# EMERGING METHODS IN TIME DEPENDENT VALUATION

*Informing Innovation: Research and Evaluation in a Changing Energy Landscape*

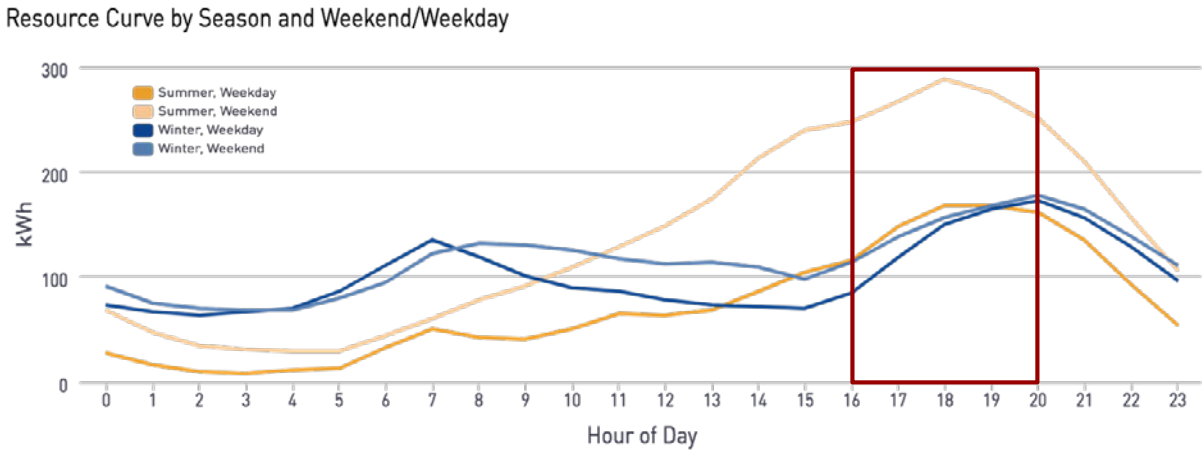
Denver, 2019

Moderator: Carmen Best, Recurve

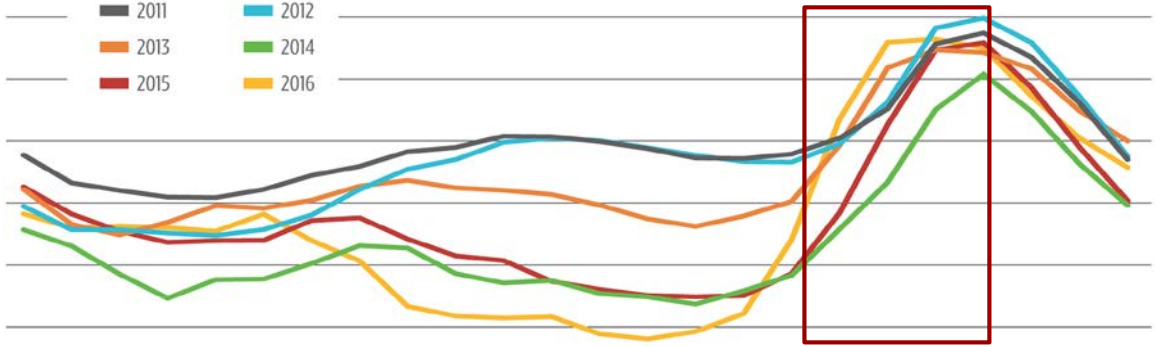
# The Challenge

- Times are a changin’
- Valuation of efficiency needs to be tied to grid opportunities
- Cost effectiveness regimes and deemed assumptions need re-examination

## Resource Curve




## Duck Curve



# The Presenters

## Miles Ingram

Senior Analyst
Energy Efficiency
Eversource Energy

+9 Years at US GAO

M.S. in Policy from Carnegie Mellon University

## Jeremy Petersen

CIP/DSM Technical Consultant
Xcel Energy

+12 years at Xcel

B.S. in Statistics from Iowa State University

## Justin Hagler

Regulatory Analyst at California Public Utilities Commission

+ Smart Grid Library

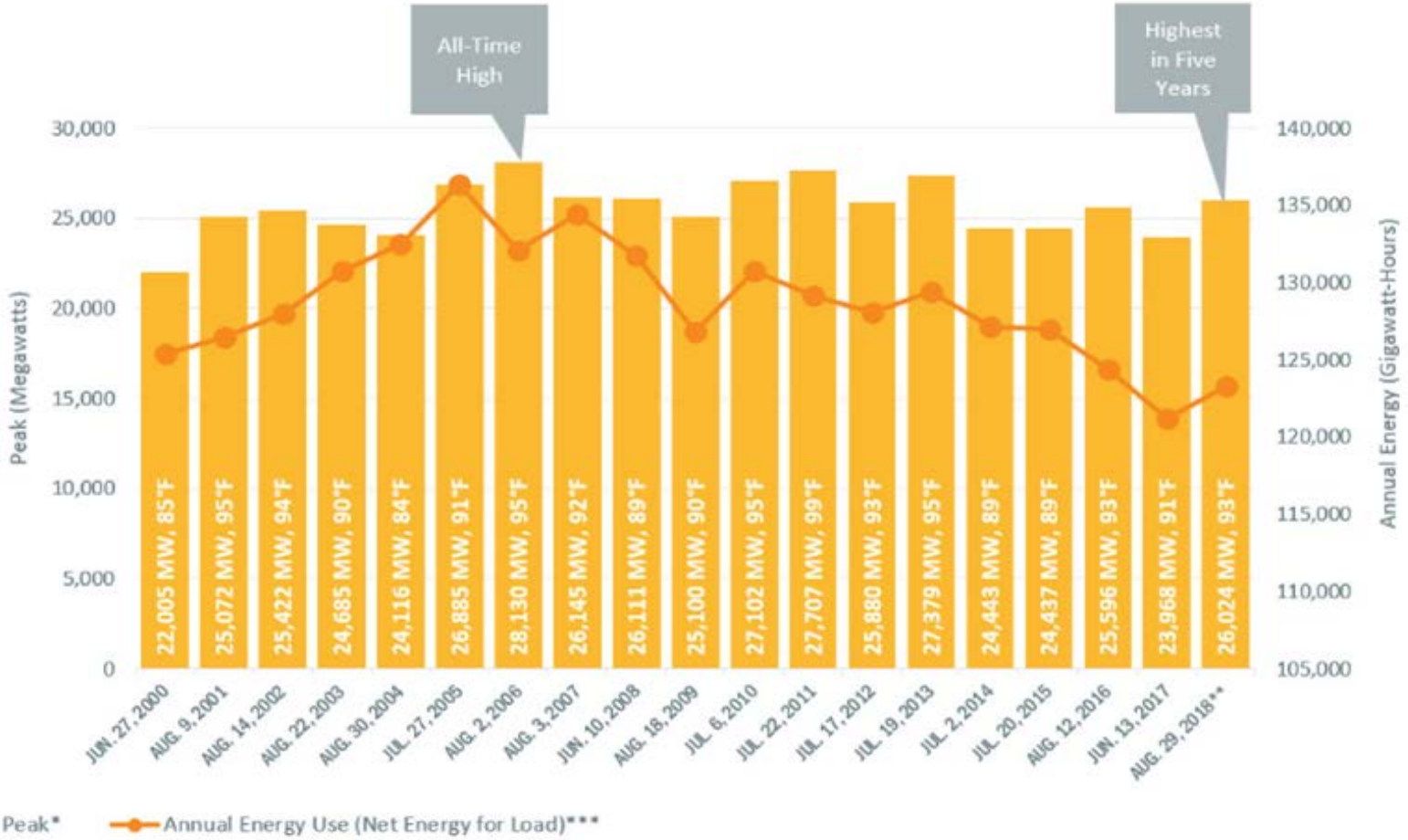
B.S. in Society & Environment from University of California, Berkeley

