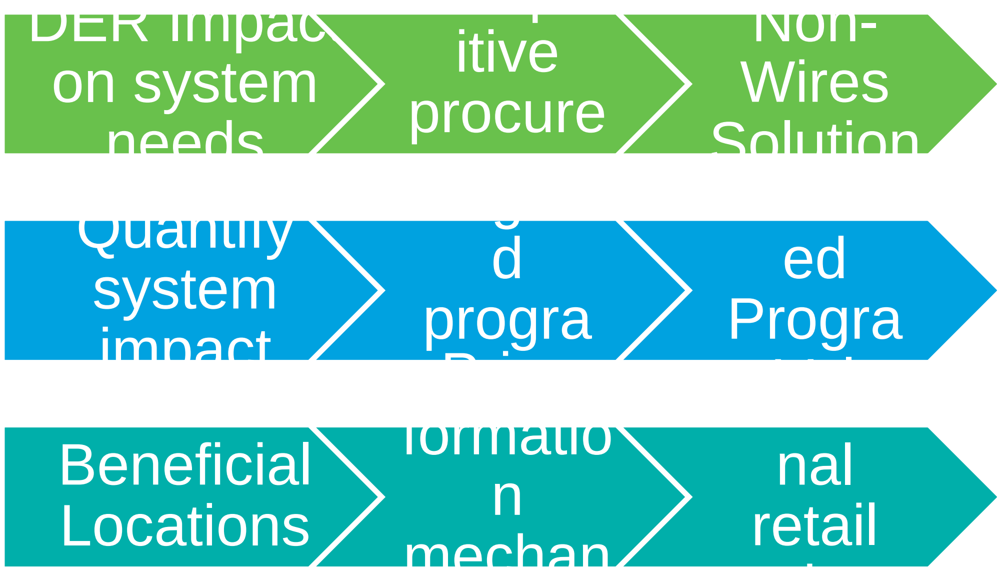
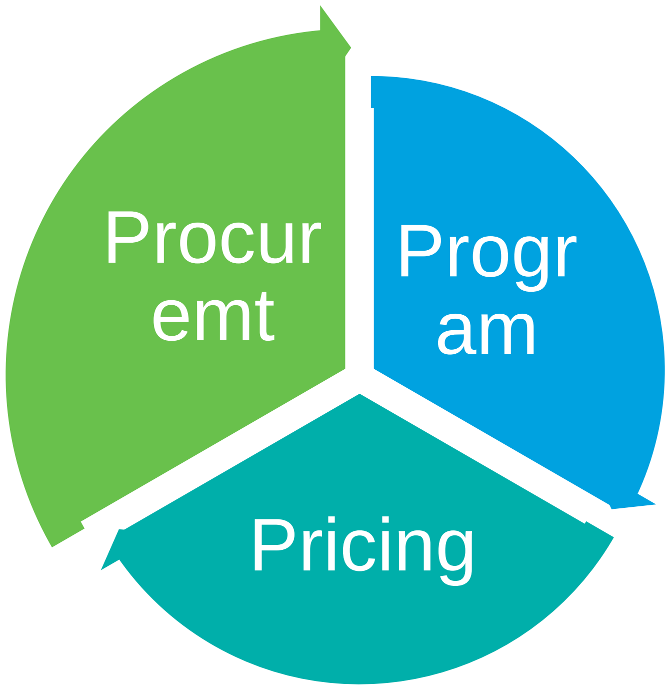
Locational Value Analysis: Use Cases

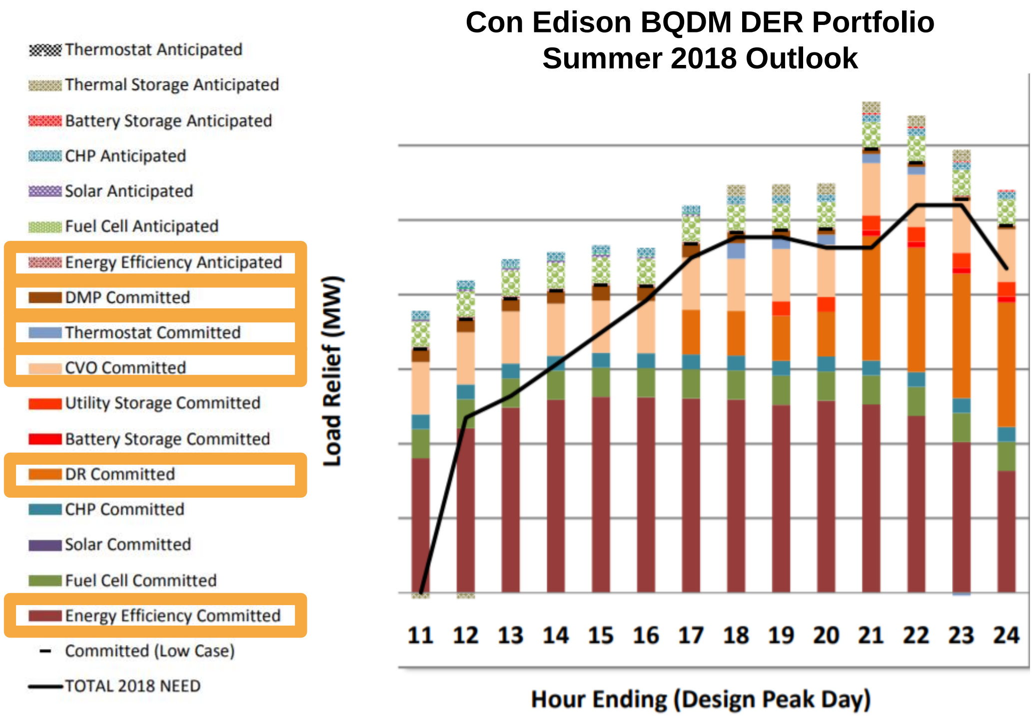




BQDM: Central Role of Efficiency and DR

- **Goal:** $1.2 B Substation Deferral with DER portfolio

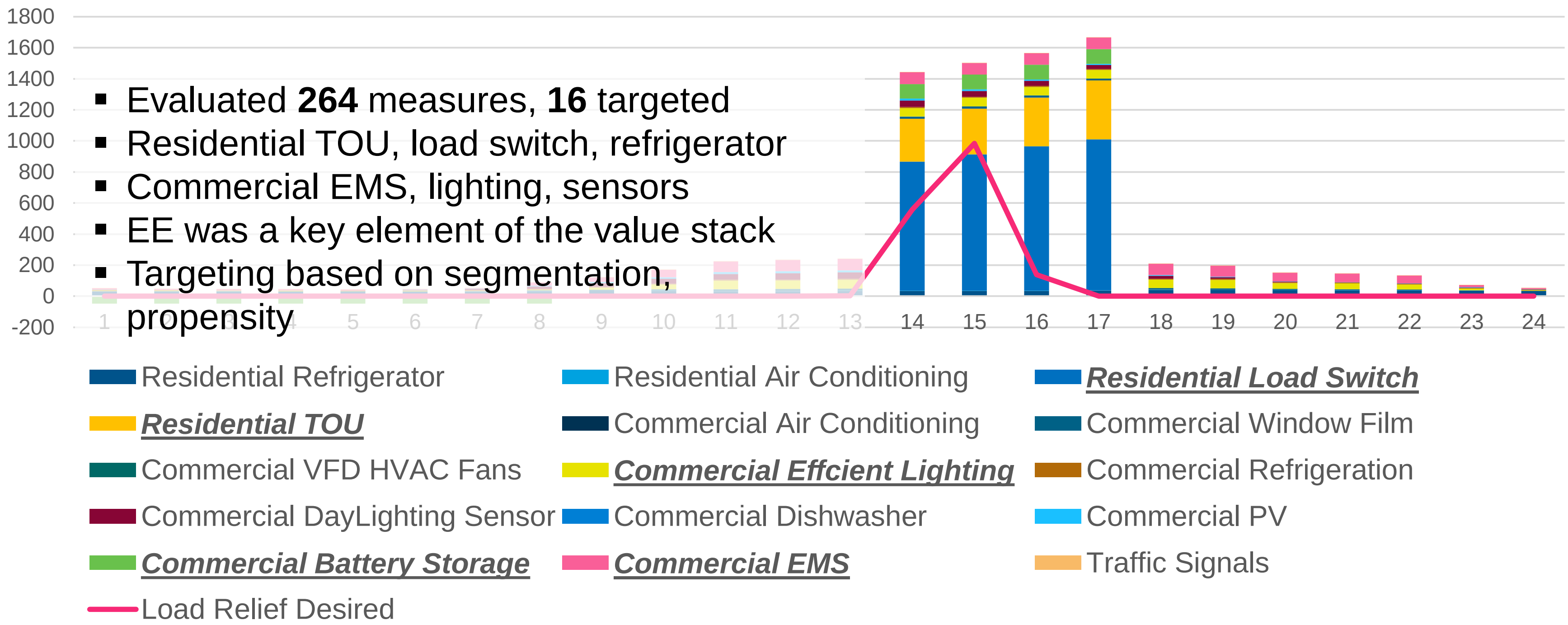
	2016	2017	2018	Total
Customer Side Solutions	9 MW	23 MW	9 MW	41 MW
Utility Side Solutions	3 MW	8 MW	-	11 MW
Total	**12 MW**	**31 MW**	**9 MW**	**52 MW**



