Guiding Lights: Valuing Energy Efficiency Via Loadshapes And Cost-Effectiveness

Moderator: Denis Bergeron, Maine PUC

Elaina Present, NREL
Natalie Mims, LBNL
Julie Michals, E4TheFuture

End Use Load Profiles for the U.S. Building Stock

Elaina Present

NEEP EM&V Annual Public Meeting

May 21, 2019

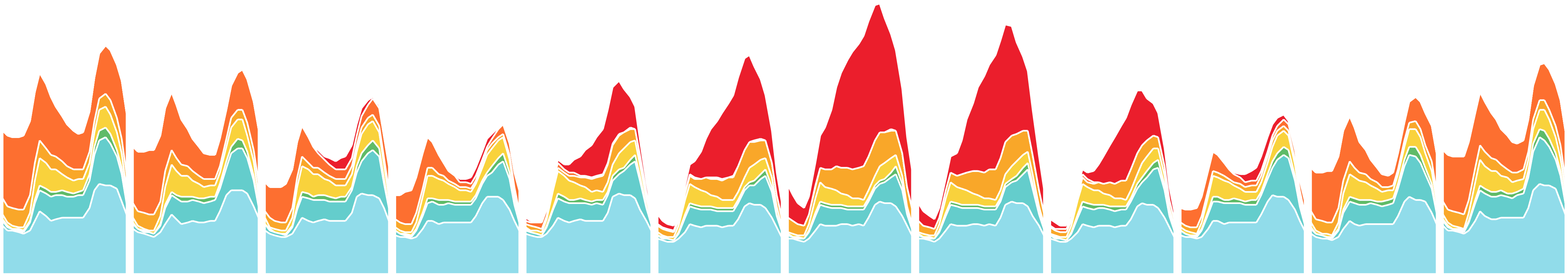
Overview

- What, Why, and Who
- How
- Where we are now

What

End use load profiles describe ***how*** and ***when*** energy is used in buildings

They are the **most essential** data resource currently missing for Time-Sensitive Valuation of Energy Efficiency



What

The project will result in:

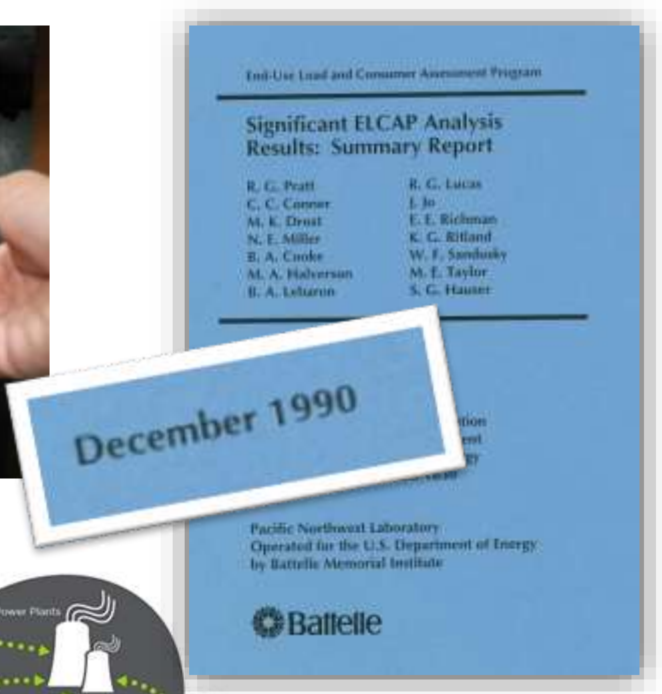
- **Validated end-use load profiles** for U.S. building stock at both aggregate and individual building scales
- Calibrated building stock end use **models with ability to estimate EE/DR savings profiles for existing and emerging technologies**
- **Documentation** of load profile use cases, critical gaps, model methodology, and user guide

All by October 2021.

Why

Existing end-use load profiles

- outdated
- limited to certain regions and building types because of the **high cost** of traditional sub-metering
- insufficient for accurate evaluation of numerous **emerging use cases**


End-Use Load and Consumer Assessment Program

Significant ELCAP Analysis Results: Summary Report

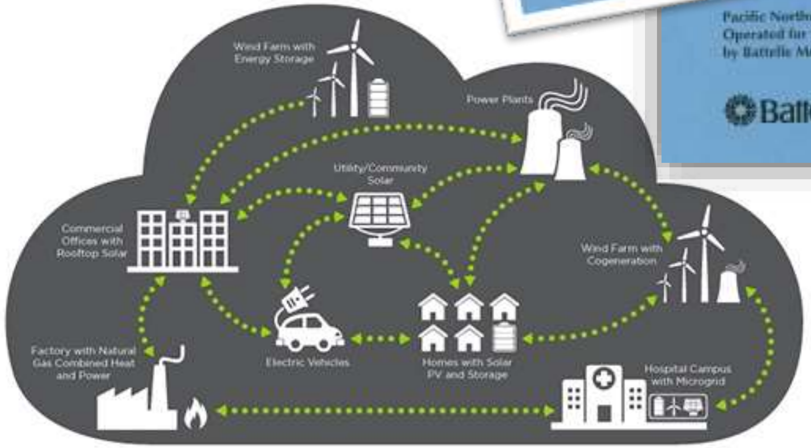
R. G. Pratt
C. C. Conner
M. K. Drost
N. E. Miller
B. A. Cooke
M. A. Halverson
B. A. Lebaron

R. G. Lucas
J. Jo
E. E. Richman
K. G. Ritland
W. F. Sandusky
M. E. Taylor
S. G. Hauser

December 1990

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

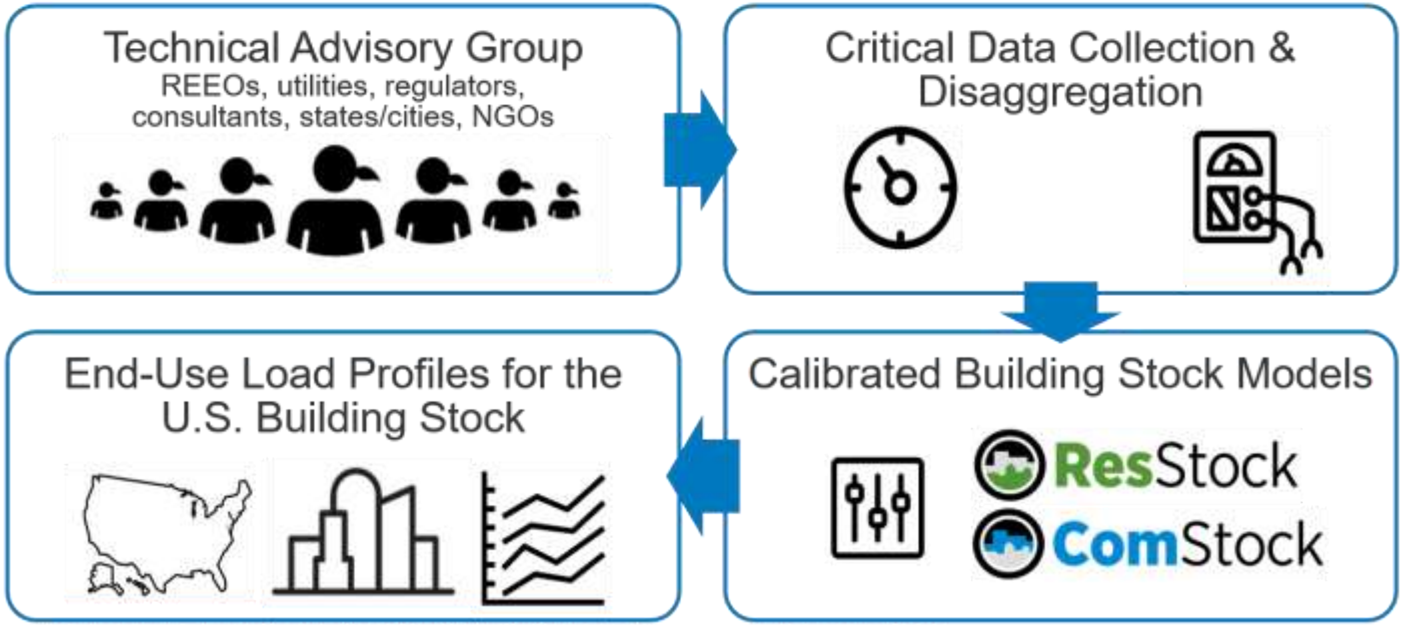


Source: Navigant

Who

Organization	Domain expertise	
NREL	Building energy modeling (BEM) Building stock modeling Residential occupant behavior	EnergyPlus OpenStudio ResStock ComStock
BERKELEY LAB Lawrence Berkeley National Laboratory	Time-sensitive valuation of EE Utility integrated resource planning Commercial occupant behavior	
Argonne NATIONAL LABORATORY	Uncertainty quantification	
EPRI ELECTRIC POWER RESEARCH INSTITUTE	Load profile conditional demand analysis Electric utility engagement	
neep Northeast Energy Efficiency Partnerships	Northeast regional stakeholder engagement Northeast regional data sources	

Our Plan:
Deliver a nationally-comprehensive dataset at a fraction of the historical cost

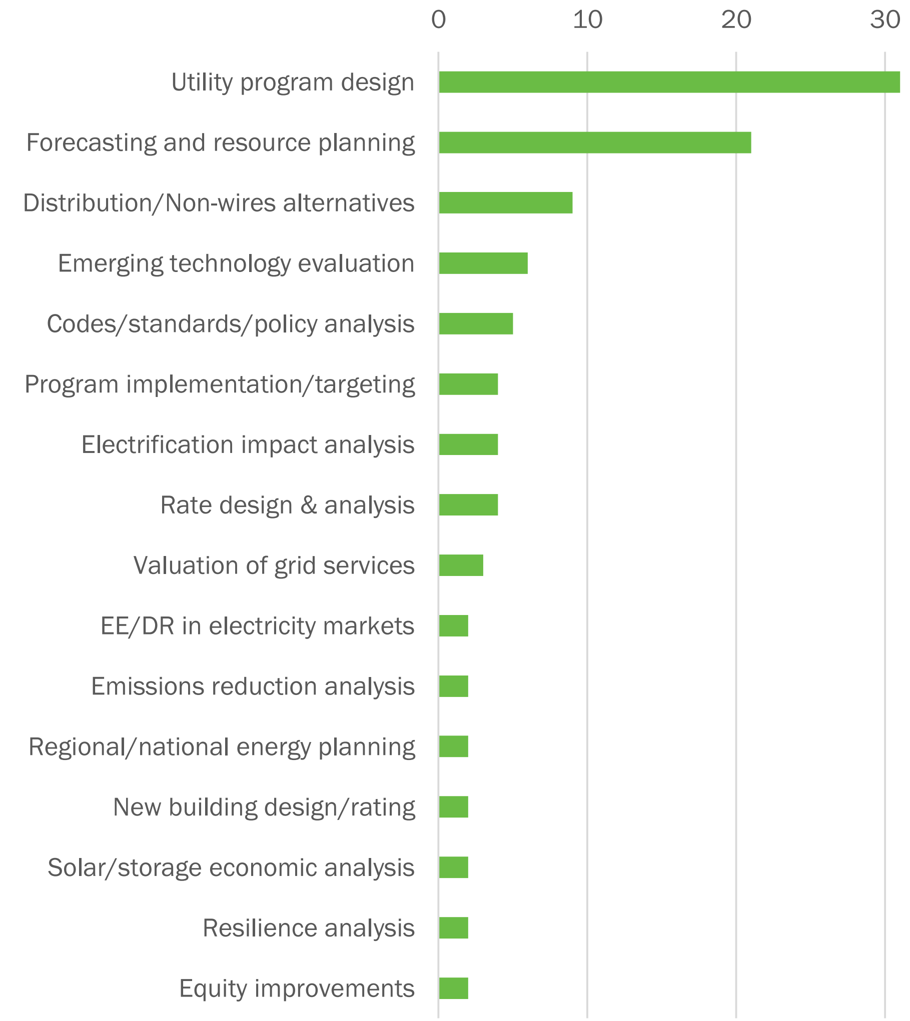


Icon attributions (thenounproject.com): People by Wilson Joseph, Meter by K, Meter by Adnen Kadri, USA by Setyo Ari Wibowo, Graph by Creative Stall, Settings by Dara Ullrich.