# Time Is Money:

## Leveraging EM&V to Value Peak Savings for Customers, Programs, and the Grid

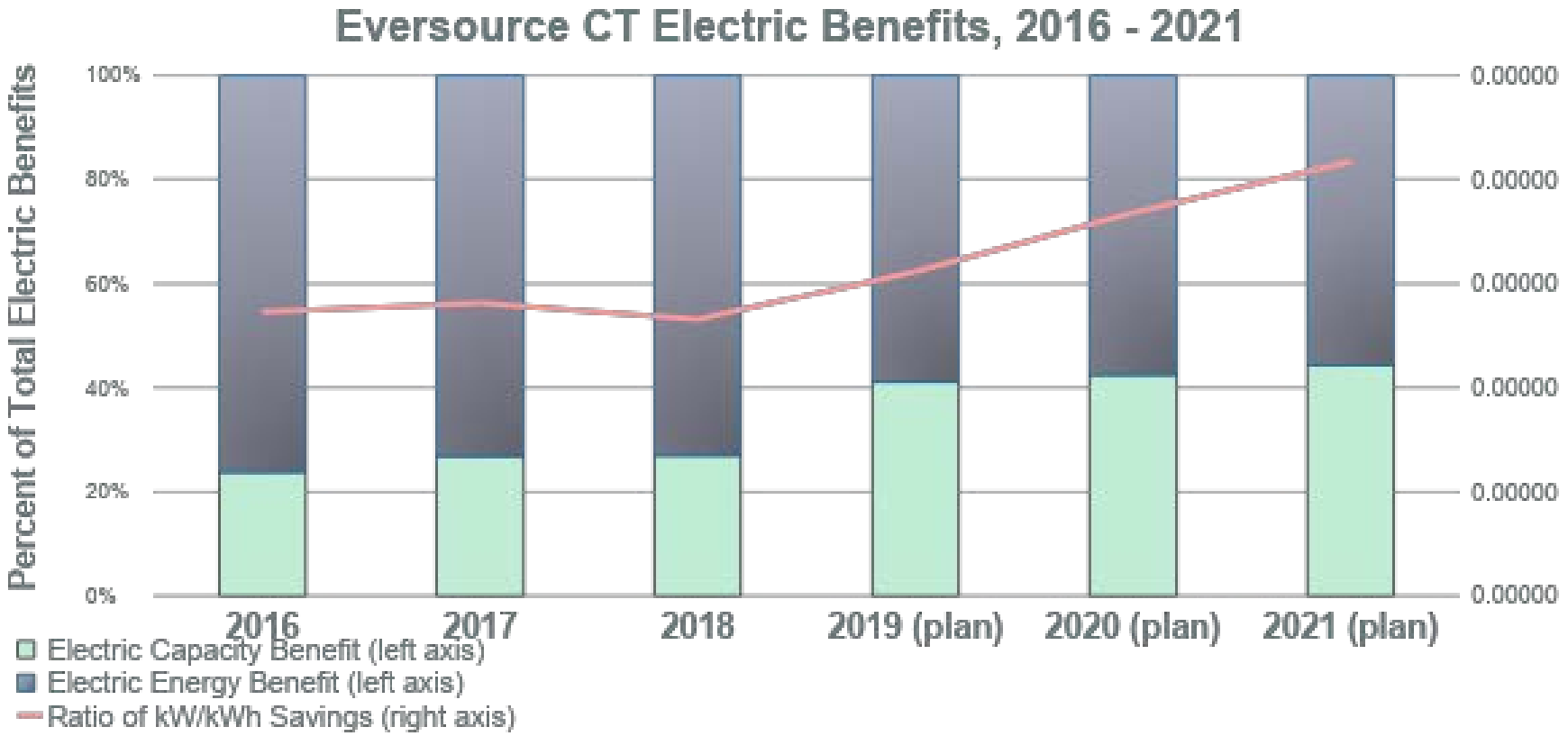
*Miles Ingram, Eversource Energy*
*Co Authors: Brian Greenfield, Eversource*
*Tom Ledyard, DNV-GL*
*Justin Spencer, Navigant*

# Peak Demand vs. Energy Use, ISO-NE



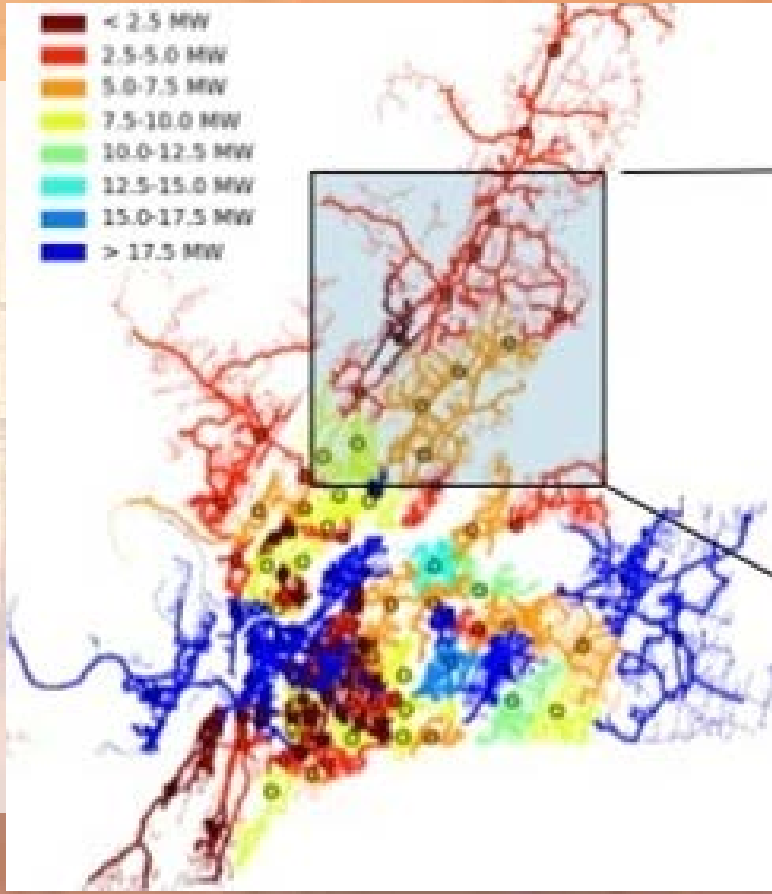

Source: ISO New England. Seasonal Peaks since 1980 Reports (8/6/2018), Net Energy and Peak Load Report (1/14/19), and Annual Generation and Load Data for ISO NE and the Six New England States Report (8/8/17).

# Programs Increasingly Focused on kW



# T&D Costs Driven by Customer Peaks

- C&I customers in particular have large variations in consumption and demand
- Transformers, wires, and substations must be on constant standby and sized for peak periods of demand
- Demand charges ensure customers who create peak demands pay for the costs of meeting the demand



# Customer Peak:

## New Hampshire Lost Base Revenue Working Group

- 2018-2020 NH Energy Efficiency Plan: NH PUC order established an LBR Working Group to "*consider the general impact of customer peak*" and "*determine the appropriate kW savings value for the Commercial and Industrial sector*" for calculating demand charge LBR

- Demand charges are typically assessed on a customer's monthly maximum demand during any 30-minute interval

- The more a measure's savings are coincident with monthly customer peak, the greater the reduction in demand charges, and the more kW LBR

**VS.**

# Constraints: Time and Money

- **Time**. Per NHPUC order, the method was to be applied beginning January 2019.
- **Money**. Total amount of kW LBR at stake estimated at around $1 million. Metering a representative sample of end uses to refine that estimate could cost almost as much as the value of the kW LBR.
- **2018-2020 Plan, Settlement Agreement.** "LBR calculations are based upon averages and … it is not feasible to track demand charge impacts on a customer-by-customer basis."