Source: Con Edison, Brooklyn-Queens Demand Management , Targeted Demand Management (April, 2017)

Schwartz Creek: DER Demand Reduction

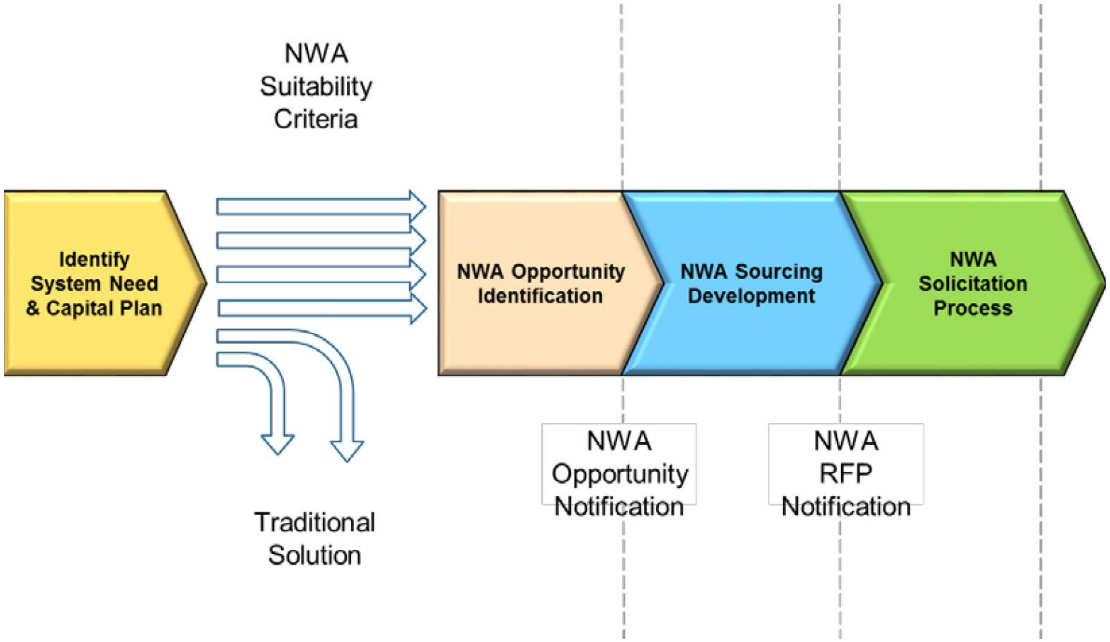
- Evaluated **264** measures, **16** targeted
- Residential TOU, load switch, refrigerator
- Commercial EMS, lighting, sensors
- EE was a key element of the value stack
- Targeting based on segmentation, propensity

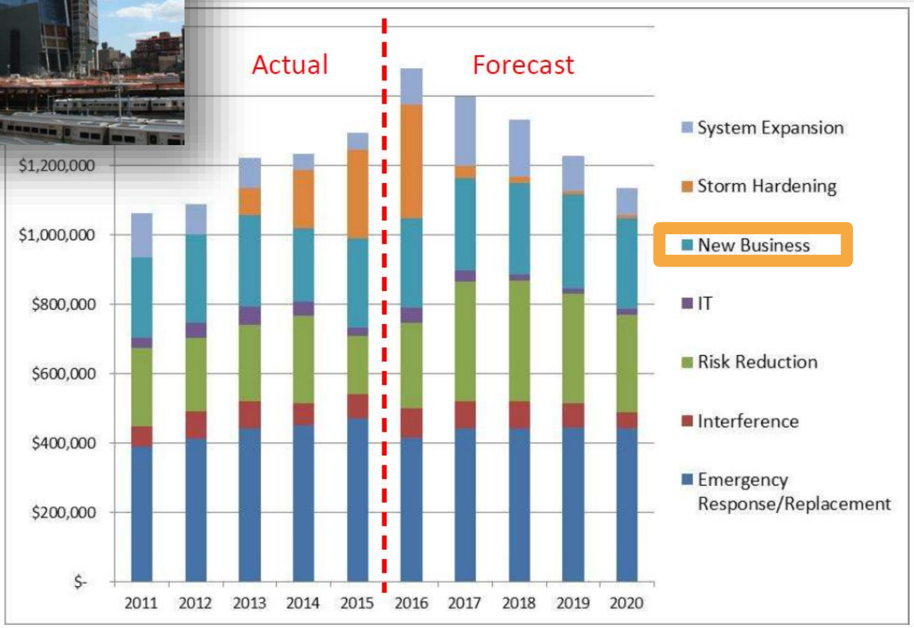


T&D Deferral

New Business

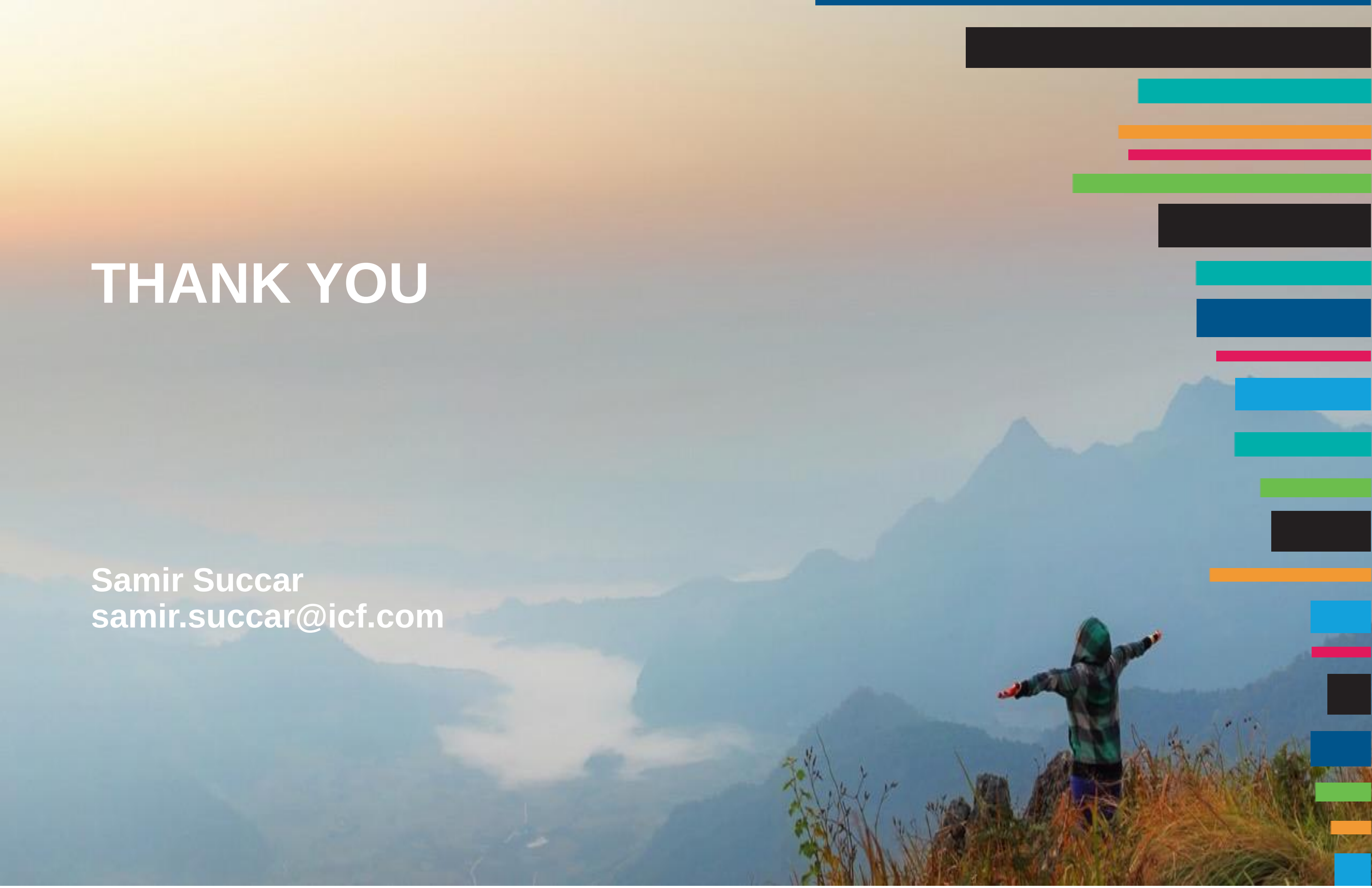
T&D Deferral


NWA
Suitability
Criteria
Identify
System Need
& Capital Plan
NWA Opportunity
Identification
NWA Sourcing
Development
NWA
Solicitation
Process
Traditional
Solution
NWA
Opportunity
Notification
NWA
RFP
Notification