Step 1: Technical Advisory Group (TAG)

TAG Membership to Date

Highest Priority Uses for End-Use Load Profiles



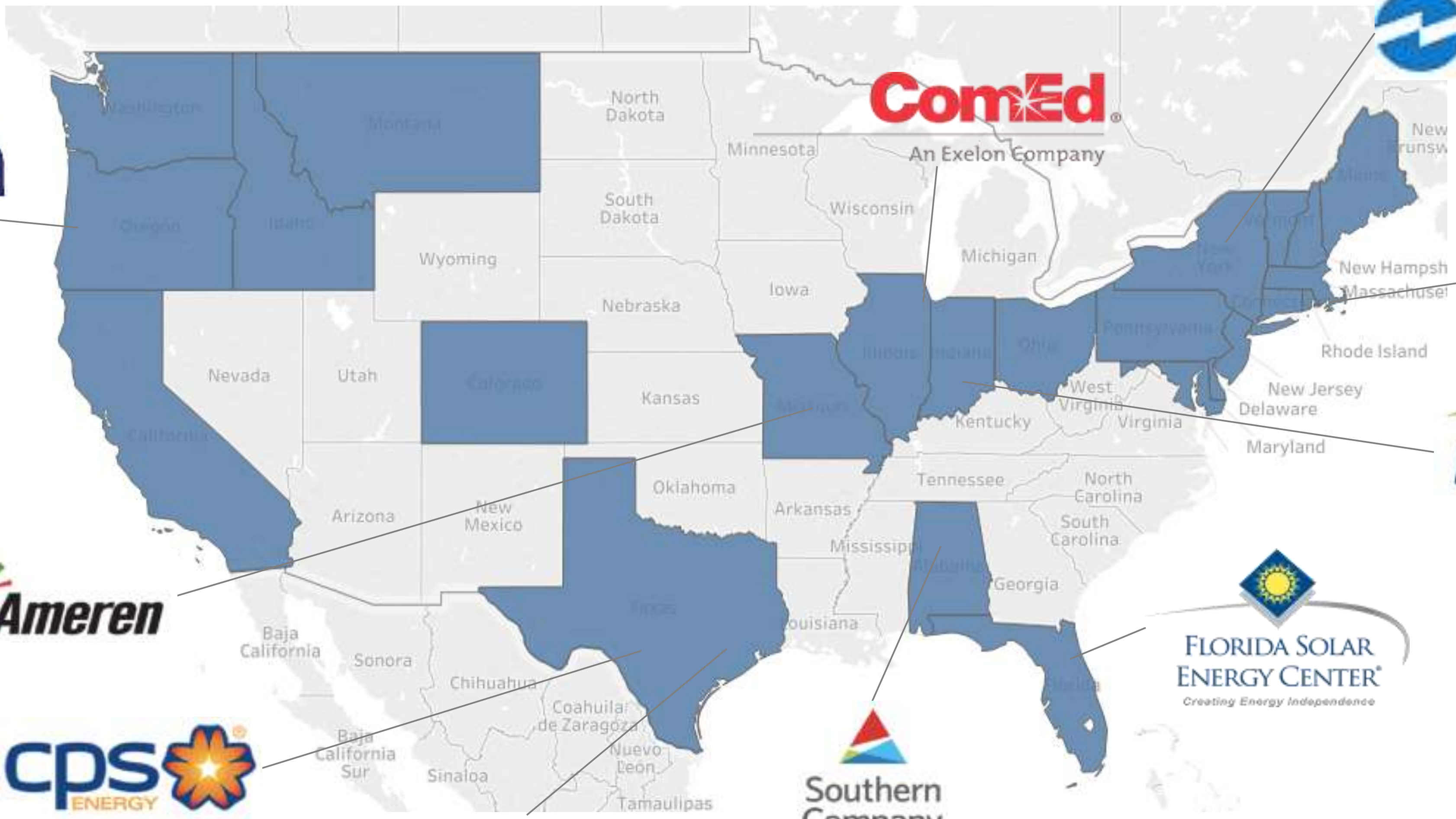
Step 2: Data Collection and Disaggregation

Data types

- Best available sub-metering
- AMI
  - More buildings & geographic areas represented
- Survey
  - U.S. Census, American Time Use Survey, American Community Survey, EIA's Residential Energy Consumption Survey and Commercial Building Energy Consumption Survey, etc.
- Myriad of other sources
  - Smart thermostat data, realtor data, etc.

Step 2: Data Collection and Disaggregation

Data sets we have or are likely to get…



neea

ecobee

Ameren

cps ENERGY

PECAN STREET

ComEd An Exelon Company

Southern Company

New York Power Authority

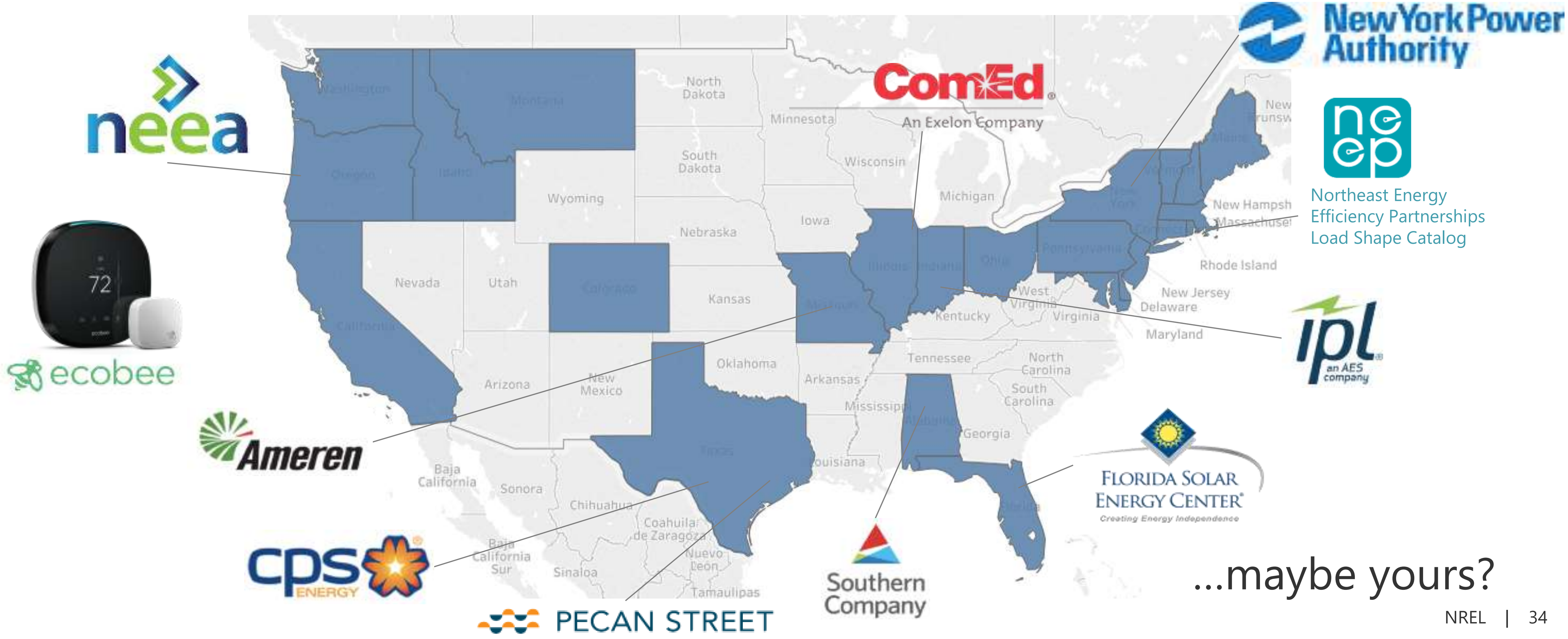
neep
Northeast Energy Efficiency Partnerships Load Shape Catalog

ipl an AES company

Florida Solar Energy Center
Creating Energy Independence

Step 2: Data Collection and Disaggregation

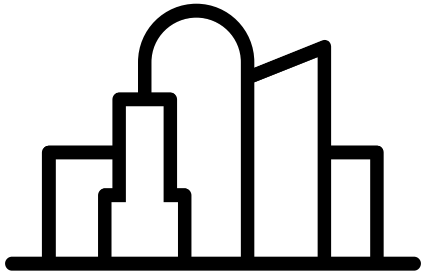
Data sets we have or are likely to get...



...maybe yours?

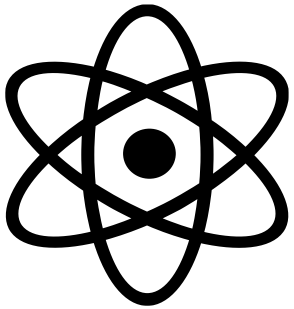
Step 3: Calibrated Building Stock Models