**Leverage existing EM&V data**

# Selected Method

The Group identified a combination of sources of available load shape data that best balanced time, cost, and accuracy.

1) **Customer class load shapes.** Existing Eversource data on average hourly demand profiles for each customer class were used to identify C&I customers' average peak hour for each month of the year

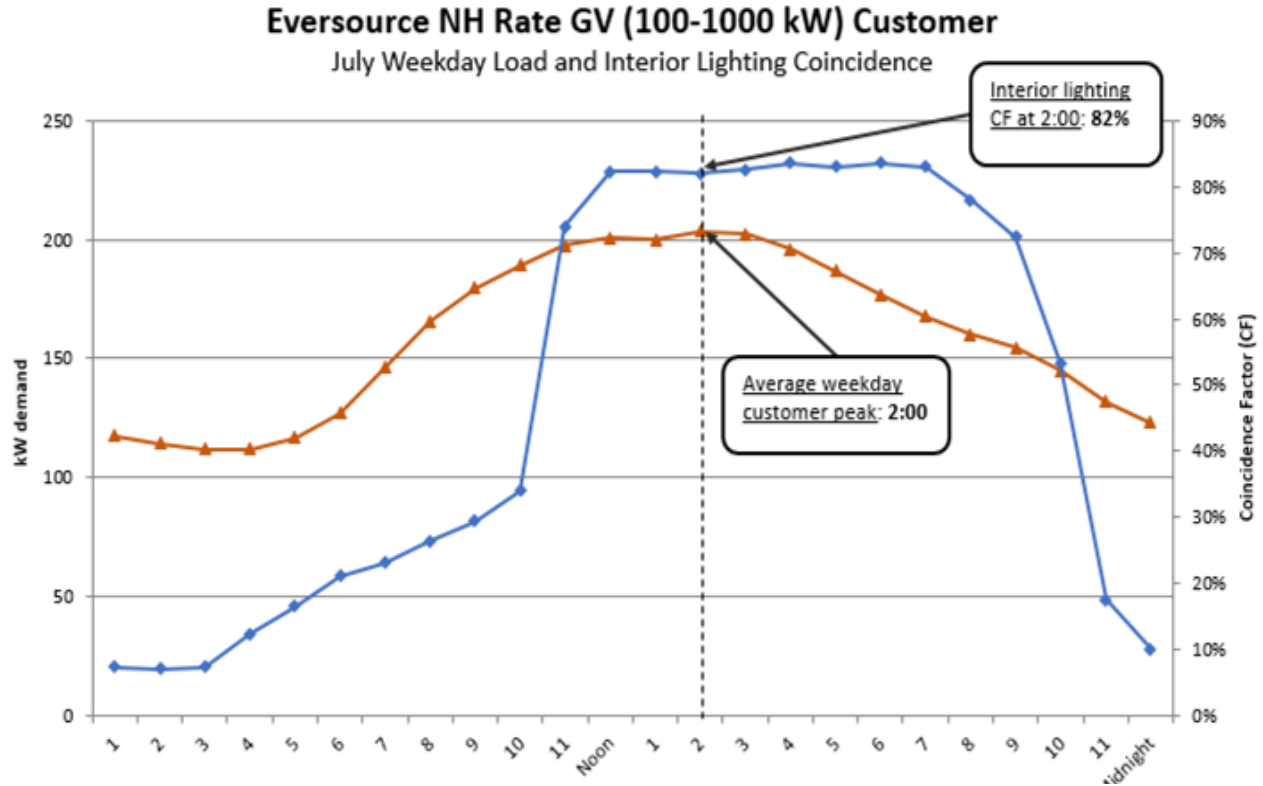
1) **End use load shapes.**

a. DNV-GL evaluation of the NH Large Business program: hourly usage data for lighting, HVAC, and other measure types. Equipment monitoring at 42 on-sites, for an average of seven weeks, annualized based on business cycles, seasonal variations in use, and planned/scheduled shutdowns.

a. Electric Power Research Institute Load Shape Library: data for end uses not captured by DNV-GL: refrigeration, domestic hot water, and motors/drives

# Analysis and Next Steps

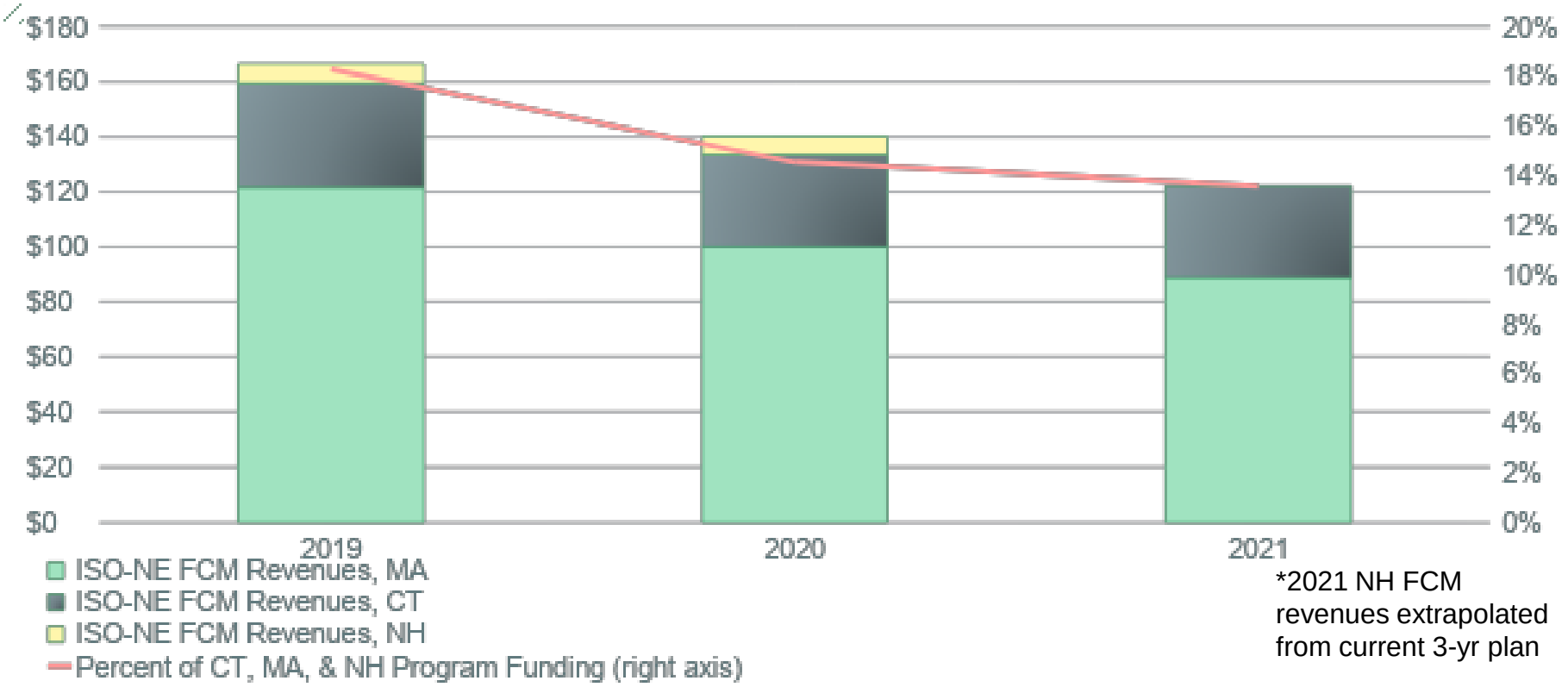
$$\textbf{LBR kW Savings} = \textit{Max connected load} * \textit{Customer Peak Coincidence} * \textit{Realization Rate} - \textit{Retirement Adjustment}$$