Distribution Capital Expenditures, Con Edison 2016

New Business



THANK YOU

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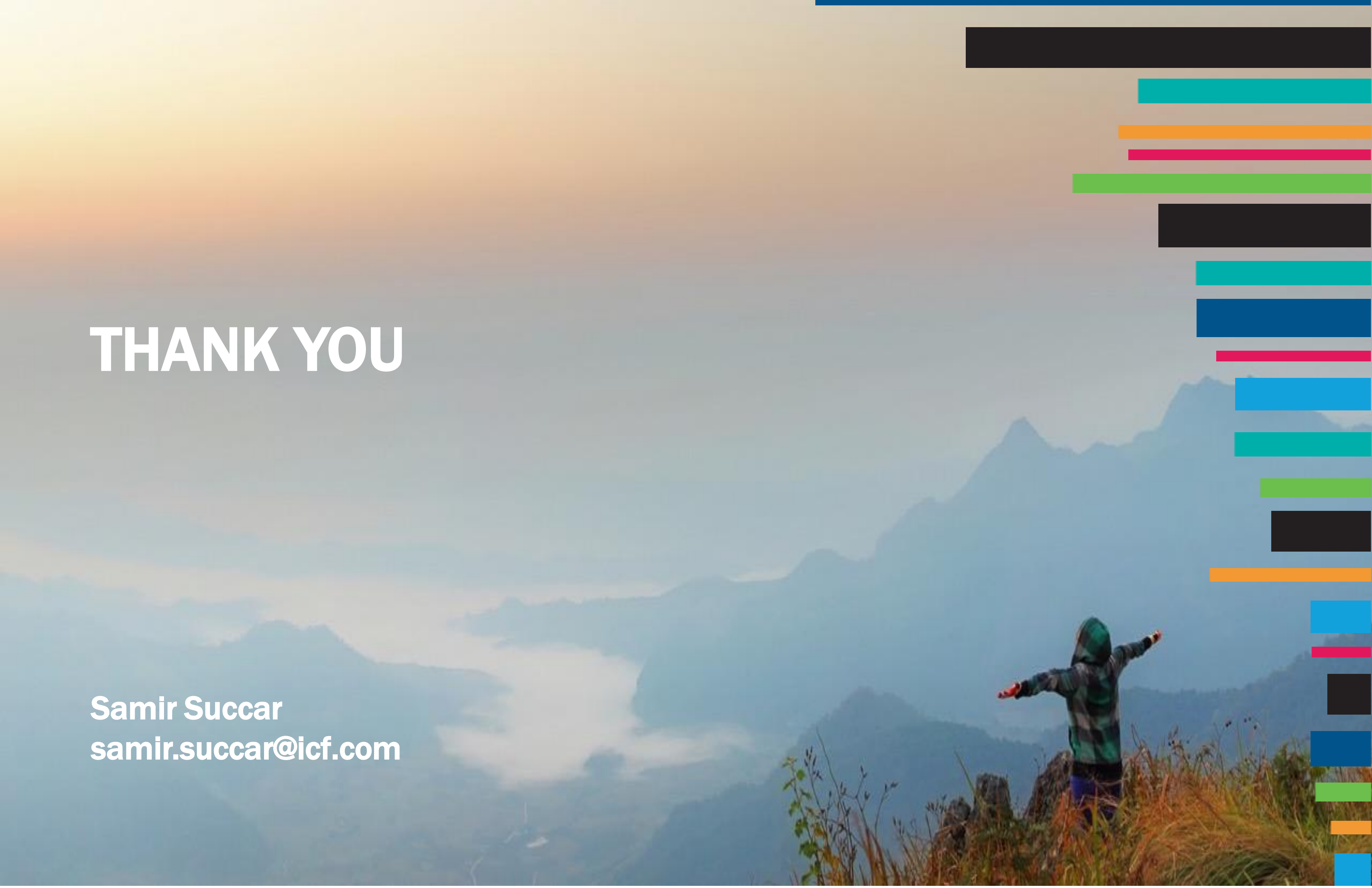

THANK YOU

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Valuing Grid Interactive Efficient Buildings

Jeannette Brinch
National Council on Electricity Policy
May 1, 2018

National Council on Electricity Policy (NCEP)

- The only national stakeholder organization that supports all state-level decision makers involved in electricity policymaking
  - Public utility commissions
  - Air and environmental regulatory agencies
  - Governor's advisers and state energy offices
  - State legislatures
  - Consumer advocate offices
- Affiliate of the National Association of Regulatory Utility Commissioners (NARUC)s Center for Partnerships and Innovation (CPI)

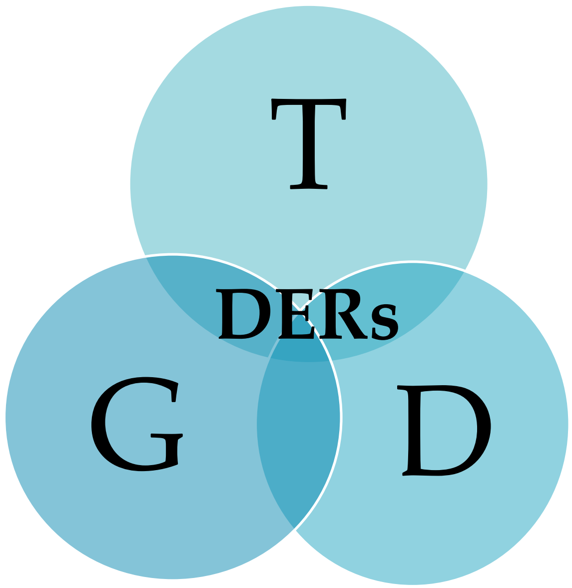
What NCEP Does

- Facilitates training and education programs, conferences, seminars, webinars, and podcasts
  - 2018 Focus:
    - Transmission planning that incorporates non-wires solutions
    - Distribution-level grid services that also support the bulk power system
    - The value of the grid – who pays, how much, and how services are measured
    - Reliability and resiliency for the bulk power and distribution systems
    - Understanding customer needs and expectations
    - Visit www.electricitypolicy.org to download podcast series for state legislators

Six overarching themes when regulators evaluate new technologies for grid enhanced buildings

What are the fixed costs? **What are the variable costs?**	**How are costs, benefits and values identified and determined?**	**How can adoption rates be used to better plan for and meet the grid revolution?**
How does a utility recover its approved revenue requirement?	**How are costs allocated and to whom?**	How can technology be used to plan, integrate, and monitor the changing nature of the grid?

Planning and Investment Decisions Could Optimize Supply and Demand



Transmission needs might be reduced with less reliance on central station power and increased DER

With customer growth of DER, **energy resource generation / acquisition** planning needs to account for quantity, location, and load shapes of resources added to distribution system

Distribution system investment decisions considering non-wires alternatives (NWAs) where cost-effective and applicable (load relief, reliability) could better meet customer needs and state policy priorities, which will impact supply needs

With greater alignment of resource and grid (T&D) planning, states & utilities could:

- Ensure future reliability and efficient use of resources
- Maximize customer and system benefits (e.g., affordability)
- Support state policy priorities
- Increase transparency of decisions and investments

What is rate design?

Rate design is the process of translating the revenue requirement of a utility into the prices paid by customers, often said to be more art than science.

Rates are set to be "just and reasonable" for customers across the utility's service territory.

How much do GEBs matter to state regulators?