ComStock ResStock



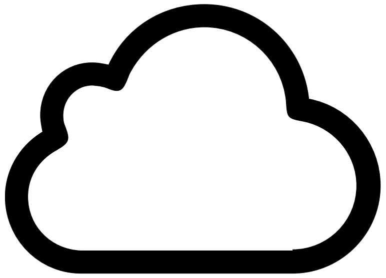
Building stock characteristics database

+



Physics-based computer modeling

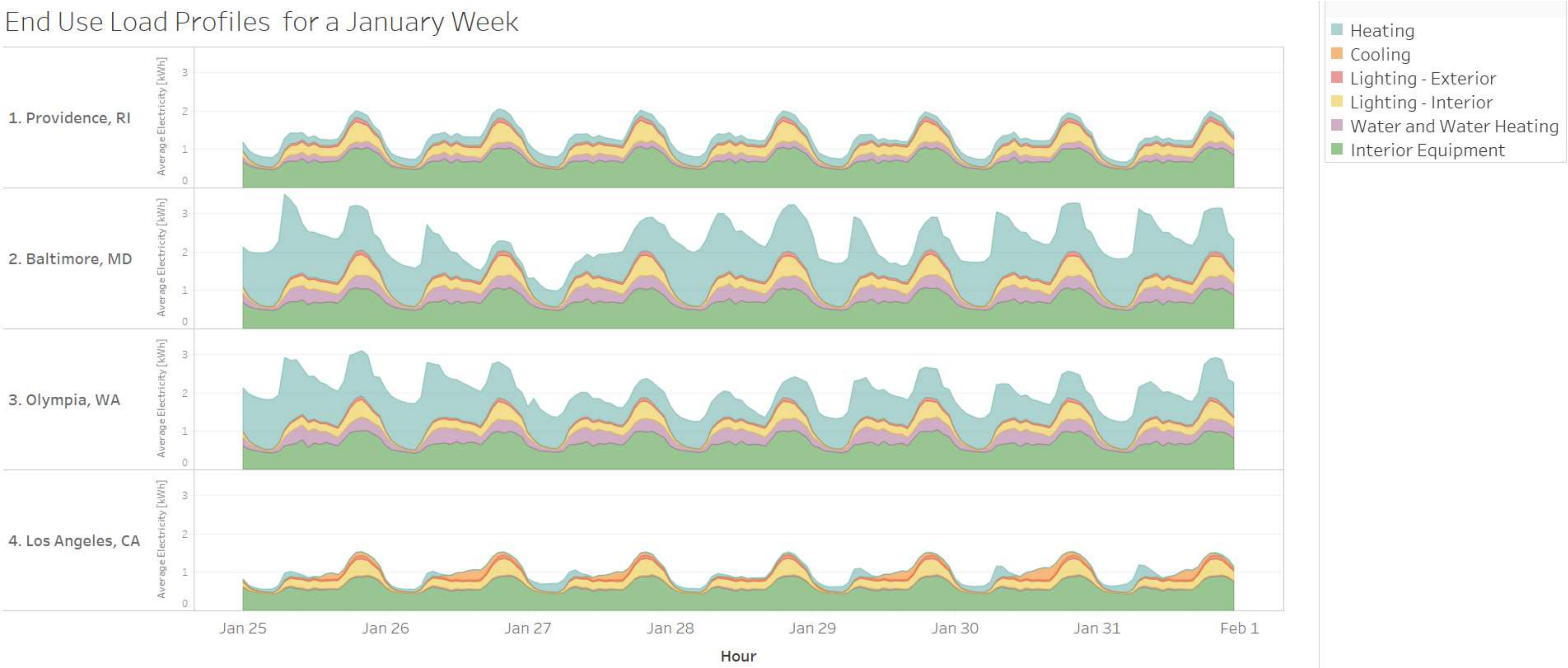
+



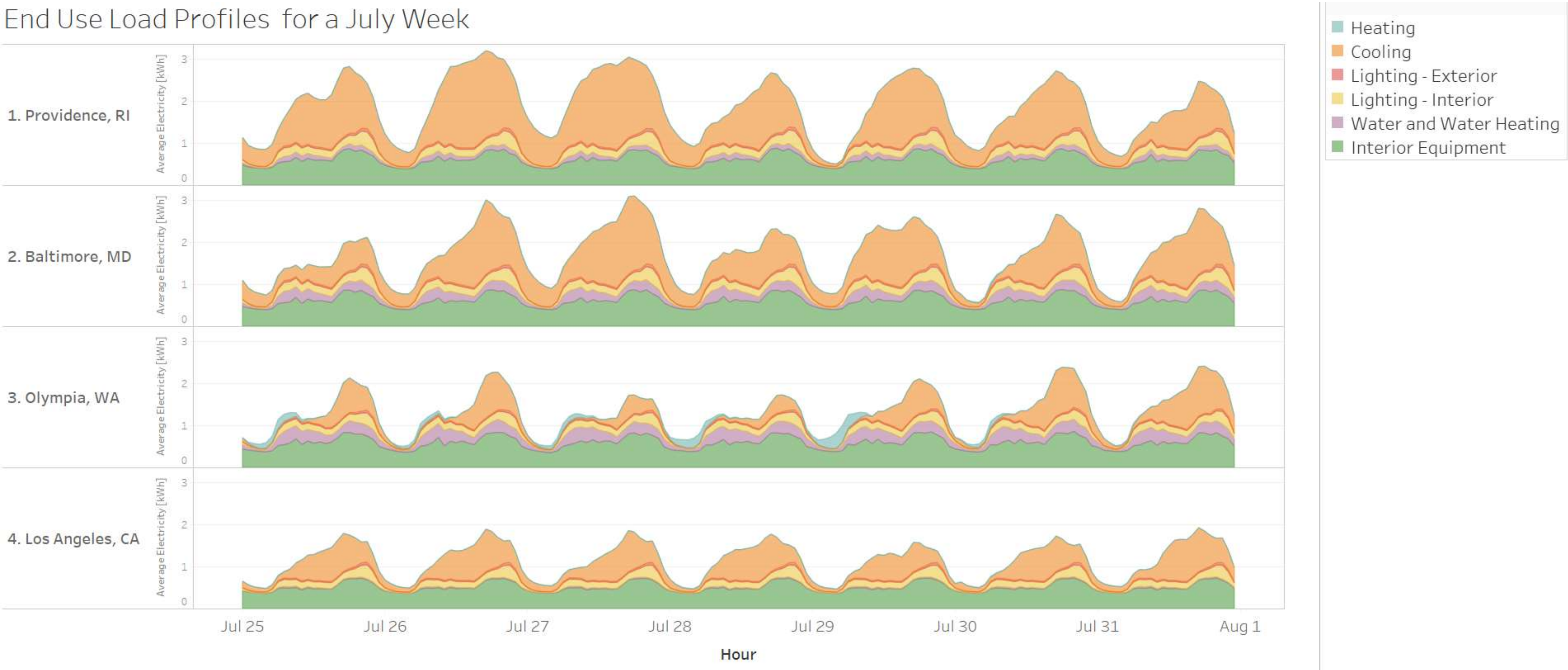
High-performance computing

- DOE-funded, NREL-developed models of the U.S. building stock
- 100,000s of statistically representative physics-based building energy models (BEM)
- Use DOE’s flagship BEM tools OpenStudio and EnergyPlus
- Produce hourly load profiles, but calibration to-date has focused on annual energy consumption

Where we are now (January in RI, MD, WA, CA)



Where we are now (July in RI, MD, WA, CA)



Thank you

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Eric Wilson, eric.wilson@nrel.gov
Andrew Parker, andrew.parker@nrel.gov
Natalie Mims Frick, nfrick@lbl.gov

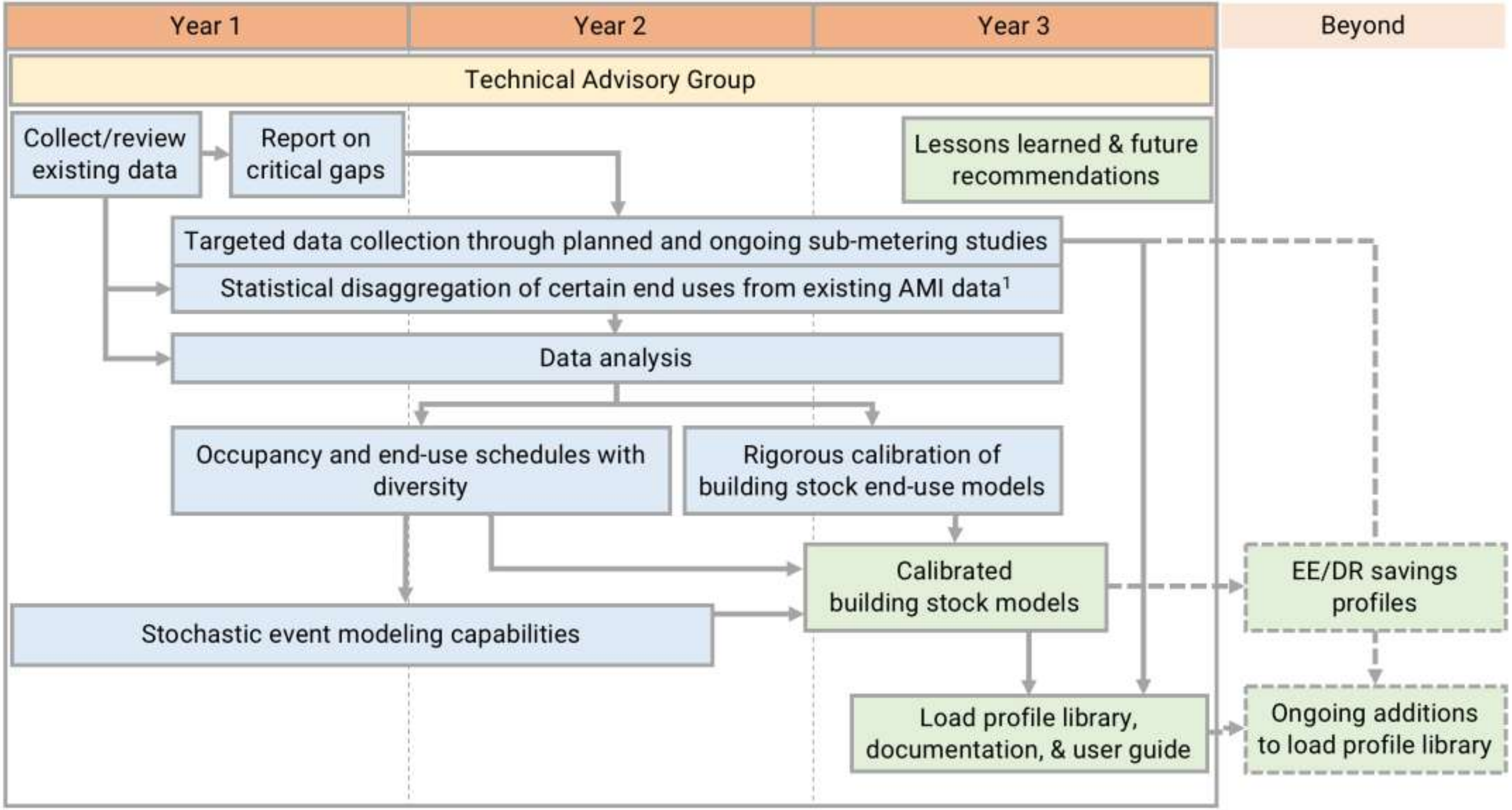
www.nrel.gov/buildings/end-use-load-profiles.html

NATIONAL RENEWABLE ENERGY LABORATORY

Backup Slides

More information, or to help answer questions

Project Timeline



[1] For example, conditional demand analysis, or inverse (changepoint/degree day) models (KEMA 2009)

ComStock

Building Types

- Small Office
- Medium Office
- Large Office
- Stand-alone Retail
- Strip Mall
- Primary School
- Secondary School
- Outpatient Healthcare
- Hospital
- Small Hotel
- Large Hotel
- Warehouse (non-ref.)
- Quick Service Restaurant
- Full Service Restaurant
- Mid-rise Apartment
- High-rise Apartment
- Supermarket

End-Uses

- Heating
- Cooling
- Interior Lighting
- Exterior Lighting
- Interior Equipment
- Exterior Equipment
- Fans
- Pumps
- Heat Rejection
- Humidification
- Heat Recovery
- Water Systems
- Refrigeration
- Generators

ResStock

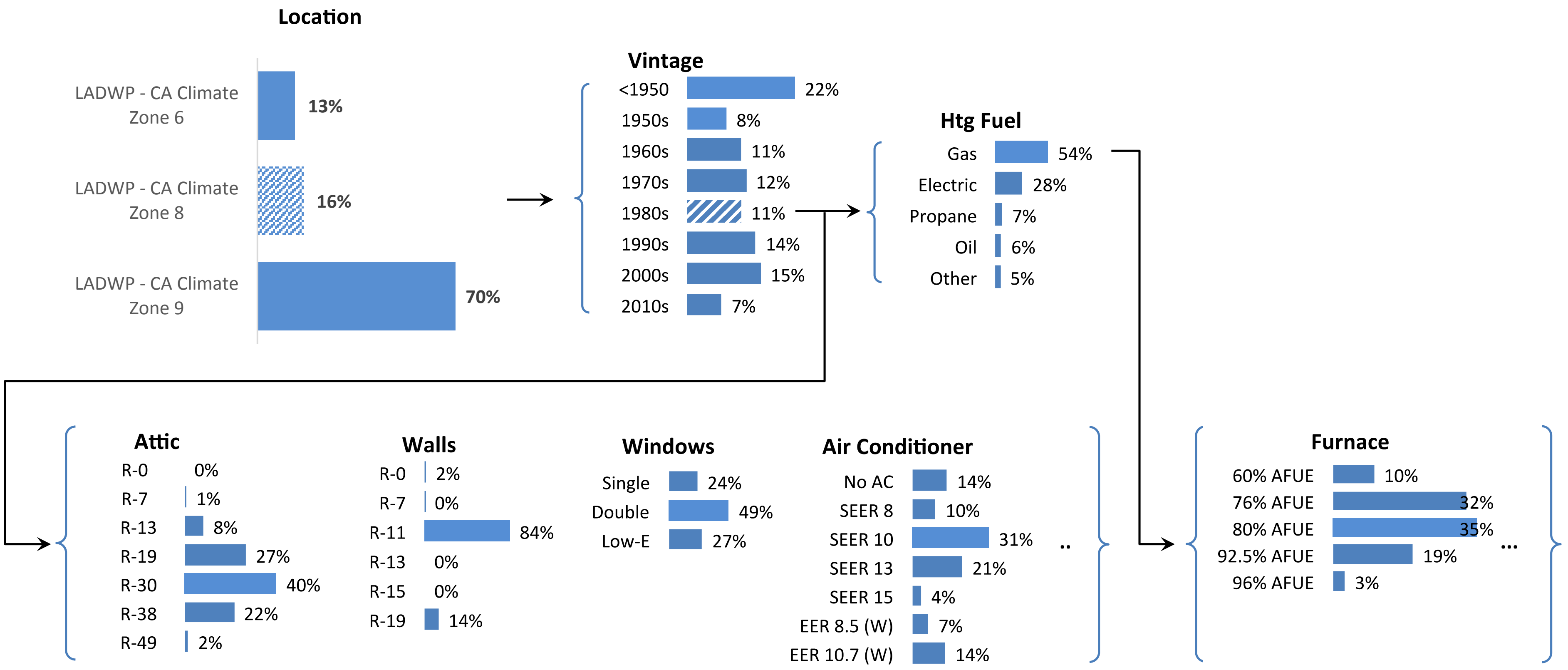
Building Types

- Single-Family Detached
- Multifamily (low-rise)
  - Single-Family Attached
  - 2 - 4 Units
  - 5+ Units