**Known limitations** future evaluations will be used to supplement results

# ISO-NE Peak: Forward Capacity Market, etc.

## FCM funding is an important, but shrinking, source of program funding




*2021 NH FCM revenues extrapolated from current 3-yr plan

# Measuring Peak Savings for the FCM

## MA vs. CT: Two peak definitions, two sets of EM&V results

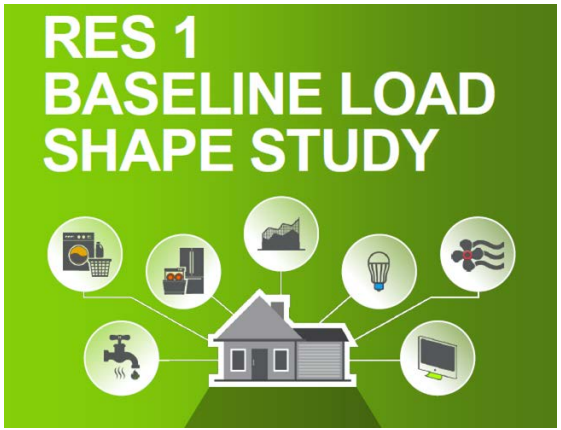
- **MA:** *On-peak resources* reduce consumption during
  - SUMMER: nonholiday weekdays, 1:00 to 5:00 p.m., in June, July, and August
  - WINTER: nonholiday weekdays, 5:00 to 7:00 p.m., in December and January

- **CT:** *Seasonal peak resources* reduce consumption in hours on nonholiday weekdays when real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak load forecast for summer or winter season *(same months as on-peak periods)*

**Can we leverage one study for two states?**

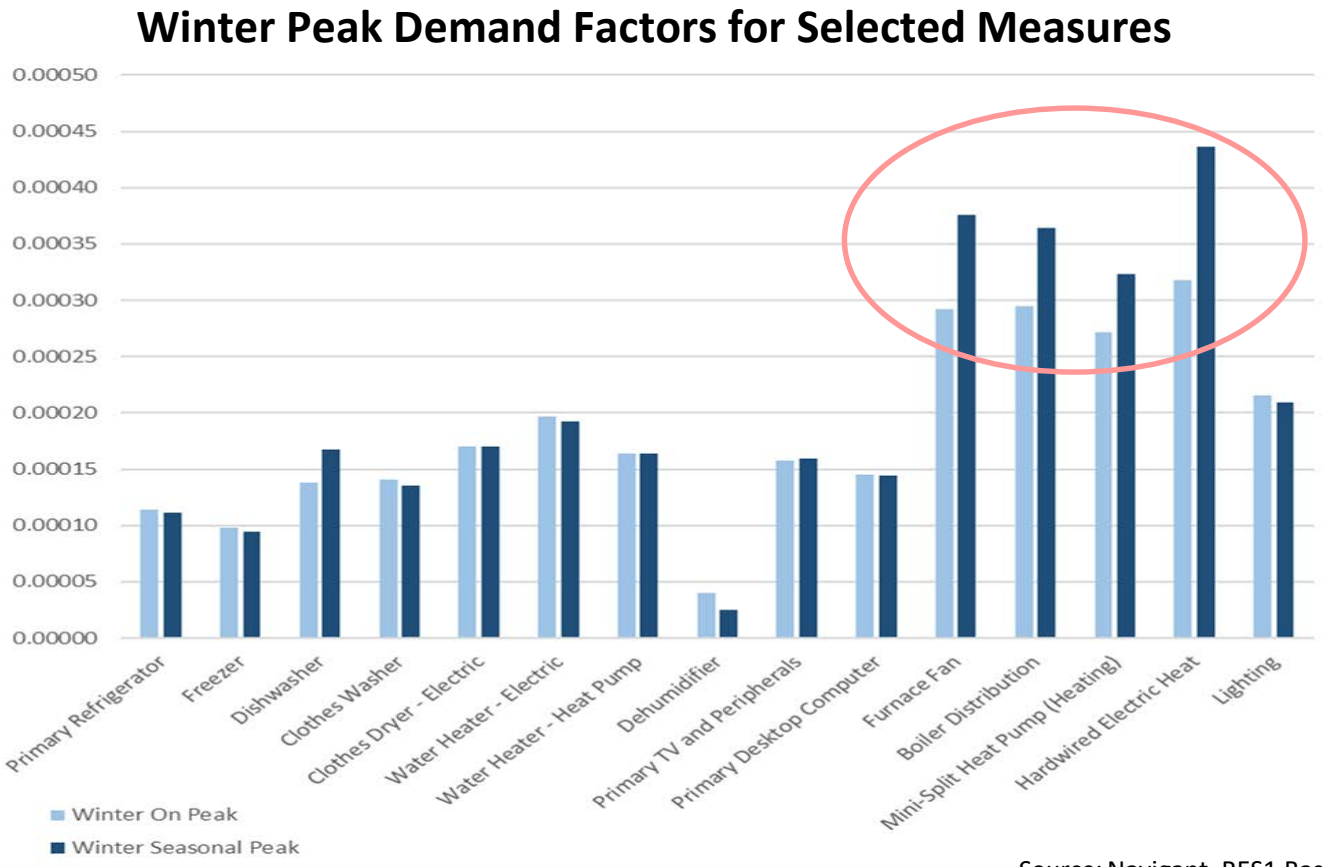
# Leveraging 8760 Data for Multiple Peaks

- Navigant, RES 1 Baseline Load Shape Study: usage data for all major electric and gas appliances, mechanical equipment, and electronics in MA homes (20 end uses)
  - 300 core site visits and 56 oversample site visits completed over 2017– 2018
  - Weather normalization models run on 15 years of actual weather data; typical year chosen for each month and each peak period from the year that produced the median energy consumption results across all end uses for that month/peak period
  - Spreadsheet model of 8760 load shapes and peak demand impacts