- Legislative and regulatory policy-making that supports energy efficiency, renewables, demand responsive rates, and other actions that effect GEBs
- Distributed energy resources (DERs) provide services that support ratemaking strategies
- Regulators integrate services into cost of service calculations

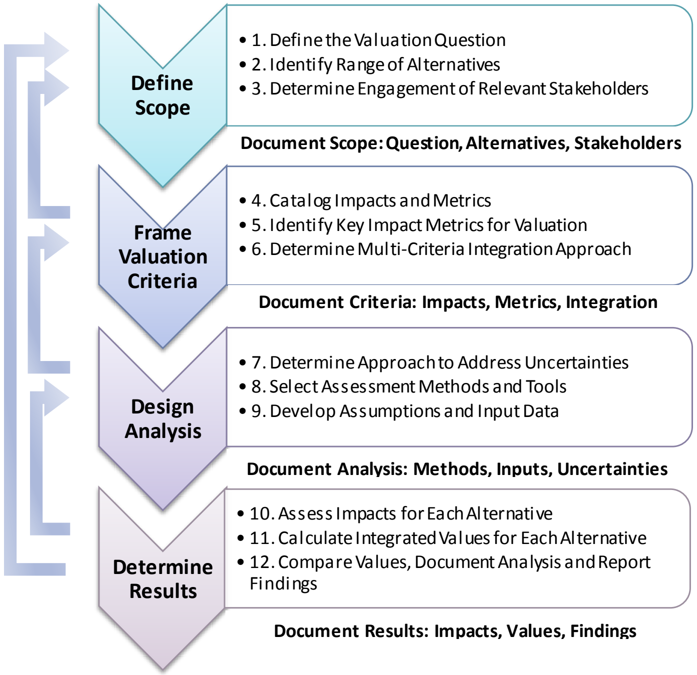
Metrics Applied to GEBs That Provide Value to the Grid

- Cost to owner
- Cost to utility
- Value stream on the bulk power system
- Value stream to the owner
- Reliability (short outages)
- Resilience on the bulk power system
- Impact on emissions
- Equity/cost distribution
- Cost minimization
- Innovation impacts

GMLC Valuation Framework

Development of a framework that enables electricity-sector stakeholders to conduct, interpret, and compare valuation studies with high levels of **consistency, transparency, repeatability, and extensibility**. The effort is grounded in a **long-term vision of "Generally Accepted Valuation Principles"** as a paradigm for valuation as a mature, sophisticated process.

Steps in Valuation Framework (Preliminary)



Expected Outcomes

The framework will be ***guidance—not another model***—creating a systematic decision process by which studies can be interpreted and conducted with key assumptions made transparent.

An industry-vetted, demonstrated, and operationalized process with practical products supporting improved power-sector decision making incorporating **value beyond monetary savings and costs** to build a more affordable, sustainable, flexible, reliable, resilient, and secure grid.

Turning ideas into reality

Stakeholder Advisory Group (SAG)

Engaged Stakeholder Advisory Group of key decision-makers including commissioners, legislators, utilities, regional transmission operators, NGOs, vendors, consumer advocates, and consultants

- Reviewing valuation framework as it is developed
- Providing real world usage implications
- Reviewed Table Top exercise on use of valuation methodologies to determine impacts resulting from closure of existing nuclear plants in three states
- SAG volunteers to represent stakeholders as the Valuation Framework is applied to a microgrid test case

Summary

- **The challenge of applying electricity generated by GEBs to utility regulation is two-fold:**
  - **Major valuation questions of what the benefits are and what they are worth**
    - Some are directly economic but others stray into (more difficult to monetize) reliability and resilience spaces
    - Creates challenges for existing regulatory models to understand the appropriate "just and reasonable" rate structure for something that is changing distribution system operational needs while also (theoretically) resulting in benefits to consumers and society.
  - **GEBs are in some ways an interface to/integrator of many of the other DER "hot topics**", i.e. solar, storage, EVs, and transactive markets. In aggregate, buildings are/will be a platform for the other challenges we face on the transmission and distribution system

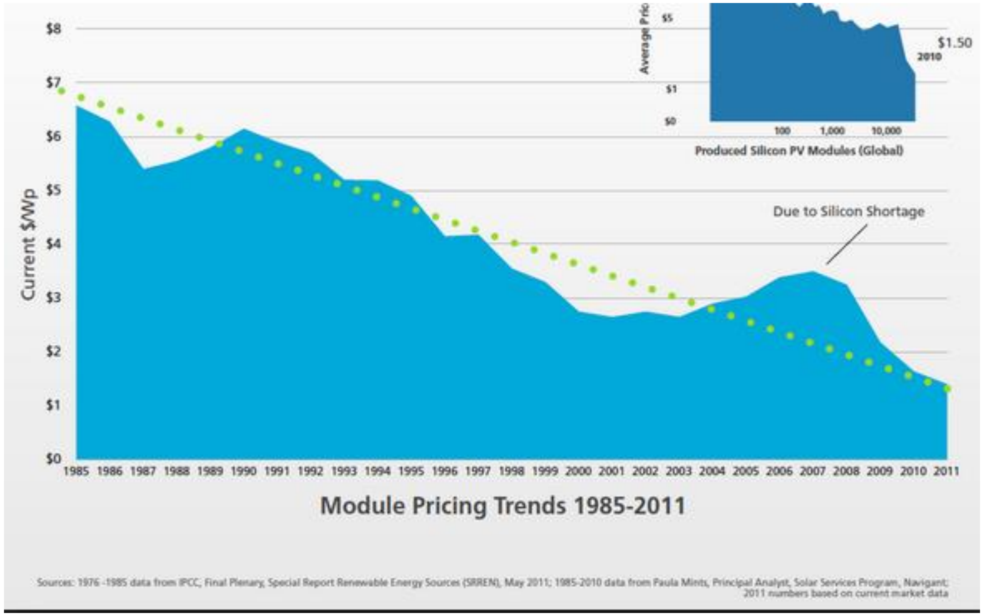
Broader challenges of distribution regulation come into play with respect to load defection, cost recovery, the role and purpose of distribution utilities in the future, etc.

The GridOptimal™ Initiative

A New Rating System and Metric For Building-Grid Interactions

New Buildings Institute
U.S. Green Building Council

PV Cost Trend Increases Solar Deployment



Load imbalance means Utilities sometimes have to pay consumers to use energy

NP Newswire Post.

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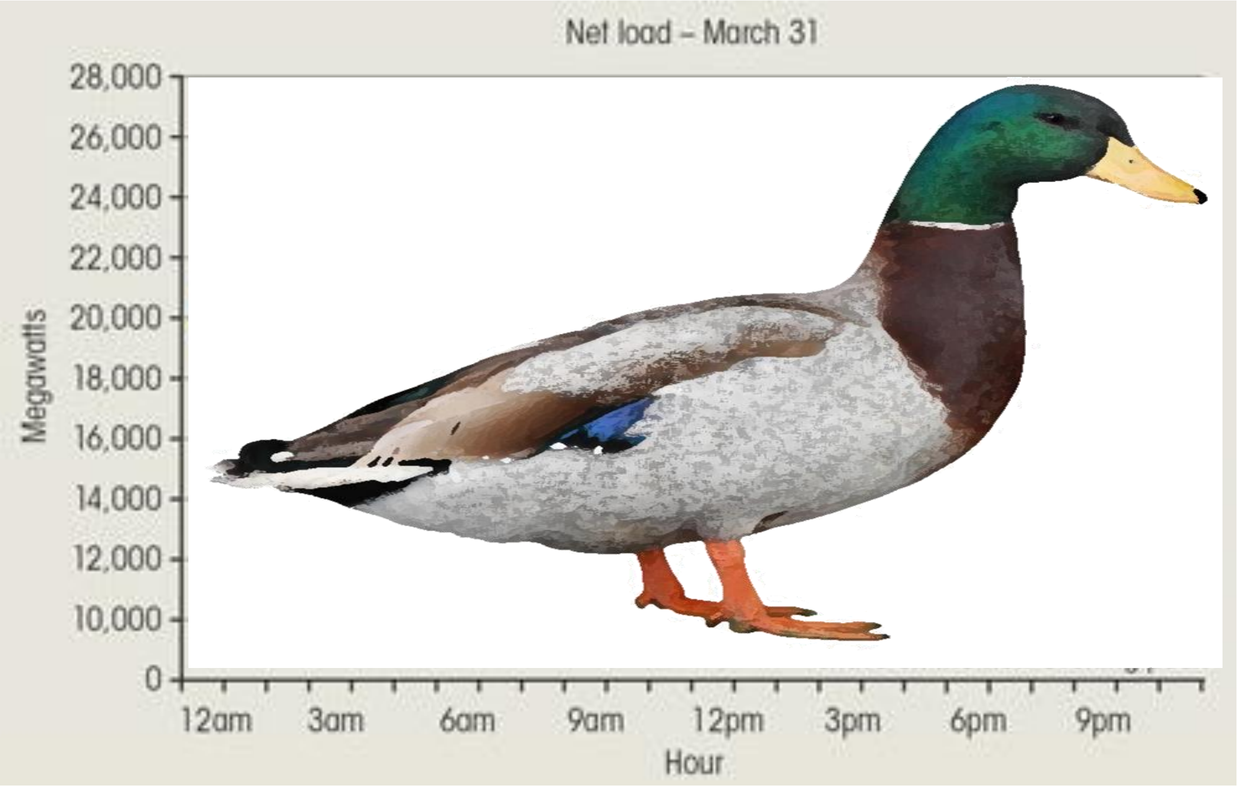
Negative Electricity Rates from Wind-Power Surplus

It's been very windy across Europe this week. So much so, in fact, that the high wind load on onshore and offshore wind turbines across much of the continent has helped set new wind power records.