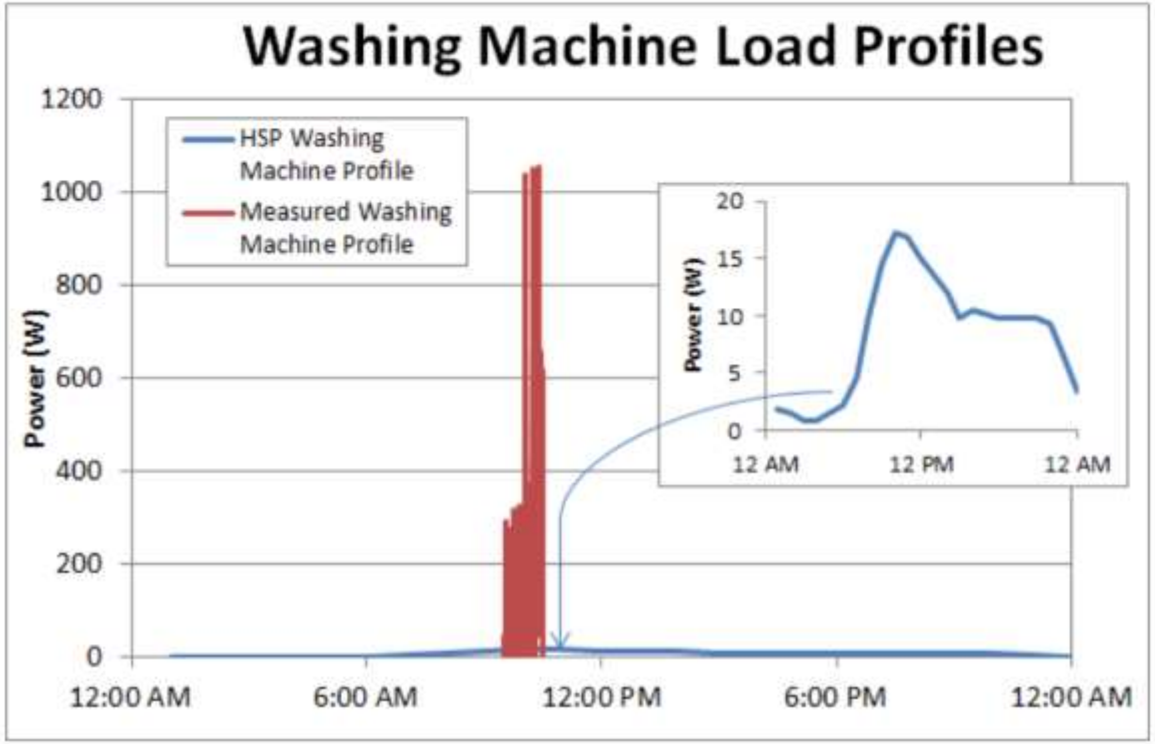
End-Uses:

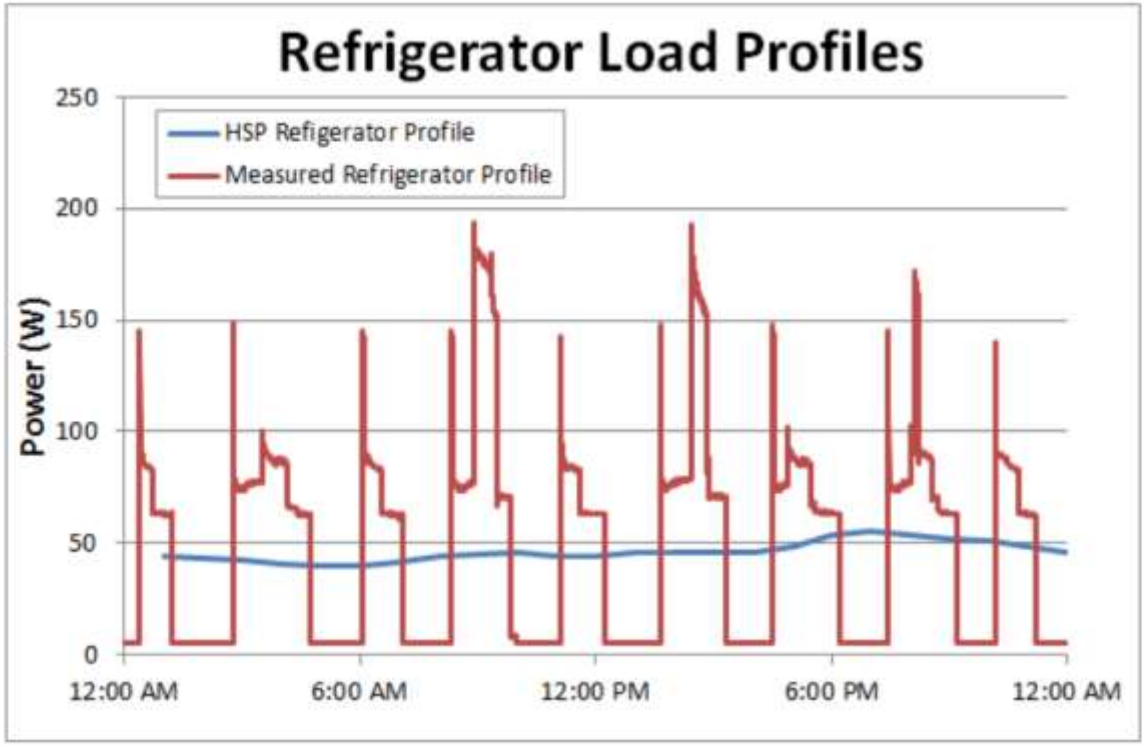
- Heating
- Cooling
- Furnace/AC fan
- Boiler pumps
- Vent. fans
- Water heating
- Interior Lights
- Exterior Lights
- Misc. plug loads
- Refrigerator
- Clothes washer
- Clothes dryer
- Dishwasher
- Cooking Range

Conditional Probability Distributions



Stochastic building loads





Time-sensitive value of efficiency

Natalie Mims Frick, Berkeley Lab

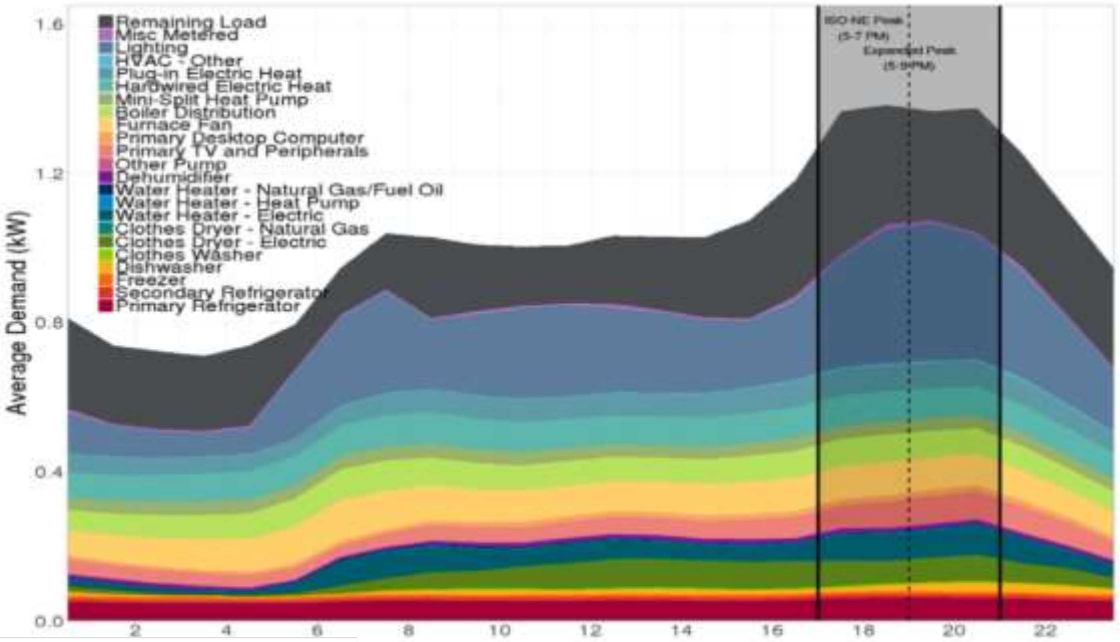
Northeast Energy Efficiency Partnerships Annual Public Meeting: Stellar EM&V

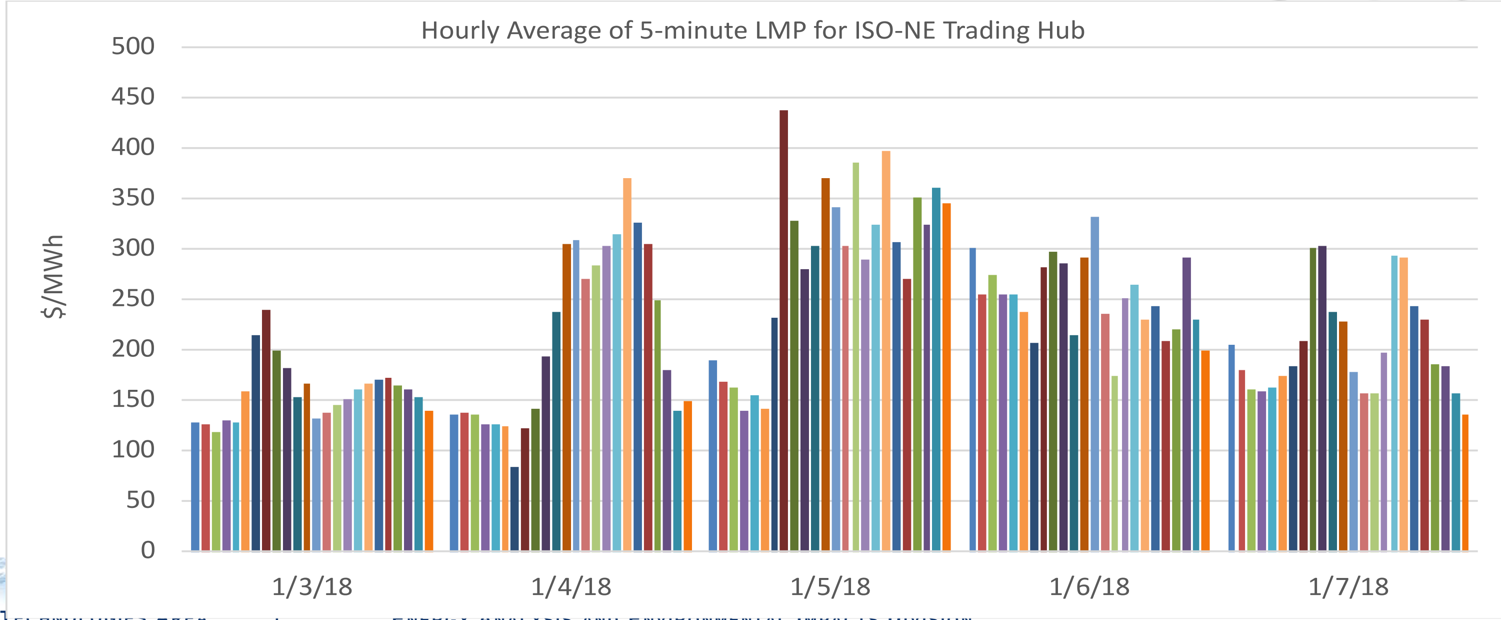
May 21, 2019

This presentation was supported by the U.S. Department of Energy's Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231

What is the time-sensitive value of energy efficiency?

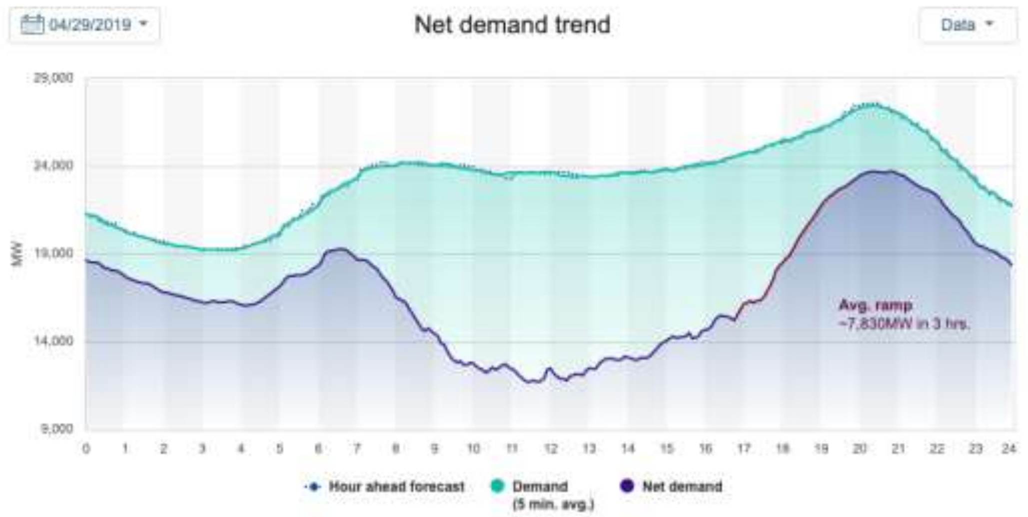
Time-sensitive value of energy efficiency (TSV-EE) considers *when* energy efficiency occurs and the *economic value* of the energy or demand savings to the electricity system at that time.