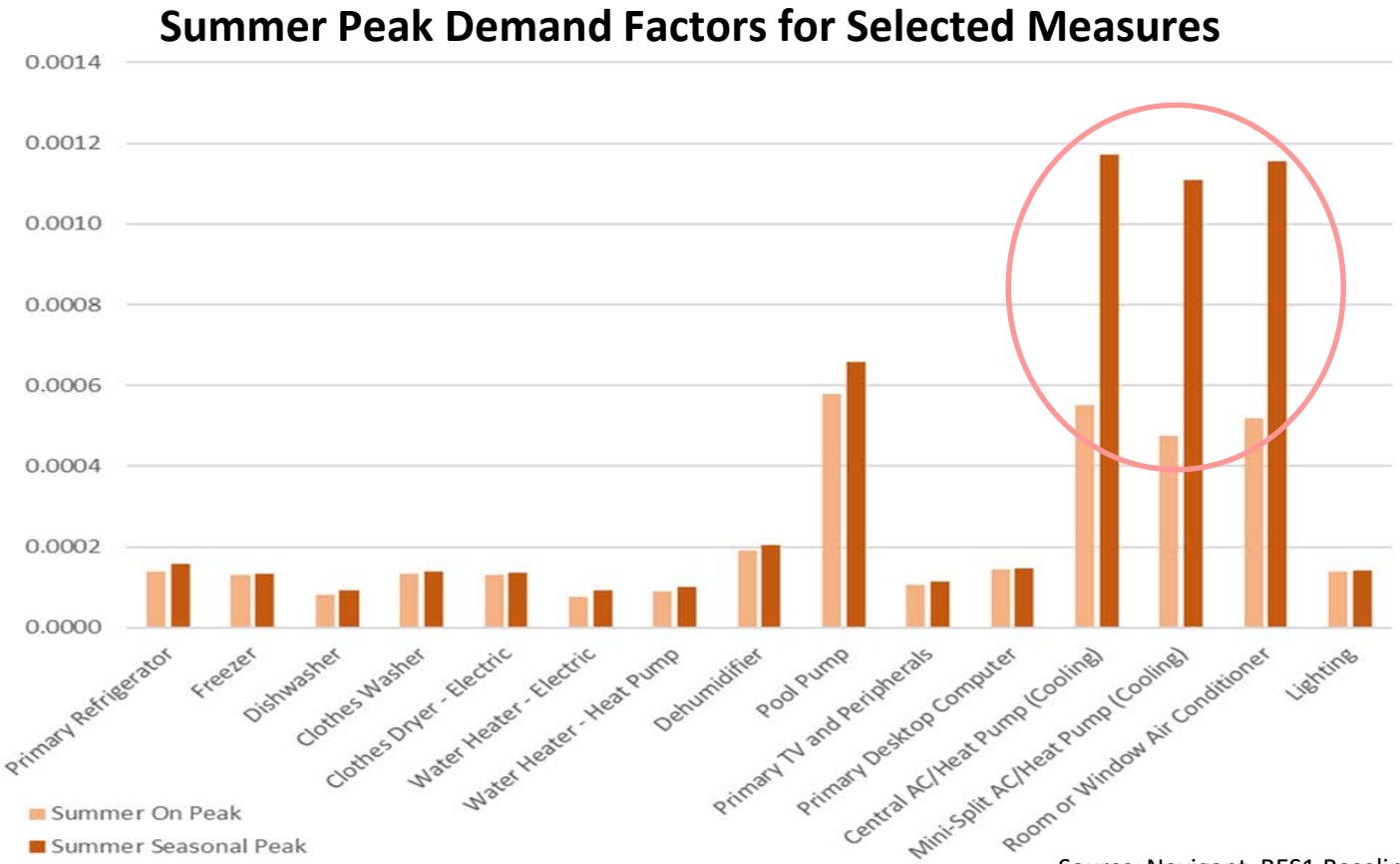

- Leveraging load shapes: Program administrators wereable to use the same underlying 8760 load shape data to develop both on-peak & seasonal peak demand factors.