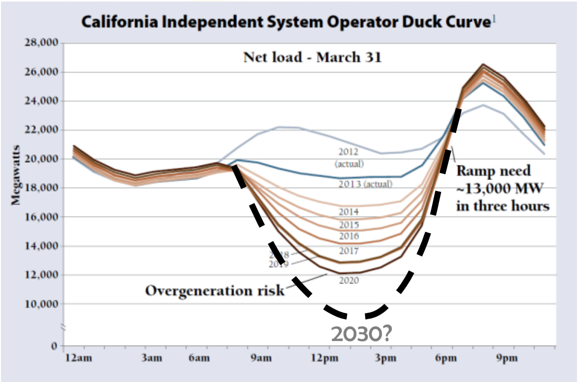
The Ominous "Duck Curve"



Change is Coming

What's Next for Buildings and the Grid?

- What is the role of buildings, renewable energy, and storage in the **utility of the future**?
- We are seeking **solutions to today's challenges** and opportunities for **market transformation.**
- We are assembling top experts to help **answer these questions.**



Source: Jim Lazar, 2016

GridOptimal: Why is it Needed?

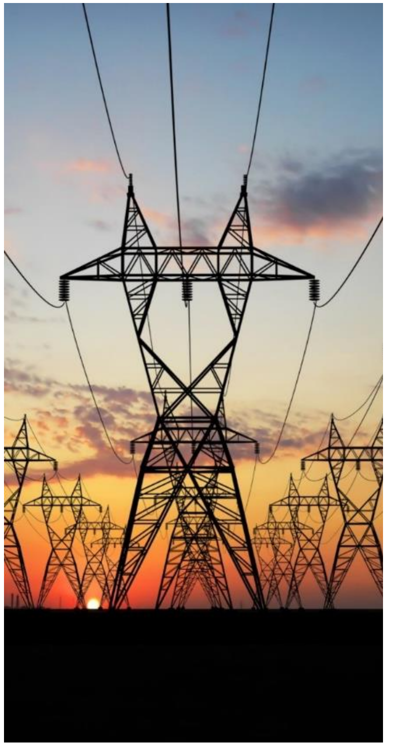
There are currently no metrics that define building-level grid citizenship, or rate building-grid interaction quality

- Different players have **different language** to discuss the topic
- New technology has introduced new **opportunities and challenges** for building owners and grid operators alike
- Need to catalyze **harmonization** of building design with grid interaction

GridOptimal: Why is it Needed?

The GridOptimal Rating System includes a New Quantitative Metric for Building-Grid Interactions

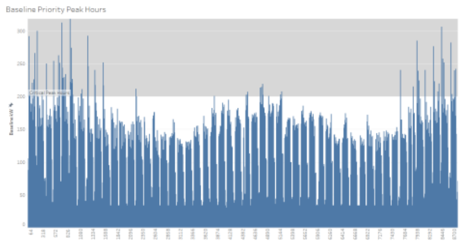
- Defines a building's **"grid citizenship"**
- Credit for **Building Technologies & Strategies**
  - Passive features
  - Dispatchable / Responsive features
- Improves **integration of DERs** onto the grid
- Ensures continued **affordability, safety, reliability, & resilience** for buildings and the grid



The GridOptimal Score:
Rating Building-Grid Interactions

Start with: min. 1 year of Load Profile Data

- 8,760 hrs Net Power Balance (kW Demand and kW Production) for **Rated Building & Baseline Building**



End with: Simple, easy-to-understand key number(s)

- GridOptimal Score integrates **an asset and an operational rating** based on building-grid interactions and capabilities

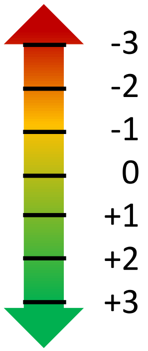


Image: Resnet

Opportunities for Building Integration with Grid

Permanent Efficiency
- Reduce building energy loads…

Peak Shifting
- Design to modify time of peak building energy use to adapt to grid…

Dynamic Response
- Actively reduce building energy use in response to short-term grid constraints…

Dispatchable Energy Storage
- Actively manage energy use patterns based on grid signals…

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Conventional passive features, carefully deployed, support grid management and resiliency goals

Thermal Mass

Daylighting

Passive Solar Gain

Natural Ventilation

Solar Shading

Natural Ventilation

Super-Insulation

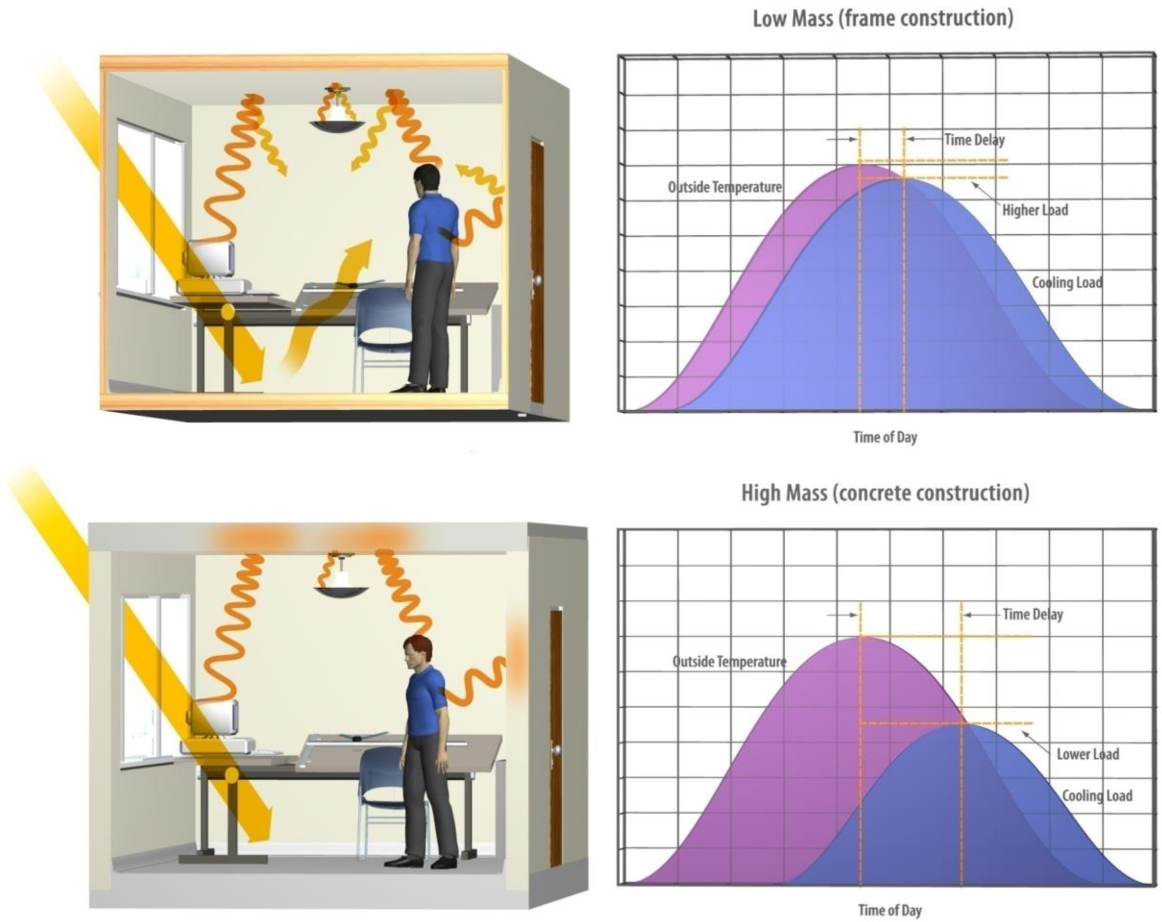
2,600 ft2 home in St. Peter, Minnesota, designed by Sarah Nettleton Architects. Photo Don Wong