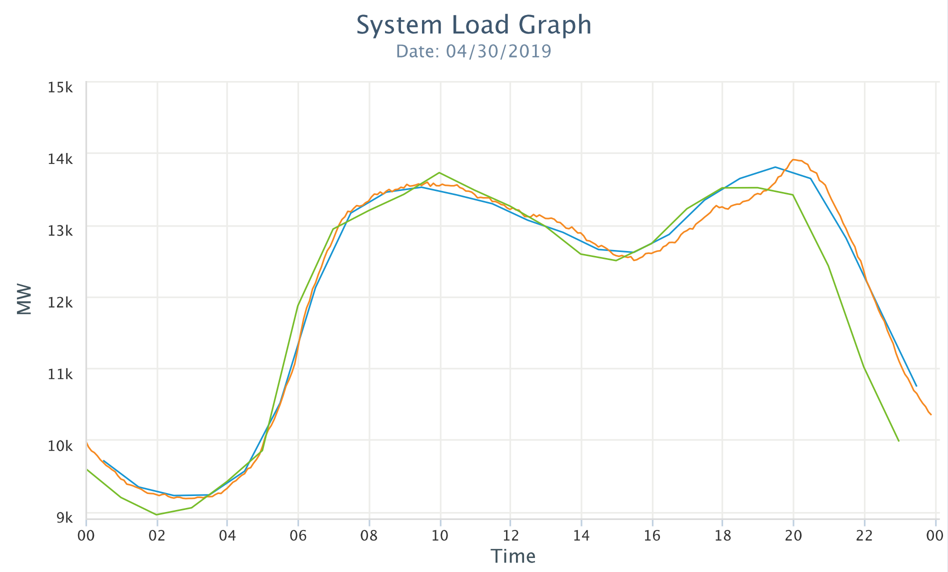


Sources: Navigant MA Baseline Load Shape Study, LBNL analysis using ISO-NE 2018 LMP data

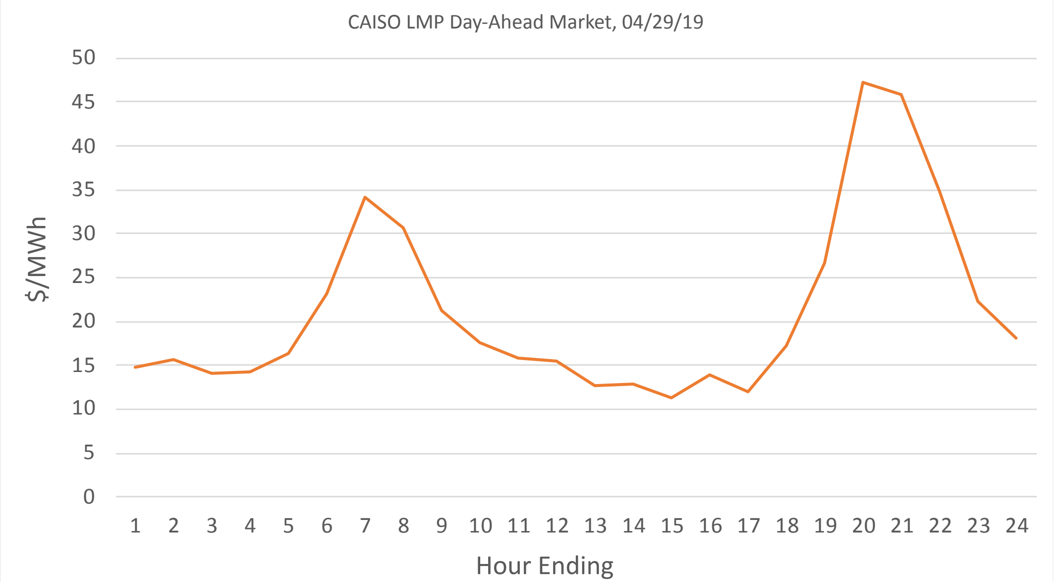
Some motivations for using the time-sensitive value of efficiency



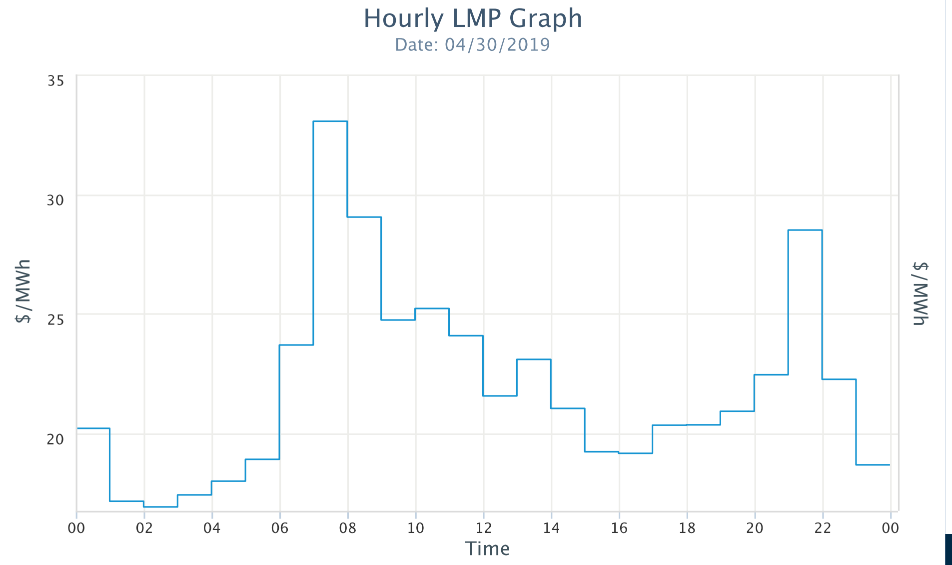
Source: CAISO



Source: ISO-NE



Source: CAISO



Source: ISO-NE

RT-.h.HUB.LMP

Recent time-sensitive value of efficiency publications by LBNL

Time-varying value of electric energy efficiency

Authors:

Natalie Mims, Tom Eckman,[1] and Charles Goldman

[1]Consultant and Senior Advisor, Northwest Power and Conservation Council

Energy Analysis and Environmental Impacts Division

Lawrence Berkeley National Laboratory

Electricity Markets and Policy Group

June 2017

BERKELEY LAB

This work was supported by the DOE Office of Energy Efficiency & Renewable Energy Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

June 2017 technical report supported by DOE’s Office of Energy Efficiency and Renewable Energy - Building Technologies Office

BERKELEY LAB | ELECTRICITY MARKETS & POLICY GROUP | TECHNICAL BRIEF | emp.lbl.gov | 1

APRIL 2, 2018

TIME-VARYING VALUE OF ENERGY EFFICIENCY IN MICHIGAN[1]

NATALIE MIMS, TOM ECKMAN AND LISA SCHWARTZ,[2] LAWRENCE BERKELEY NATIONAL LABORATORY

In December 2016, the Michigan Legislature passed new laws (SB 341 and 342) that require the Public Service Commission (PSC) to create regulations for integrated resource planning (IRP) and determine the potential of energy waste reduction resources to meet electricity needs. Following stakeholder engagement meetings, the PSC requested technical assistance from Berkeley Lab to better understand how to account for the time-varying value of electricity savings in IRP and demand-side management (DSM) planning in Michigan. Working collaboratively with the PSC, Consumers Energy and DTE Energy, Berkeley Lab calculated the time-varying value of electricity savings for five energy efficiency measures in the utilities' service areas.

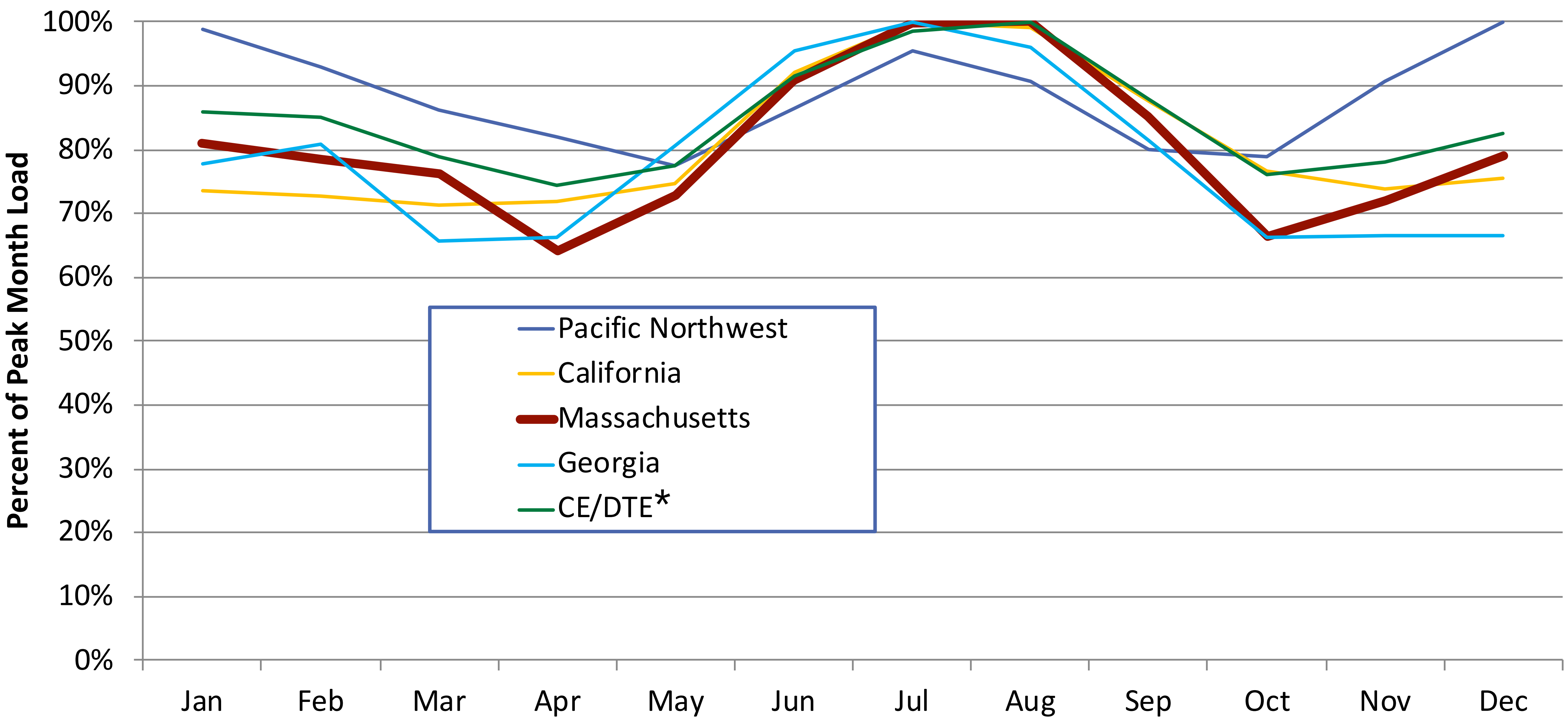
Quantifying the time-varying value of energy efficiency is necessary to properly account for all of its benefits and costs and to identify and implement efficiency resources that contribute to a low-cost, reliable electric system (Mims et al. 2017; Boomhower and Davis 2016). Historically, most quantification of the benefits of efficiency have focused largely on the economic value of annual reductions in energy use. Due to the lack of statistically representative, metered data on end-use load shapes in Michigan (i.e., the hourly or seasonal timing of electricity savings), the ability to confidently characterize the time-varying value of energy efficiency savings in the state, especially for weather-sensitive measures such as central air conditioning, is limited.

Based on our analysis of data from Consumers Energy and DTE Energy, we conclude that: (1) overall, the ratio of the total utility system value of energy savings to their energy-related value in Michigan aligns with other states with similar system load shapes; (2) end-use load shape research that is specific to Michigan would enable more accurate analysis of the time-varying value of efficiency; (3) 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 (EPRI) End Use Load Shape Library that are applicable to Michigan); and (4) an investigation of all value streams for energy efficiency (e.g., avoided risk and air emissions values) in Michigan will help avoid undervaluing this resource.

Still, electric utilities in Michigan can take advantage of opportunities to incorporate the time-varying value of efficiency into their planning. For example, end-use load research and hourly valuation of efficiency savings can be used for a variety of electricity planning functions, including load forecasting, DSM, demand-side evaluation, capacity planning, long-term resource planning, renewable energy integration, assessing potential grid modernization investments, establishing rates and pricing, and customer service (KEMA 2012). In addition, accurately calculating the time-varying value of efficiency may help energy efficiency program administrators prioritize existing offerings, set incentive or rebate levels that reflect the full value of efficiency, and design new programs.