# Leveraging 8760 Data for Multiple Peaks



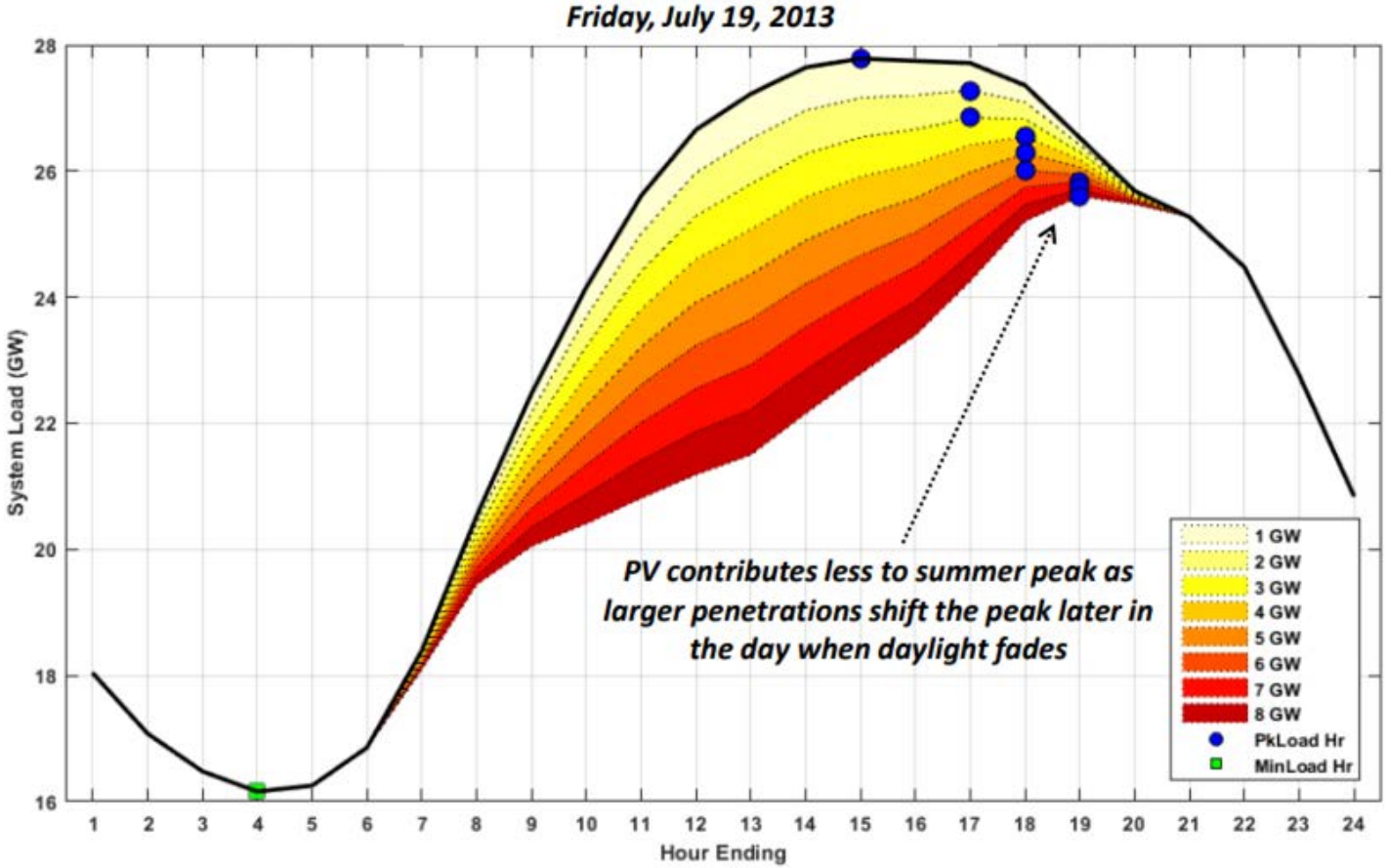

*Source:* Navigant, RES1 Baseline Load Shape Study

# Leveraging 8760 Data for Multiple Peaks




*Source:* Navigant, RES1 Baseline Load Shape Study

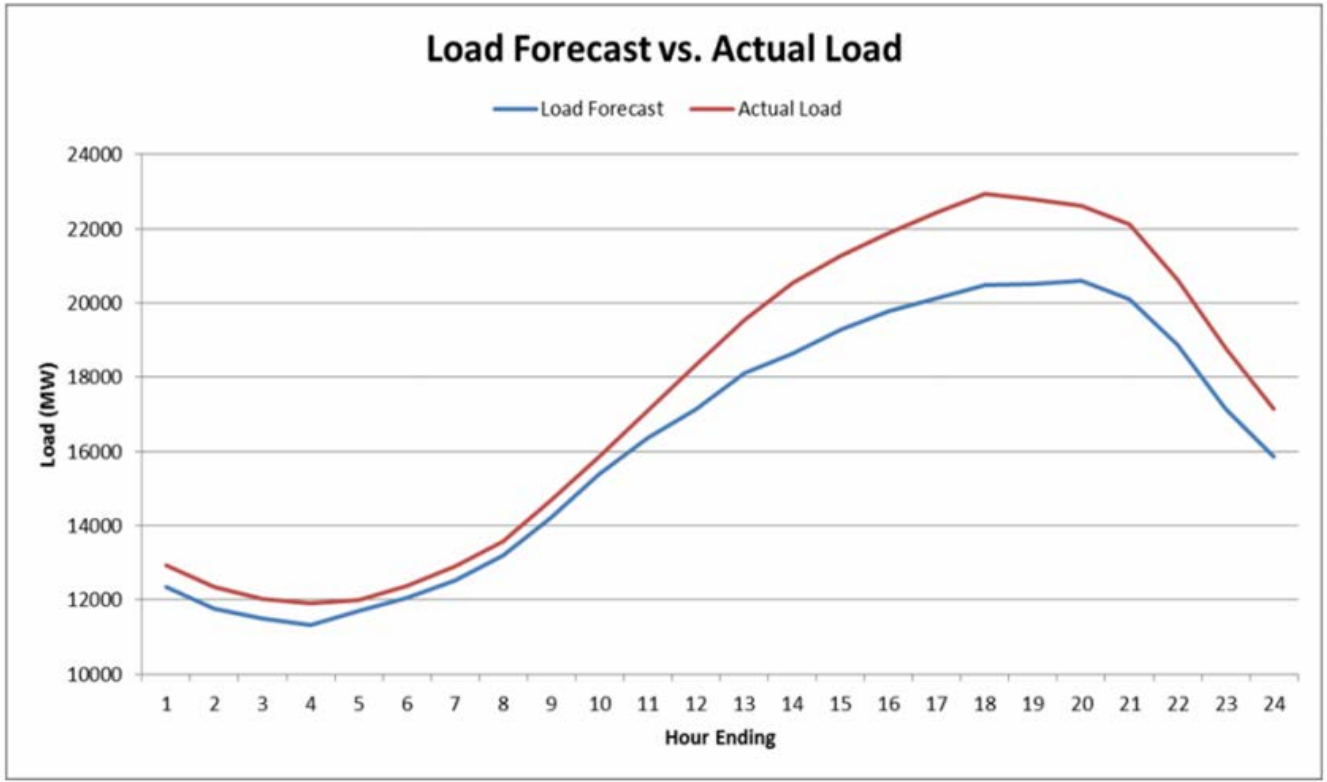
# ISO-NE Peak: Future EM&V Needs




Source: ISO-NE, "*Understanding the Impact of Behind-the-Meter Solar on Grid Operations and Regional Planning*," presented at the Consumer Liaison Group Meeting, June 1, 2017.

# ISO-NE Peak: Future EM&V Needs

September 3, 2018 capacity scarcity condition: an “off peak” peak, exacerbated by ~1650 MW unplanned generator outages




**How should the performance of energy efficiency resources be measured—and compensated—during “off peak” periods?**

# ISO-NE Peak: Future EM&V Needs

Stakeholder process to determine how to estimate the performance of EERs in all hours:
Several limitations to 8760 were noted:

- **Cost and timing considerations**. Currently, ISO-NE FCM requires precise M&V for the *3.8% of hours* occurring during defined peak periods.
  - More hours = more money, more time to quantify
- **Less consistent measure types (e.g., custom measures)** can represent a third or more of Eversource's portfolio energy savings, depending on the year.
  - More difficult & costly to quantify.
- **Performance during demand-driven peaks.** Without dynamic weather-based modelling capabilities, 8760 data will reflect savings based on typical weather conditions, and will understate performance during a weather-driven event (e.g., Labor Day 2018)

**Outcome of stakeholder process still TBD**

# Bang for the EM&V Buck

Goal to prioritize "*methods that require the least time and expense to develop and implement.*"

- **"Shaping Option A."** Use existing peak values to estimate off-peak performance, multiplying by ratio of system load during a CSC to the projected load during that year's peak period

## Leverage existing EM&V data

$$ACP_{ee} = Perf_{ee,\ On-Peak} * \frac{SL+PV}{ASL_{s,w}+APV_{s,w}} * 1.08$$

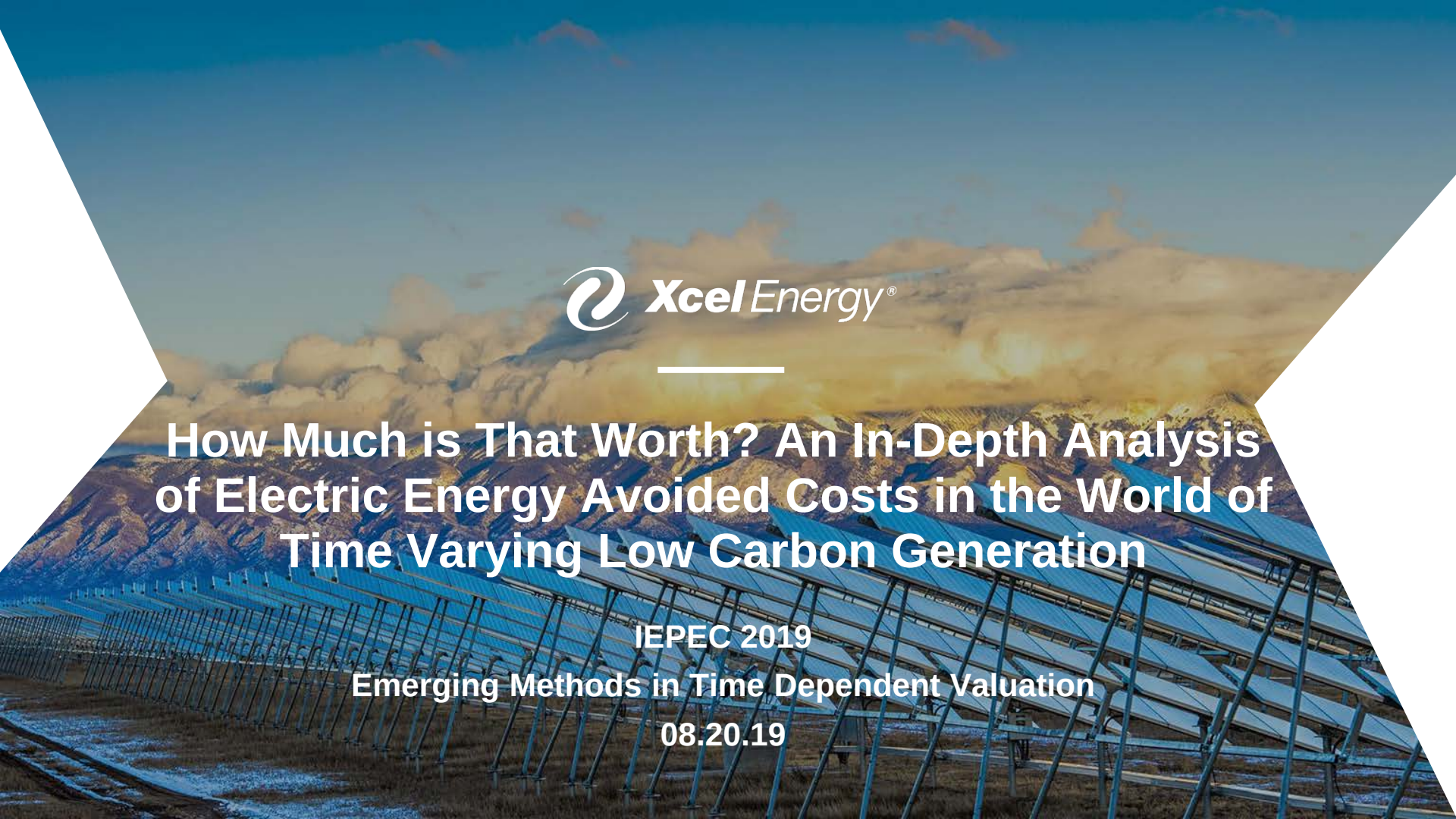
**Longer term**: shifting peaks + shifting EE measure types = shifting needs for EM&V

- Need to balance **cost**, **rigor**, and **long-term value…**
  - *i.e., resilience to a broad range of future peak scenarios*
- Regulators and stakeholders are seeking (***cost***) savings…
  - Inter-state/regional collaboration
  - Declining costs of communicating metering equipment

# Time-Dependent Valuation for Parents

# How Much Is That Worth? An In-Depth Analysis of Electric Energy Avoided Costs in the World of Time Varying Low Carbon Generation


*Jeremy Petersen, Xcel Energy*
*Co Authors: Erin Buchanan, Xcel Energy*
*Nick Minderman, Xcel Energy*
*George McGuirk, Xcel Energy*