New grid-integrated technologies and active systems becoming more common to support grid operation

- Direct Demand Response Capabilities
- Thermal Storage
- Dynamic Glazing
- Grid-Integrated Appliances
- On-Site Storage
- Renewable Generation
- Integrated Vehicle Charging
- Staged Workstations

Fossil Ridge High School, Fort Collings
Thermal Ice Storage System

Night Ventilation with Thermal Mass



Indirect Evaporative Hybrid

With support from:

Northwest Energy Efficiency Alliance
www.nwalliance.org

Matrix of Building and Operational Features that Support Grid Integration Goals

Grid Integration Goals		Building Features											
		Design							Operation				
Maintaining grid operation requires carefully balanced loads and generating resources. The ability to shift or modify loads makes it easier to maintain balanced operation. **Buildings with design and operating features that can interact directly with the grid allow for more dependable and efficient grid operation**		**Energy Efficiency Features**	**Passive Building Operation Capabilities**	**Actively Managed Thermal Mass**	**Thermal/Energy design performance parameters**	**On-site Grid Connected Energy Storage**	**On-site Cogeneration**	**On-site Renewable Generation**	**Scheduled Vehicle Charging**	**Staged Shutdown (Demand Response)**	**Emergency Staging (soft-start after outage)**	**Time of Peak Power Consumption Adjustable**	**Equipment for Isolated Operation**
Goal	**Description**												
Avoid peak	Reduce energy use during grid-peak periods. Operate building for more even and predictable energy use.	x	x	x	x	x	x	x	x	x	x	x	x
Support Valley	Shift building loads to coincide with grid-surplus periods.		x	x	x	x	x		x			x	
Load Balance	Building power consumption is smoothed by PV/storage combination to reduce 'peakiness' and potential impact on spinning reserves	x	x	x	x	x	x	x	x	x	x	x	x
Instant grid response	Building can respond instantly or over short term to grid signals to reduce (or increase) power consumption. Response time and degree of load shift variables define level of grid value.			x		x	x		x	x	x	x	x
Self-contained operation	Building can operate independently or at reduced load for defined periods of time.	x	x	x	x	x	x	x		x	x	x	x
Two-way intertie	Distribution system serving building is capable of managed two-way power flow.									x		x	x
On-site generation	Building generates power on site					x	x	x					x
Grid-connected storage	On-site storage can be managed by grid					x			x		x	x	

Stakeholders and Market Applications

Grid Perspective (Regulators, Utilities, Program Administrators):

- Incentive Programs: Distributed Energy Resources & Buildings
  - Upfront incentive for GridOptimal design
  - Favorable rates
  - “New Business” charge for connecting a building to grid upon completion
- Target building upgrades for grid operation/stability
- Provide predictable building load reductions to grid managers and for bidding into electricity markets
- Reduced demand ramp up/down leads to greater overall generation efficiency and reliability for grid operator

Building Perspective (Customers, Developers, Designers):

- Design & Specification Process
- Real Estate & Building Asset Valuation
- Insulation against demand charge changes

Regulatory and Policy Framework:

- Aligns with ZE Building Goals and Policies
- Regulatory and Policy Frameworks (e.g. CA Title 24, New York REV)
- Model Codes & Standards (e.g. ASHRAE 189.1, IECC, etc.)

Building Owners & Managers
Key Benefits

- Create a new revenue stream from existing assets
- Enhance access to utility incentives & programs
- Improve building valuation
- Improve Risk Management
  - Insulate against demand charges
  - Reduce bottom-line impacts of rate structure changes
- Meet Sustainability goals/mandates
- Ensure that building staff are engaged in energy performance

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How Can Agencies Participate?

- Become a Partner/Sponsor of the GridOptimal Initiative
- Join the Technical Advisory Committee
  - Guide GridOptimal development and implementation
  - Access to leading experts in a collaborative environment
- Participate in Webinars, Workshop(s)
- Pilot the GridOptimal Score in federal buildings

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RESEARCH CODES & POLICY TOOLS & GUIDES EVENTS NEWS BLOG ABOUT NBI DONATE MY ACCOUNT

ZERO NET ENERGY ADVANCED BUILDINGS OUTCOME-BASED PERFORMANCE DEEP ENERGY RETROFITS

GRIDOPTIMAL INITIATIVE

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Our Work

- Zero Net Energy +
- Advanced Buildings +
- Outcome-Based Performance +
- Deep Energy Retrofits +

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Sign up to receive updates from NBI.

https://newbuildings.org/gridoptimal-initiative/

Thank You!

Eric Makela
Associate Director
EricM@newbuildings.org

David and Lucille Packard Foundation Building
Courtesy: EHDD

Time-Varying Value of Efficiency

Building Technologies Office Peer Review

Natalie Mims

May 1, 2018

This work was supported by the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy - Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231

Why study the time-varying value of efficiency savings?

- LBNL recently published two studies on the time-varying value of efficiency.
- There were multiple motivations for studying the time-varying value of efficiency:
  - Advance consideration of the value of efficiency measures during times of peak electricity demand and high electricity prices.
  - Increase awareness of:
    - Available end-use load research and its application to time-varying valuation of energy efficiency.
    - Gaps in (and need for) research on energy savings shapes.
- The goals of our research were:
  - Calculate the time-varying value of efficiency for 5 regions
  - Recommend methodology(ies) to appropriately value efficiency for meeting peak demand.
  - Consider changes to efficiency valuation methodologies to address the changing shape of net load (total electric demand in the system minus wind and solar).

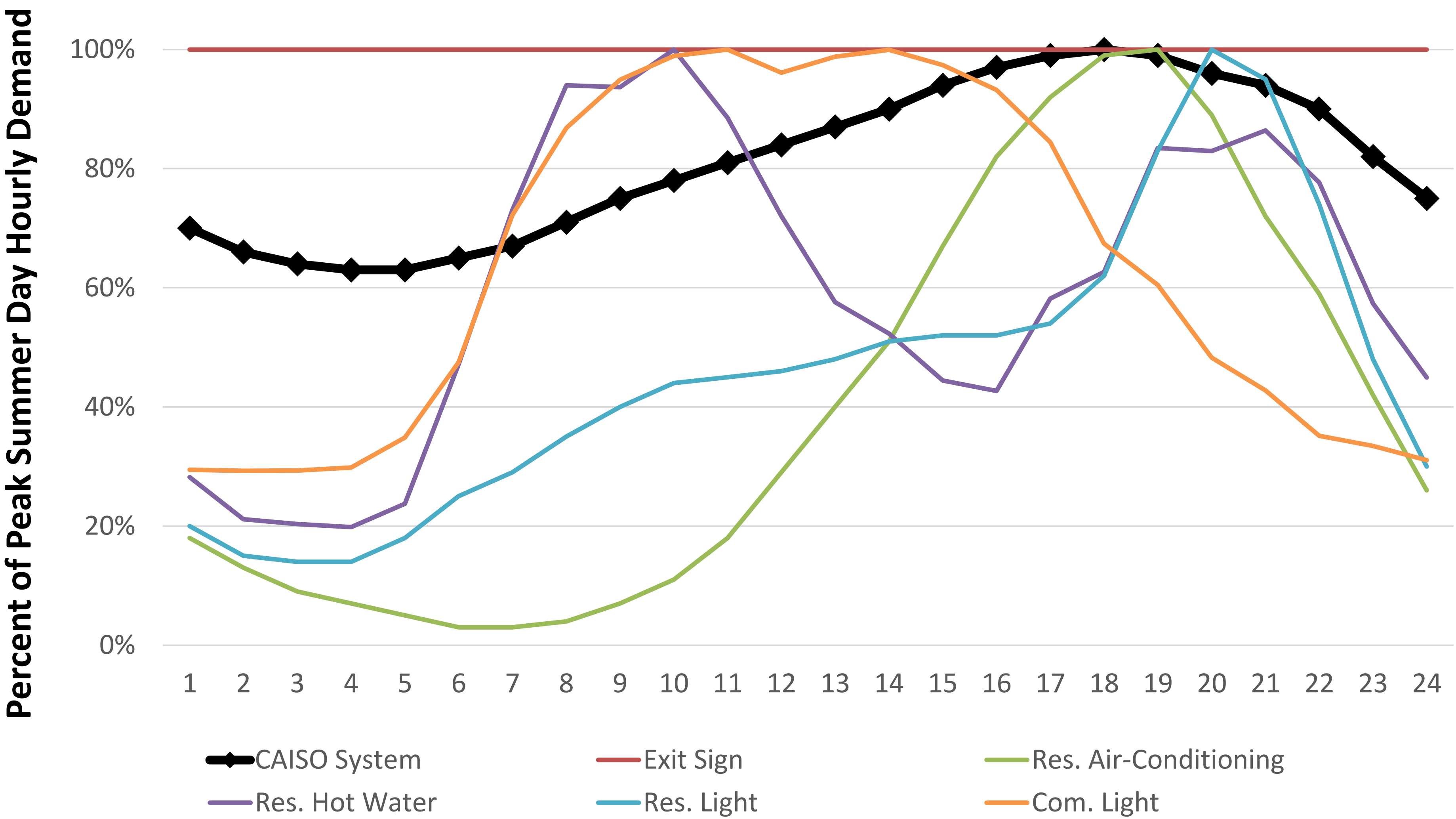
Approach

- Provide background for the studies by summarizing existing analyses that quantify benefits of electric efficiency measures and programs during peak demand and high electricity prices.
- Use publicly available avoided costs and end-use load shapes from state or regional sources.
- One of the following methodologies was used for each region:

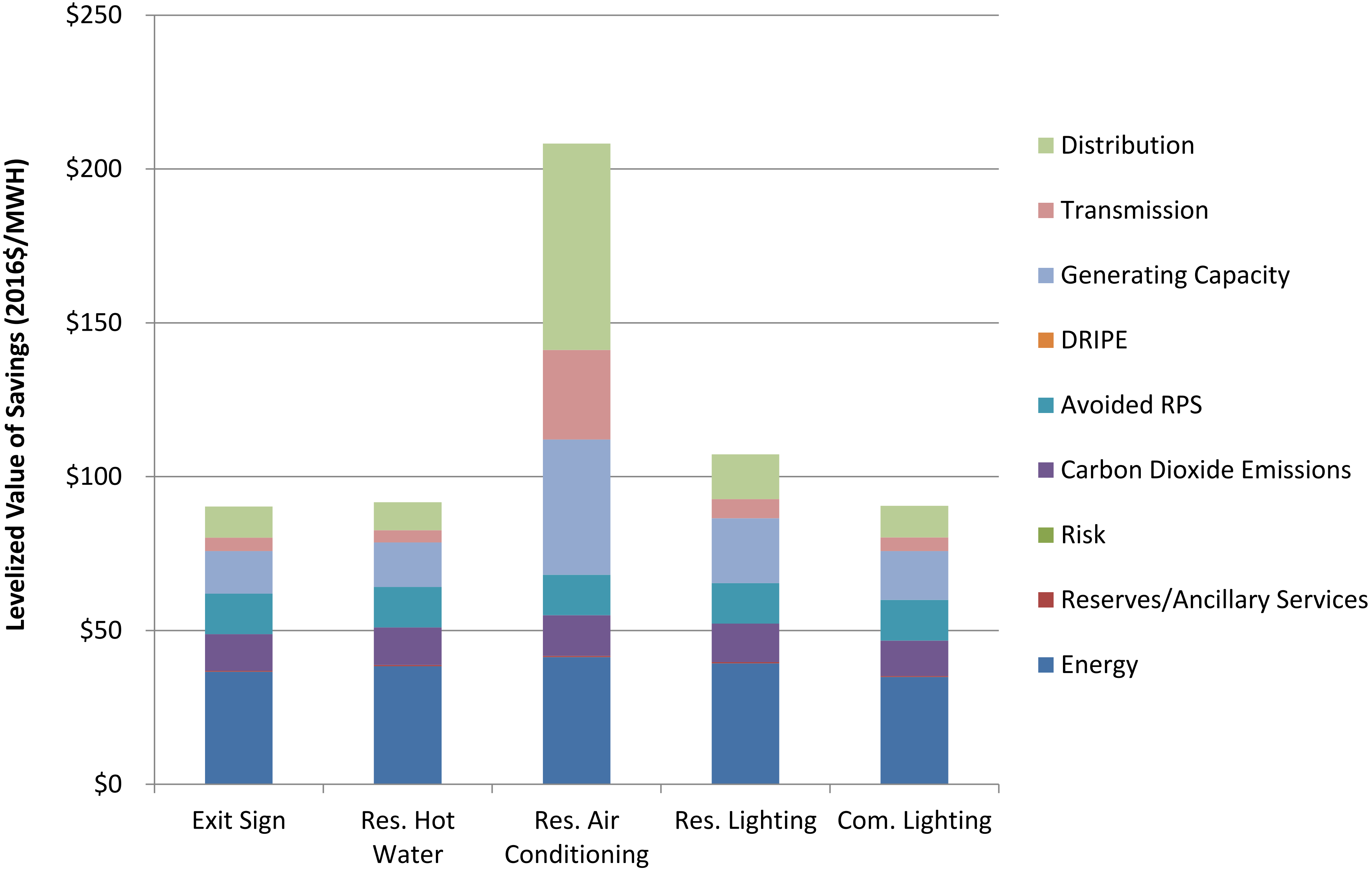
1. Apply hourly avoided costs to each measure load shape to calculate the time-varying value of measure, *or*
2. Use seasonal system peaks, coincidence factors and diversity factors to determine peak/off-peak savings and apply seasonal avoided costs to savings.

- If hourly avoided costs and end-use load shapes were available, LBNL used that data. Often times, that data was not available and the second methodology was used.

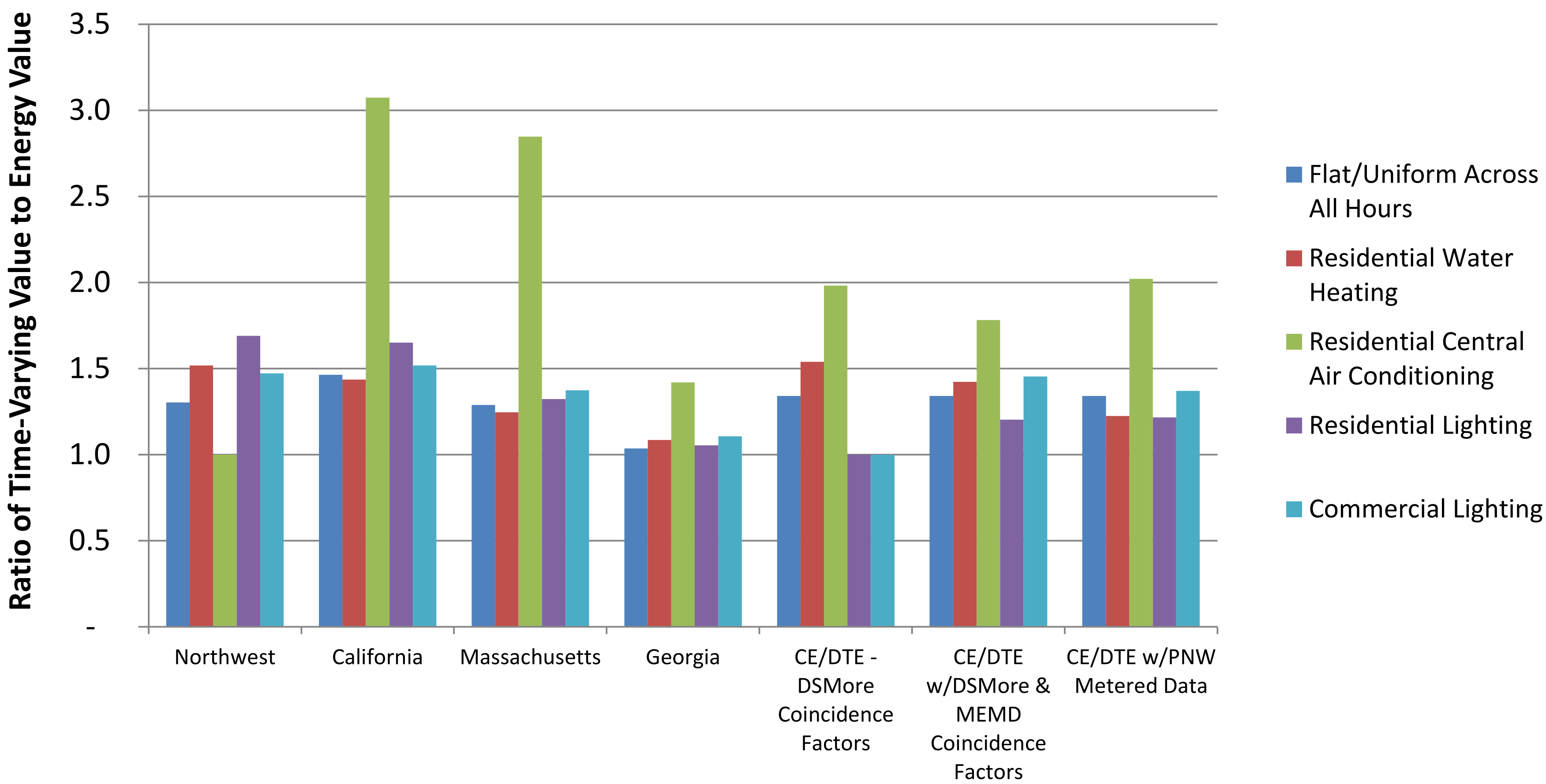
California System Shape and End-Use Load Shapes