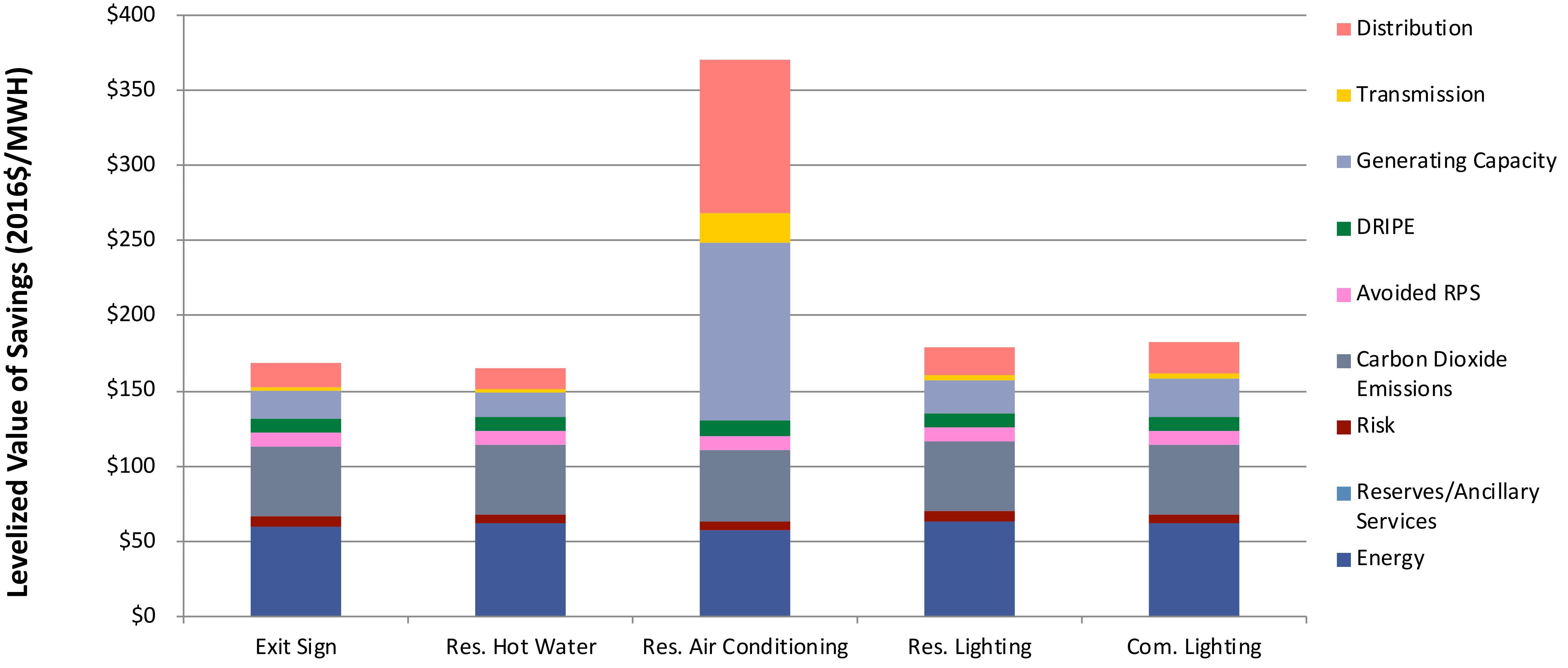
April 2018 technical brief supported by DOE’s Office of Electricity – Transmission Permitting and Technical Assistance

Annual System Load Shapes

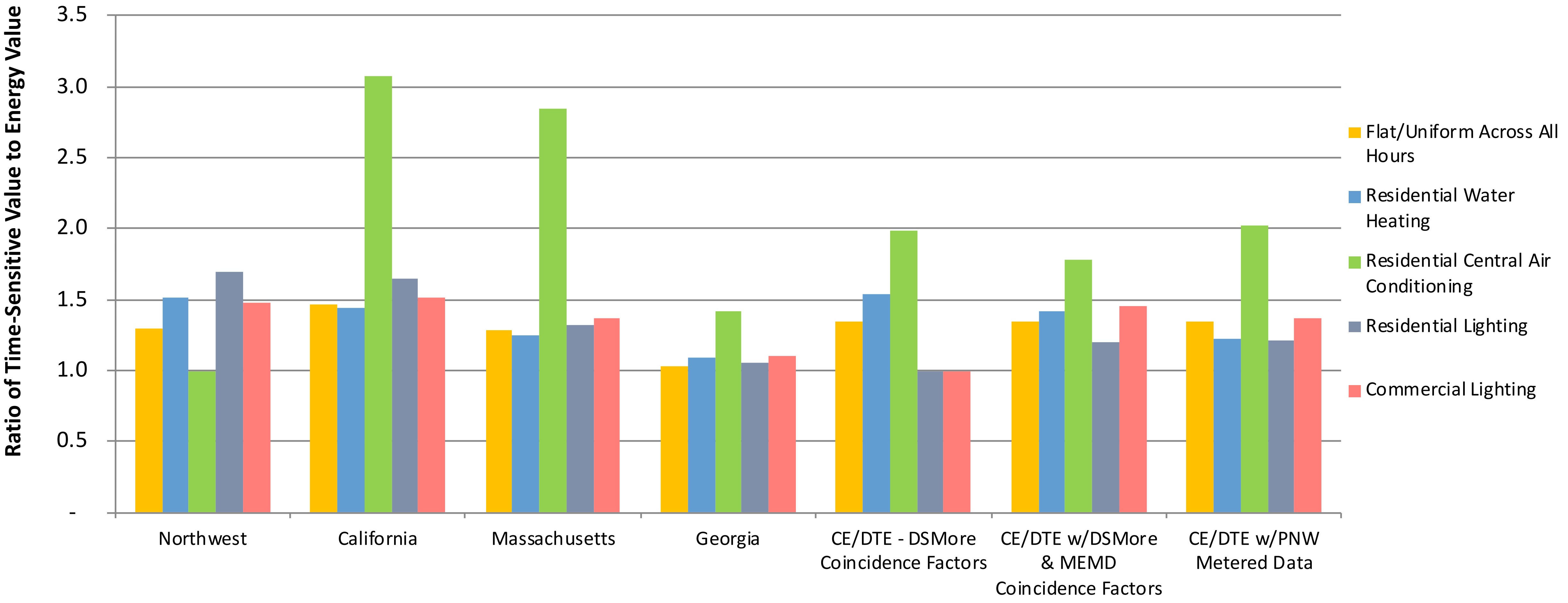


*CE/DTE is Consumers Energy and DTE Energy, utilities in Michigan

Massachusetts Time-Sensitive Value by Load Shape



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

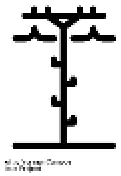


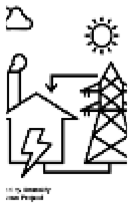
Notes: The flat load shape is an exit sign. Energy value includes: energy, risk, carbon dioxide emissions, avoided RPS and DRIPE, as applicable if reported. Total time-varying value includes all energy values and capacity, transmission, distribution and spinning reserves. Ratios are calculated by dividing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

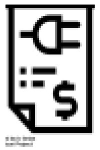
Forthcoming Berkeley Lab TSV-EE report

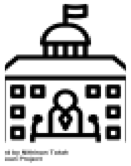
- *Time-Sensitive Value of Efficiency: Use Cases in Electricity Sector Planning and Programs*
- Study identifies 5 use cases that consider the time-sensitive value of efficiency


Energy efficiency planning


Distribution planning


Integrated resource planning


Rate design


State policies

Energy efficiency program design: Oncor

Select Incentives for Oncor 2019 Commercial Standard Offer Program

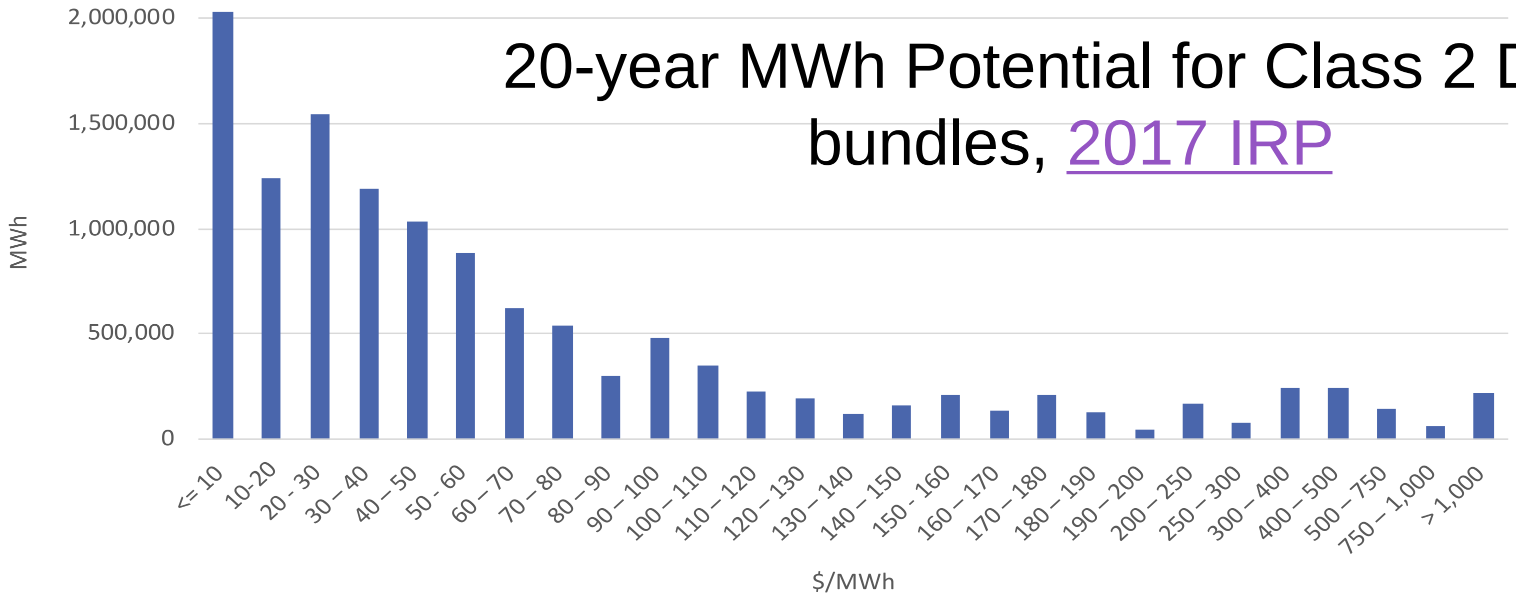
Description	Measure Life	$/kW for On Peak Demand Reduction	$/kWh for Annual Energy Reduction
Air Cooled Chiller	25	$387.81	$0.125
LED	15	$209.21	$0.057
Energy Star Commercial Dishwasher	11	$193.11	$0.054
Hot Food Holding Cabinet	12	$164.21	$0.041
Zero Energy Doors for Refrigerated Cases	12	$123.16	$0.025
Lodging Guest Room Occupancy Sensors	10	$86.51	$0.022
Refrigeration Evaporator Fan Controls	16	$49.57	$0.010
Vending Machine Controls	5	$20.64	$0.021
Pre-Rinse Spray Valves (Food Service)	5	$12.38	$0.004

TSV-EE Application: Several utilities in Texas, including Oncor, provide energy efficiency program incentives for both energy and peak demand savings. Peak demand reductions are calculated for each utility using methodologies described in the statewide technical reference manual.