# How Much is That Worth? An In-Depth Analysis of Electric Energy Avoided Costs in the World of Time Varying Low Carbon Generation

**IEPEC 2019**

**Emerging Methods in Time Dependent Valuation**

**08.20.19**

# Changing Generation Landscape


**Renewable Generation**

- Wind and Solar increased from 2% (2009) to 9% (2018) of US Generation[1]
- Expected to be the fastest growing segment of generation 2019 and 2020[2]
- Not Dispatchable

**Energy Efficiency**

- Annual Energy Efficiency Increased from 0.6% (2013) to 0.7% (2017)[1]
- Annual Goals of 1.0% to 2.0%
- Generally affects build of fossil-fuel generation


**Fossil-Fuel Generation**

- Coal and Natural Gas declined from 68% (2009) to 62% (2018) of US Generation[1]

1 – US Energy Information Administration (EIA)

2 – EIA, *Short-Term Energy Outlook*

# Energy Efficiency Marginal Energy Sources

**Regional Transmission Operator**

- Locational Marginal Prices (LMPs)
- Static Regional Generation Portfolio


**Utility Dispatch Model**

- Static Utility Generation Portfolio
- Runs w/ and w/o Future Energy Efficiency


**Proxy Plant Method**

- Resource Planning Modeling
- Delta in Generation Assets w/ and w/o Future Energy Efficiency

**w/o EE**


–

**w/ EE**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# Coal Generation Retirement Case

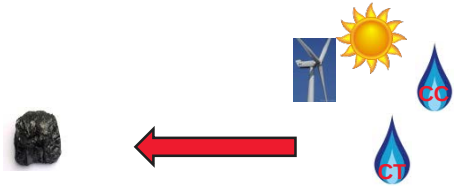
**Resource Planning modelling shows Future Energy Efficiency accelerates retirement of last coal plant on Utility System**

**Regional Transmission Operator**

- Utility Coal Retirement has little effect


**Utility Dispatch Model**

- Coal removed from Generation Portfolio




**Proxy Plant Method**

- Entirely Coal Energy

**w/o EE**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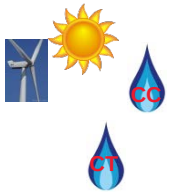
**w/ EE**

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# Xcel Minnesota Example

**Summary of Marginal Energy Sources for Xcel System serving Minnesota Customers**

**Regional Transmission Operator**

- Midwest Independent System Operator
- Generation Assets from Region
- Load includes Energy Efficiency Impacts
- Hourly Marginal Energy: LMP at regional node

**Utility Dispatch Model**

- PLEXOS Model
- Generation Assets from Xcel System + Limited external assets
- Load includes Energy Efficiency Impacts
- Hourly Marginal Energy: Production Cost

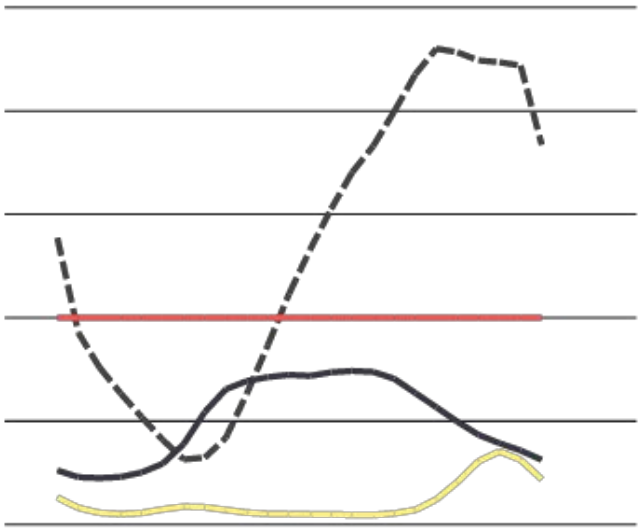
**Proxy Plant Method**

- Xcel 2019 Upper Midwest Resource Plan
- Energy Efficiency (DSM) results in deferral of coal plant
- Coal plant identified as Proxy Plant
- Annual Marginal Energy across all hours

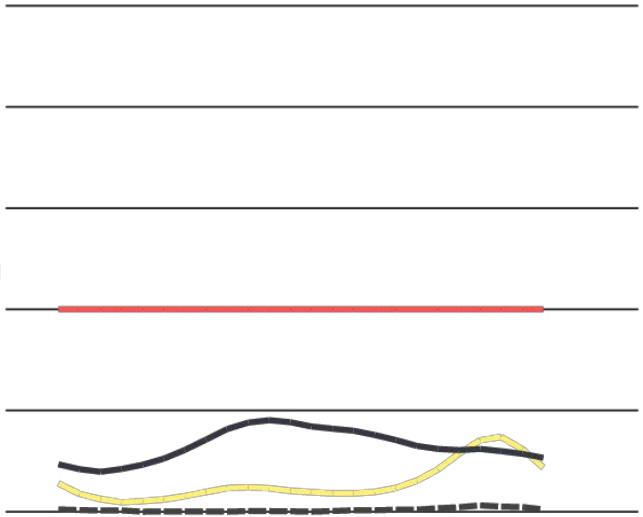
# Impact on Avoided Energy

**Four Common Energy Efficiency Technologies**

**Summer Weekday**

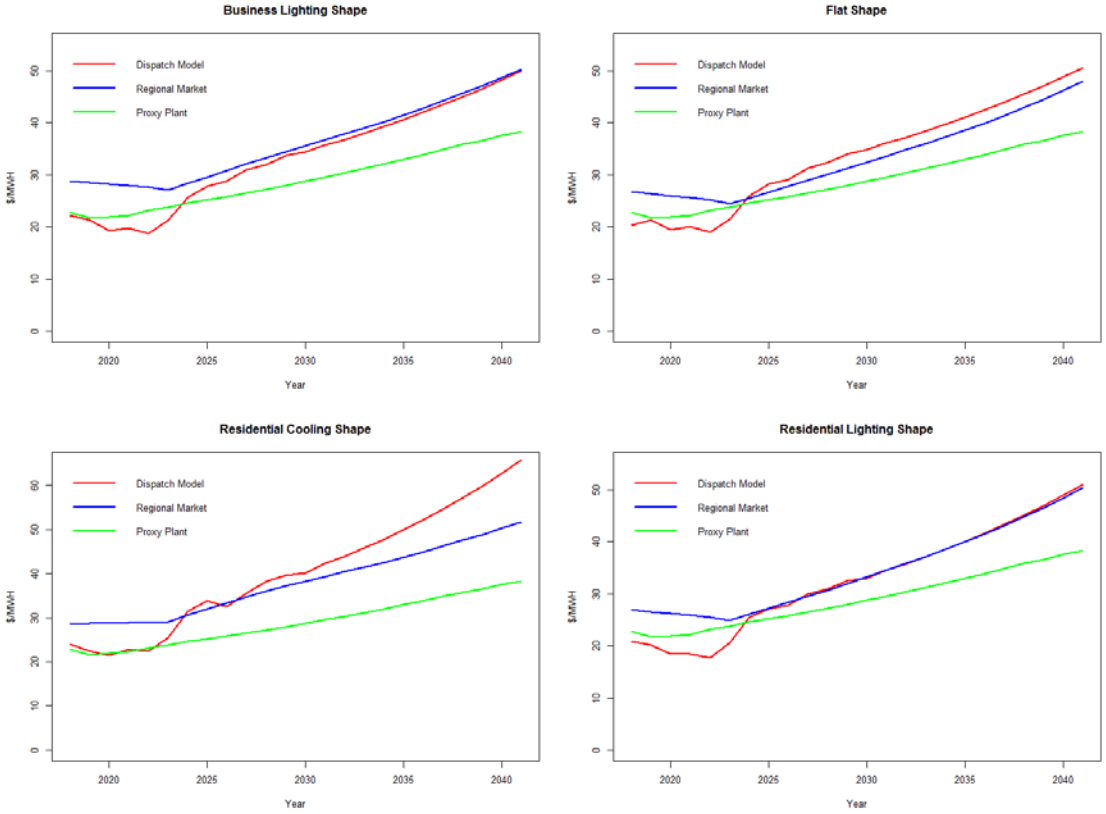


**April Weekend**



Residential Cooling
Flat
Residential Lighting
Business Lighting

# Impact on Avoided Energy



# Marginal Energy Source Considerations

- **Key Factors**
- ***Are there material differences between the generation assets with and without DSM?***
- ***Will a plant be avoided or deferred?***
- ***What is the source of the energy that is avoided?***
- ***What applications will these results and methods be used for?***
- ***How do policies influence the methods?***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# Changing Objectives of Energy Efficiency Evaluation in a Renewable Energy Driven Grid