California Time Varying Value by Load Shape



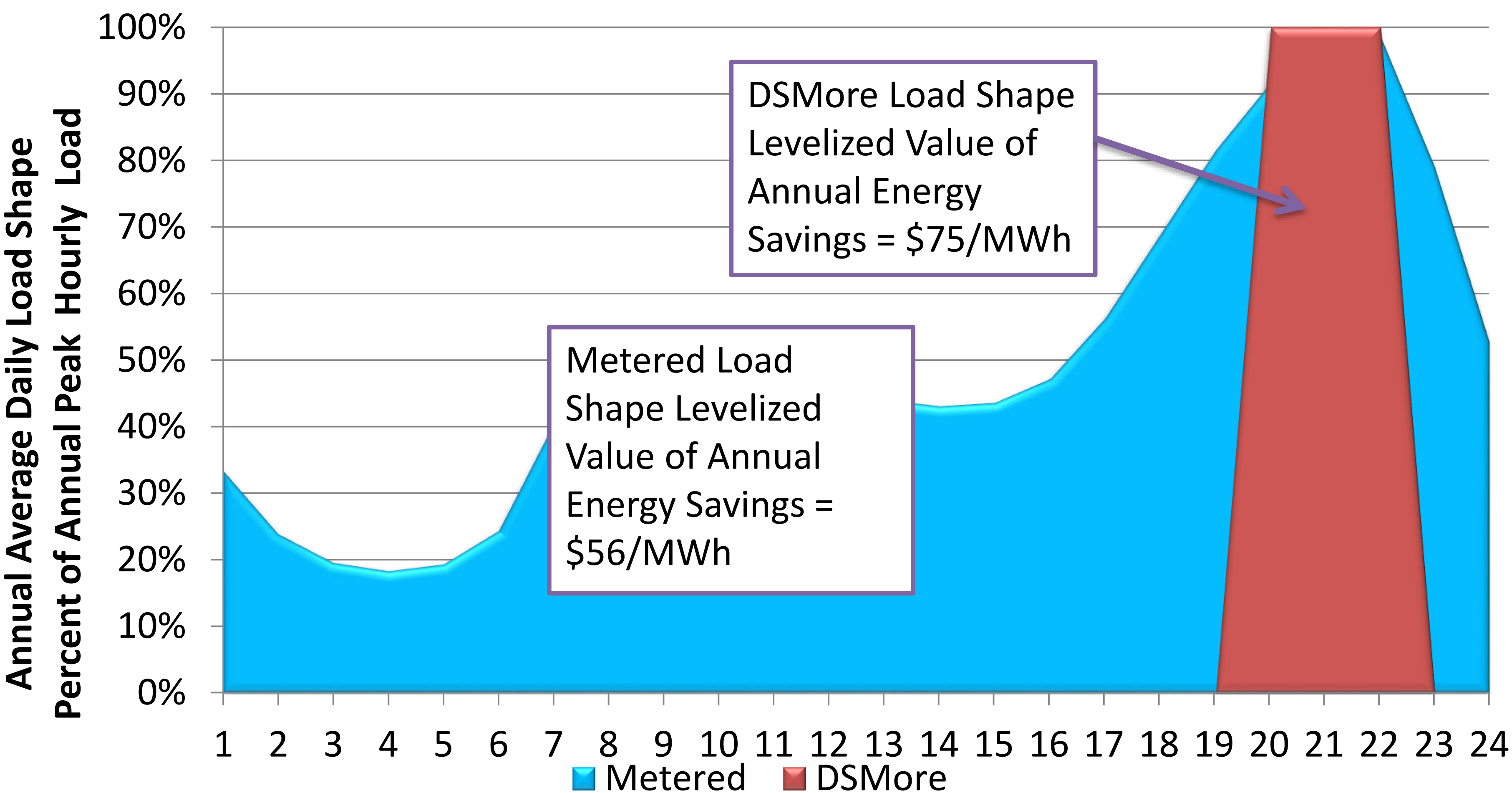
Results: Total Utility System Value of Savings Compared to Only Their Energy Value



Notes: The flat load shape is an exit sign. Energy value includes: energy, risk, carbon dioxide emissions, avoided RPS and DRIPE, as applicable if reported. Total time-varying value includes all energy values and capacity, transmission, distribution and spinning reserves. Ratios are calculated by dividing total time-varying values by energy-only values.

Why Accurate Load Shapes Matter: Michigan Residential Lighting Example

When DSMore (modeled) and metered load shapes disagree, they produce significantly different values for annual energy savings.



Conclusions from Studies

- The time-varying value of efficiency measures varies across the locations studied because of physical and operational characteristics of the individual utility system, the time periods that measure savings occur and differences in the value and components of avoided cost considered.
- Across the four locations studied, some of the largest capacity benefits from energy efficiency are derived from the deferral of transmission and distribution system infrastructure upgrades. However, the deferred cost of infrastructure upgrades also exhibited the greatest range in value of all the components of avoided cost across the locations studied.
- Of the five measures studied, residential air-conditioning has the most significant added value when the total time-varying value is considered in summer peaking systems.
- The increased use of distributed energy resources (e.g., rooftop solar, storage) and the addition of major new electricity consuming end-uses (e.g., electric vehicle charging) are anticipated to significantly alter the load shape of many utility systems in the future.

Conclusions from Studies

End-Use and Savings Shapes (1)

- Data used to estimate the impact of energy efficiency measures on electric system peak demands will need to be updated periodically to accurately reflect the value of savings as system load shapes change.
- Publicly available data on end-use load and energy savings shapes are limited, concentrated regionally, and should be expanded.
- End-use load shape research that is specific to Michigan would enable more accurate analysis of the time-varying value of efficiency.
- Until such time that statistically representative, metered data on end-use load shapes in Michigan are available, data from regions with similar energy consumption characteristics should be considered for adoption (e.g., we used Pacific Northwest end-use load shapes in our analysis because they are based on metered data and are very similar to the end-use load shapes for some measures from the Electric Power Research Institute End Use Load Shape Library that are applicable to Michigan).

Conclusions from Studies

End-Use and Savings Shapes (2)

- In Michigan, use of current DSMore load shapes to determine both energy and peak savings may overstate the value of residential water heating savings and understate the value of residential air-conditioning savings.
- Lack of statistically representative metered end-use load shape data for Michigan limits the ability to confidently characterize the time-varying value of energy efficiency savings, especially for weather-sensitive measures such as residential air-conditioning.
- Investigating alternative data sources for the analysis, we found that substitution of simulated end-use load shapes may not accurately represent the hourly distribution of energy use unless the data reflects diversity of occupant behavior.

Conclusions from Studies

Avoided Cost

- Publicly available components of electric system costs avoided through energy efficiency are not uniform across states and utilities. Inclusion or exclusion of these components and differences in their value affect estimates of the time-varying value of efficiency.
- LBNL found that in states where avoided cost includes a value for the risk mitigation benefits of energy efficiency, the total value of savings increased by 3-5 percent, depending on load shape. Including DRIPE also increased the value of savings by about 5 percent. For those jurisdictions which include a value for reduced carbon dioxide emissions, the total value of energy savings increased significantly — 6-13 percent in California, 13-28 percent in Massachusetts, and 32-52 percent in the Pacific Northwest.

Reports

- Time-varying value of energy efficiency report available at: https://emp.lbl.gov/publications/time-varying-value-electric-energy

- Technical brief available at: http://eta-publications.lbl.gov/sites/default/files/lbnl_tve_michigan_20180402_final.pdf

Definitions

- **End-use load shape:** Hourly consumption of an end use (e.g., residential lighting, commercial HVAC) over the course of one year.
- **Energy savings shape:** The difference between the hourly use of electricity in the baseline condition and the hourly use post-installation of the energy efficiency measure (e.g., the difference between the hourly consumption of an electric resistance water heater and a heat pump water heater, or the difference between the hourly lighting use in a commercial building pre- and post-installation of daylighting controls or occupancy sensors) over the course of one year.
- **Electric system shape**: The annual system load shape, by month, for each location.

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