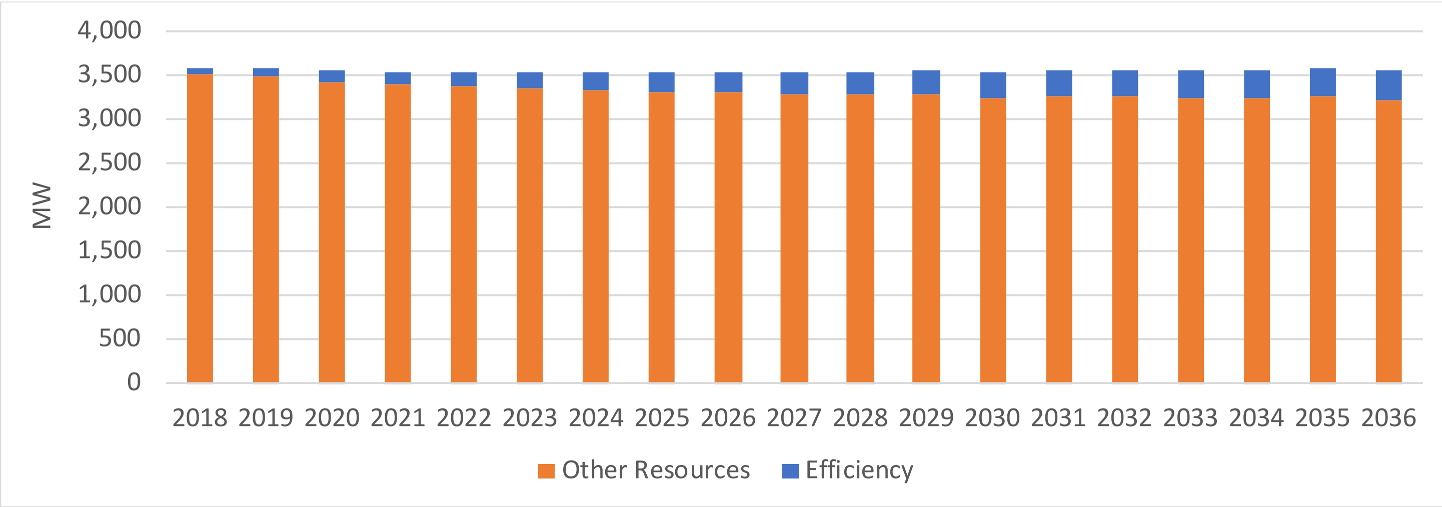
Integrated resource planning: PacifiCorp

TSV-EE Application: PacifiCorp creates energy efficiency cost curves using annual hourly (8,760) load shapes, which are inputs to the IRP capacity expansion model with all other resources. Allowing efficiency to compete with all other resources creates a reliable portfolio at least cost.

20-year MWh Potential for Class 2 DSM bundles, 2017 IRP

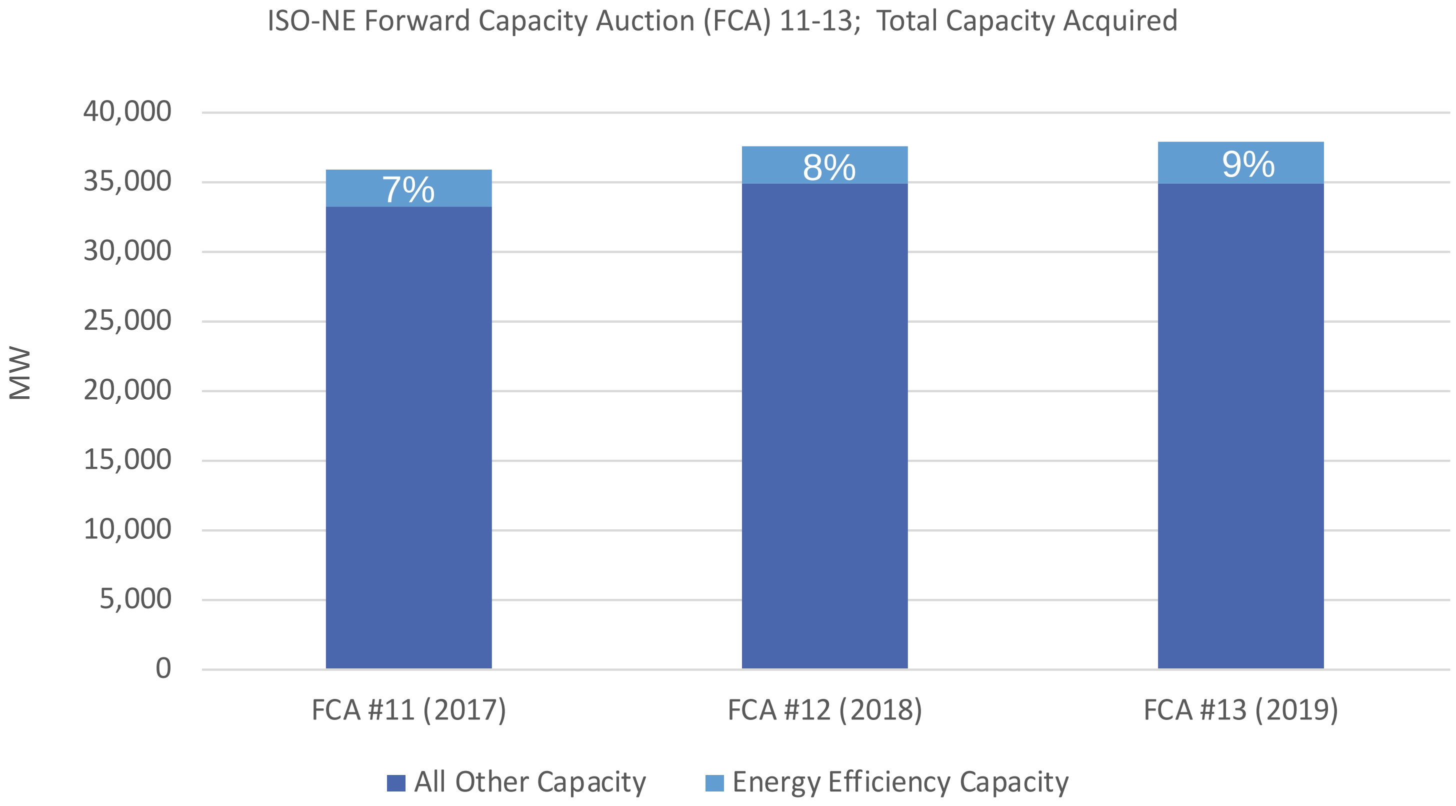


PacifiCorp-West Summer Capacity Load and Resource Balance, 2017 IRP Update



Capacity markets: ISO-NE

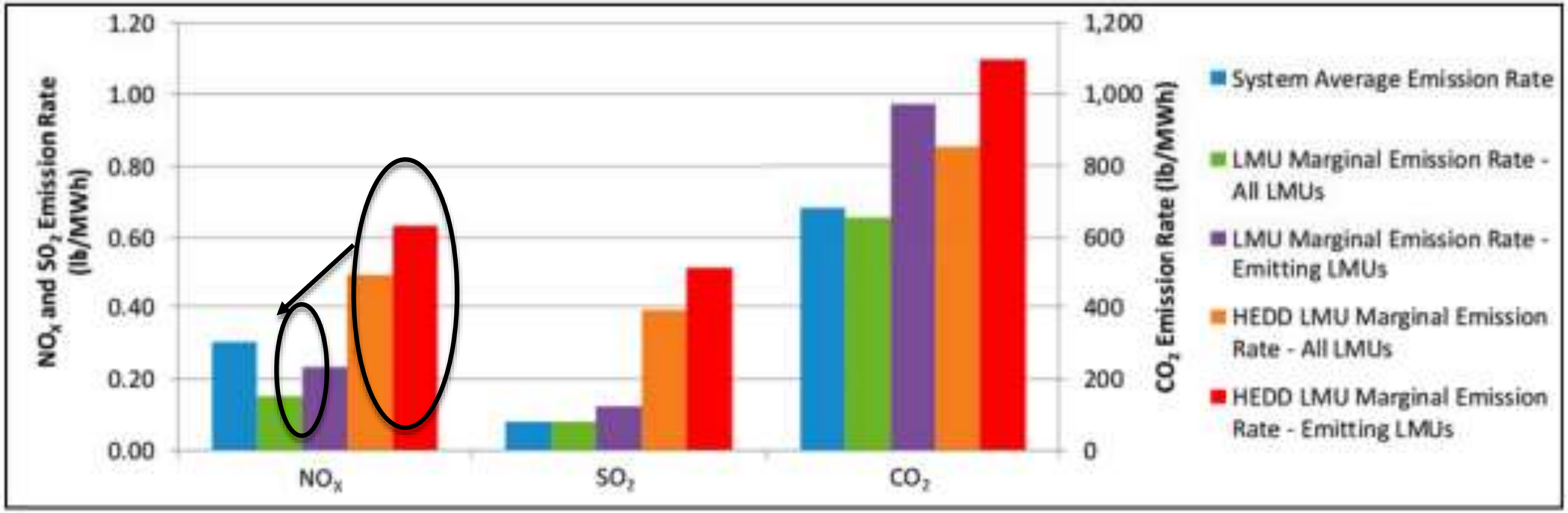
On-Peak Resources Performance Hours



Source: FCA #11, FCA #12, FCA #13

TSV – EE Application: Energy efficiency may participate in ISO-NE's Forward Capacity Market by bidding resources that produce demand reductions during designated hours for both summer and winter seasons.

Time-Sensitive Value: Criteria pollutant emissions reduction



This chart was made by ISO-NE and is included in their 2017 ISO New England Electric Generator Air Emissions Report

- The top 5 high energy demand days (HEDD) marginal emission rate for emitting locational marginal units are significantly higher than the marginal emission rate on all other days.

Questions for target audiences to consider

- Among the questions that states, utilities, program administrators, ISOs/RTOs and stakeholders can ask about this study as they consider implications for their jurisdiction:
  - In what ways is the time-varying value of efficiency — *energy, demand and economic value* — considered for planning and programs in the electric utility sector?
  - Are these time-varying values considered *uniformly* across the range of planning processes and programs?
  - What granularity and accuracy of data is needed to support a reliable, least-cost electricity system and other state energy goals?
  - Are data transparent and accessible to interested stakeholders?
  - If additional or updated data are needed, can multiple utilities leverage economies of scale for collection and use the same information?*
  - How will forecasted shifts in electricity consumption (e.g., due to distributed energy resources, changes in end-use loads) affect the value of efficiency throughout the day and year, as well as the need for time-based data?
  - How can the use cases in this report — and other research on time-varying value of efficiency — be used to improve planning and programs (e.g., how programs are prioritized, designed and evaluated)?
  - How can the use cases in this report — and other research on time-sensitive value of efficiency — be used to improve planning and programs (e.g., how programs are prioritized, designed and evaluated or how risk can be mitigated in electricity resource planning and procurement)?

*See Time-varying value of energy efficiency in Michigan (2018)

Related research

- End-Use Load Profiles for the U.S. Building Stock
  - Building Technologies Office (BTO) funded project that is a multi-lab collaboration to create end-use load profiles representing all major end uses, building types, and climate regions in the U.S. building stock.
  - Electricity Markets and Policy energy efficiency research
- Time and locational sensitive value of efficiency
  - Time-varying value of electric energy efficiency (2017)
  - Time-varying value of energy efficiency in Michigan (2018)
  - No Time to Lose: Recent research on the time-sensitive value of efficiency (webinar)
- The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Customers of Publicly Owned Utilities: 2012–2017 (forthcoming)
- Collecting and Analyzing Peak Demand Impacts from Electricity Efficiency Programs (forthcoming)
- Energy Efficiency in Electricity Resource Planning (forthcoming)

These are examples and are not meant to be a comprehensive list of related research.

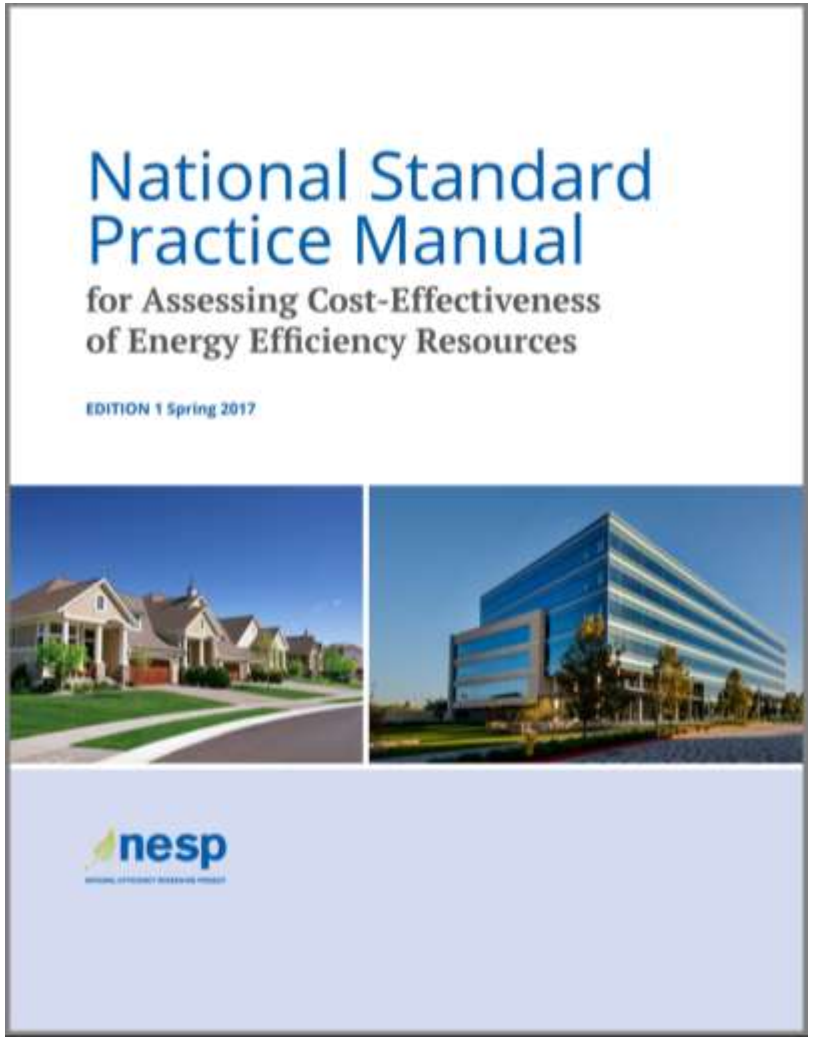
National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources

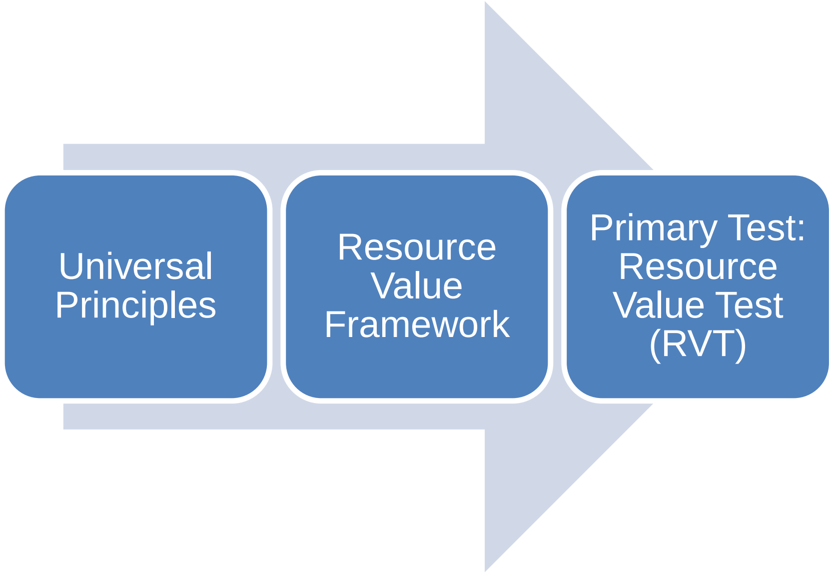
Julie Michals - E4TheFuture
NEEP EM&V Annual Public Meeting
May 21, 2019

Overview

1. Background – NSPM for EE
2. NSPM for DERs (coming in 2020)
3. Non-Wire Alternatives/Solutions (NWA/NWS)

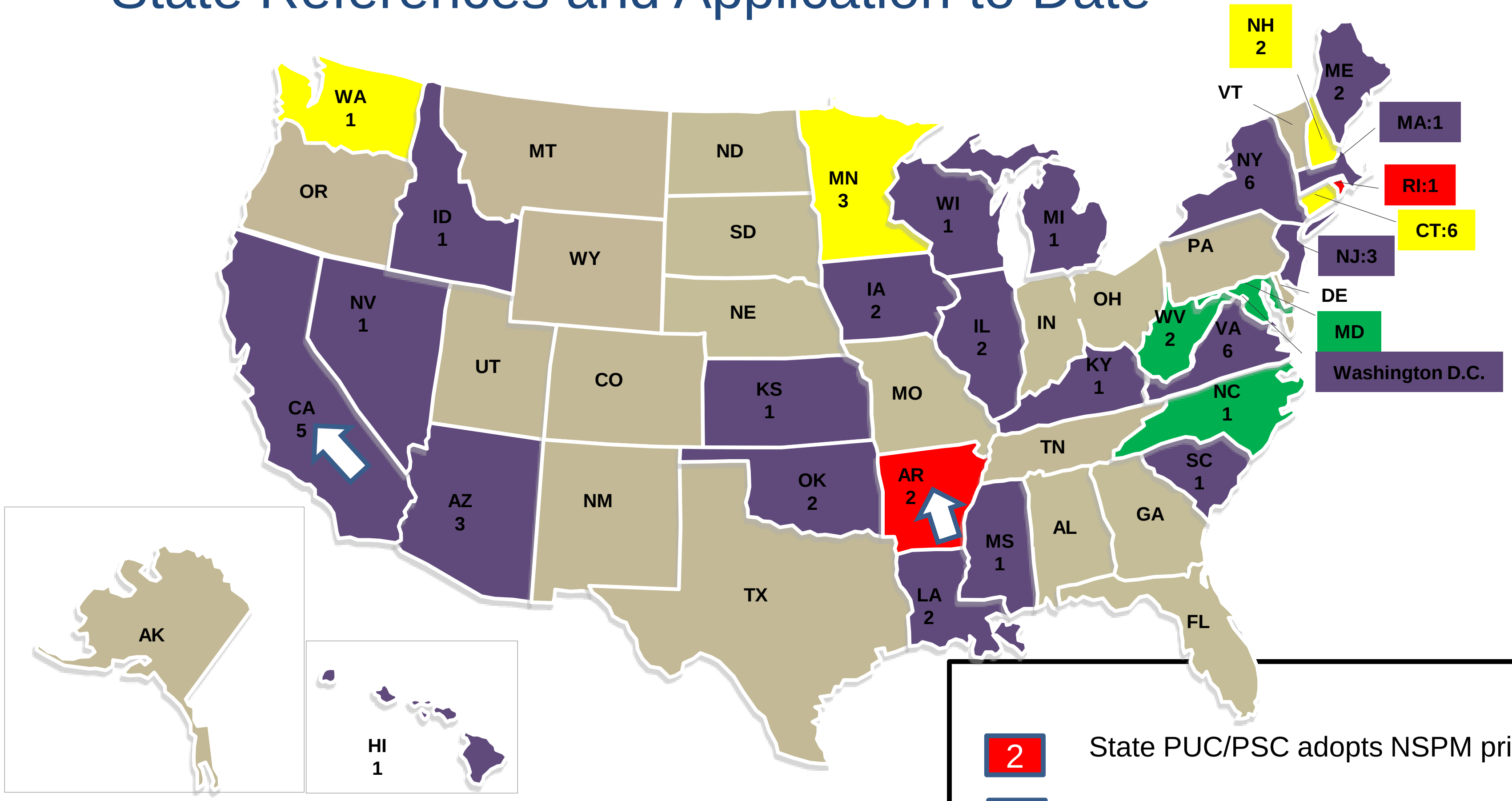
Background: NSPM for EE (May 2017)





- Align with applicable state policies
- Treat costs & benefits symmetrically
- Account for relevant impacts (even if hard to quantify)
- A state's test may align with a traditional test…. or not

NSPM for Energy Efficiency
State References and Application to Date



2	State PUC/PSC adopts NSPM principles
5	State actively applying NSPM review current test
3	State is in process of learning about the NSPM
20	References have been made in PUC proceedings but no official action yet taken

Why an NSPM for DERs?

- Growing interest in range of DERs as grid resources and for distribution planning → regulators need further guidance to support BCA considerations and common framework for DER analyses
- States currently are using different techniques, methodologies, and assumptions for DER BCA, leading to inconsistency even within states
- NSPM for DERs - will generally apply principles from the NSPM for EE guidance to DERs to support consistent and economically sound BCA policies and practices
- Project Schedule:

NSPM for DERs - Advisory Group

Name	Affiliation
Adam Cooper	Edison Foundation
Allison Clements	Energy Foundation
Andy Satchwell	Lawrence Berkeley Lab
Arthur Haubenstock	CA Efficiency + Demand Council
Ben King	US Dept of Energy
Carol White	National Grid
Chris Porter	National Grid
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Dan Cross-Call	Rocky Mountain Institute
Dan Delurey	Wedgemere Group
Dan Violette	Navigant Consulting
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Elizabeth Titus	Northeast Energy Efficiency Partnerships
Gregory Ehrendreich	Midwest Energy Efficiency Alliance
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Name	Affiliation
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Rodney Sobin	NASEO
Rob Kasman/Lucy Morris	PG&E
Ryan Chan	PG&E
Ryan Katofsky	Advanced Energy Economy
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NSPM for DERs - Consulting Team

Name	Company/Org
Brenda Chew*	Smart Electric Power Alliance
Chris Neme	Energy Futures Group
Karl Rabago	Pace Energy Center
Steve Fine	ICF
Steve Schiller	Schiller Consulting
Tim Woolf – Proj Coordinator	Synapse Energy Economics

* with Janet Gail Besser as Advisory Group member

The Goal of the NSPM for DERs:
Answering Key Questions

1. Why a common framework for assessing the value of DERs?
2. How should the Utility Cost test or Societal Cost test be used in assessing DERs? What costs and benefits should be accounted for?
3. Should a different, state-specific test be used in assessing different types of DERs? If so, how should that test be designed?
4. Should multiple tests be used to assess DERs? If so, how? Or should the same tests be used for all DERs? If not, why not?
5. How should DER analyses account for revenue-shifting, cost-shifting, rate increases, or rate decreases?
6. How should third party capital be assessed in valuing DERs (in particular for non-utility system impacts)?

Three Tiers of DER Analyses

1. Single-DER analysis; where one type of DER is assessed relative to a fixed (i.e., static) set of alternative resources.

2. Multiple-DER analysis; where multiple DERs are assessed and optimized relative to a fixed set of alternative resources.

3. Integrated-DER analysis; where all electric resources, both distributed and utility-scale, are optimized.

NSPM for DERs will focus on #1-2

NSPM for DERs Table of Contents

Ch 9. Non-Wires Alternatives/Solutions

NWA/NWS: use a portfolio of DERs in a specific geographic location to defer or replace need for specific T&D equipment upgrades

9.1 BCA Issues and Challenges

9.2 Relevant Costs and Benefits

9.3 Participant Impacts

9.4 Cost-Shifting

Ch 9. Non-Wires Alternatives/Solutions cont.

- Provide guidance on key challenges for NWA BCAs for multi-DER analysis:
  - interactive effects between DER operations;
  - magnitude of T&D costs (avoided upgrades);
  - approaches to identify order of DER implementation
  - temporal and locational value of DERs
- Temporal and locational aspects of avoided costs - important to get right (especially for some DERs) with focus: will NWA provide net benefits to customers?
- Point to latest literature (including LBL and NREL work) on methodologies used to estimate temporal or locational values
- Smart Electric Power Association (SEPA) – lead author on chapter

https://sepapower.org/resource/non-wires-alternatives-case-studies-from-leading-u-s-projects/

Project will Build on Past & Ongoing Projects

State BCA DER efforts (NY, CA, MN, etc.)

A Framework for Integrated Analysis of Distributed Energy Resources: Guide for States, LBNL+DOE 2018

- A framework for states to plan for and assess DER utility and non-utility impacts at the individual, multiple, and integrated levels.

NARUC-NASEO Task Force CEP 2019

- A task force on comprehensive electricity planning to align distribution system and resource planning processes.

NARUC-NASEO GEBs Working Group

- GEBS 2018: Grid-interactive Efficient Buildings - role of GEB in grid-mod efforts

Integrated Distribution Grid: Decision Guide, vol iii (DSPx), 2017

- DOE 2017: A review of what is necessary to develop a grid with integrated DERs and five common BCA test overviews.

EPRI, 2014 + other Integrated Grid Projects

- A framework for DER-grid integration planning, including a BCA methodology which considers Distribution System, Bulk System, Customer, and Societal Impacts.

Thank you!

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Lunch and Thank you to our State Partners

CONNECTICUT

State Partners: CT DEEP, CT Energy Efficiency Board, Eversource Energy, United Illuminating Company, Southern Connecticut Gas and Connecticut Natural Gas

Partners in 2017 / 2018 / 2019

DISTRICT OF COLUMBIA

State Partners: Department of Energy and Environment and DC Sustainable Energy Utility

Partners in 2017/2019

NEW HAMPSHIRE

State Partners: NH Office of Strategic Initiatives, NH Public Utilities Commission, Eversource Energy, NH Electric Coop, Unitil and Liberty Utilities

Partners in 2017 / 2018 / 2019

NEW YORK

State Partners: NYSERDA

Partners in 2017 / 2018 / 2019

RHODE ISLAND

State Partners: RI Office of Energy Resources, National Grid RI, RI Department of Education and RI Energy Efficiency & Resource Management Council

Partners in 2017 / 2018 / 2019

VERMONT

State Partners: Efficiency Vermont

Partners in 2017 / 2018 / 2019