*Justin Hagler, California Public Utilities Commission*

# Changing Objectives of Energy Efficiency Evaluation in a Renewable Energy Driven Grid

Justin Hagler
California Public Utilities Commission
San Francisco, CA

# Introduction

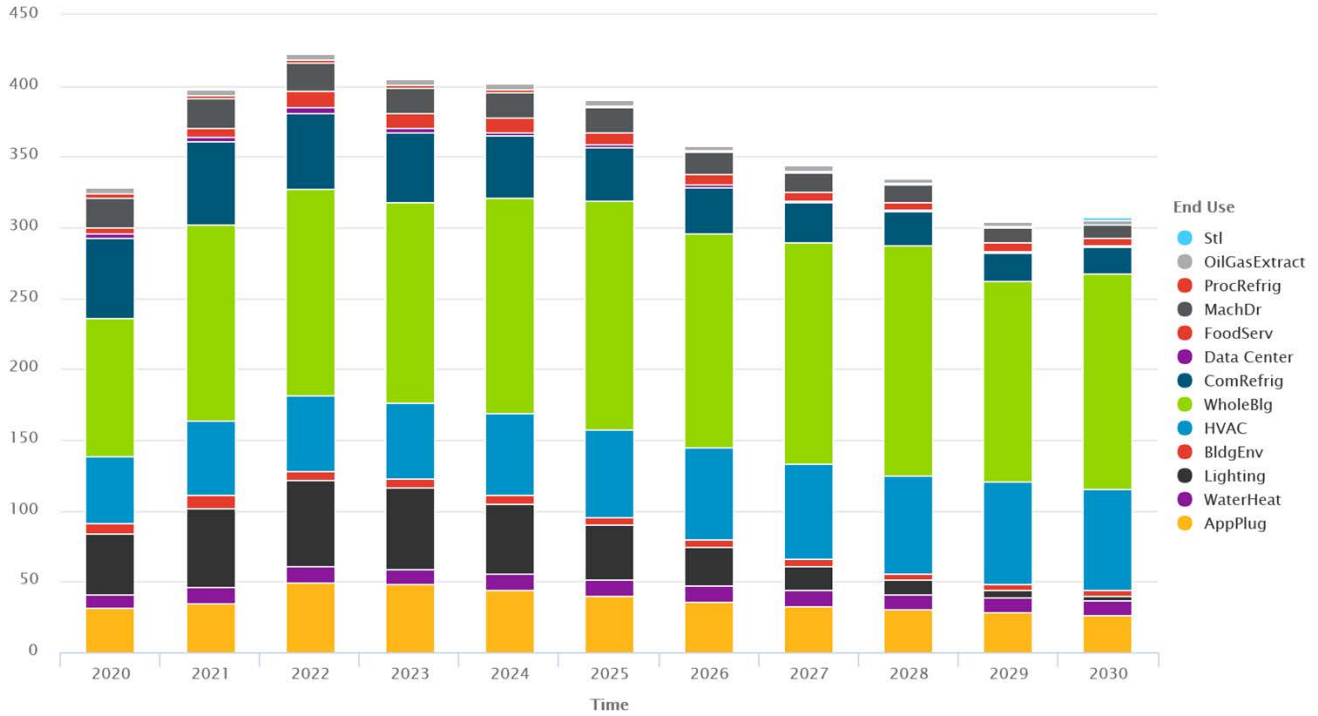
- California is a leader in renewable energy procurement Since 2002
  - CA SB 350- 50% renewable energy by 2030
  - CA SB 100- 100% carbon free retail sales by 2045

- Electric load from HVAC can exceed 30% of California's total electric demand on peak days, and more units are being installed every year.

- How do hour and season dependent savings from HVAC efficiency programs impact the use of renewable energy? What are the policy implications?

# HVAC Efficiency Potential

- CPUC modeling forecasts a 47% increase in incremental efficiency savings from HVAC (19% of total portfolio) through 2030



# Background

- In 1976, 25% of new California homes had central air conditioning. Today, it is 95%
  - **New home size has increased, and are being constructed in hotter areas of California**

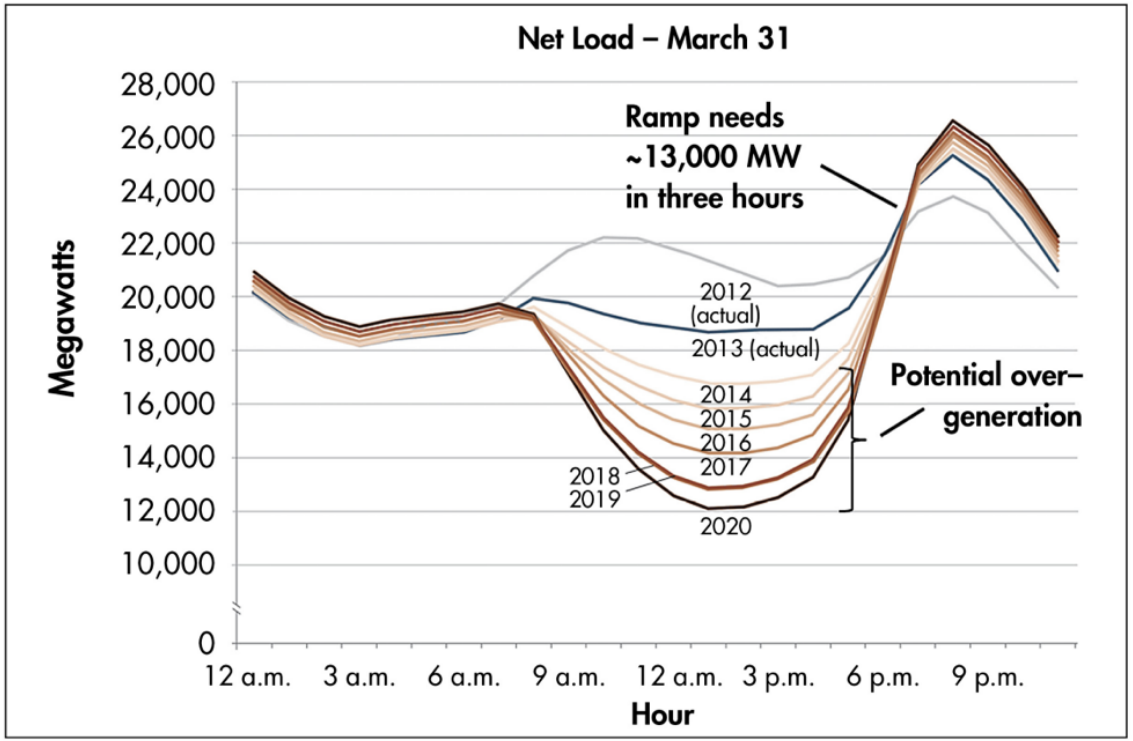
- Adding Solar to meet RPS requirements has increased curtailment of renewable energy

- How can we evaluate HVAC programs with grid conditions in mind?

# Renewables and California System Operations

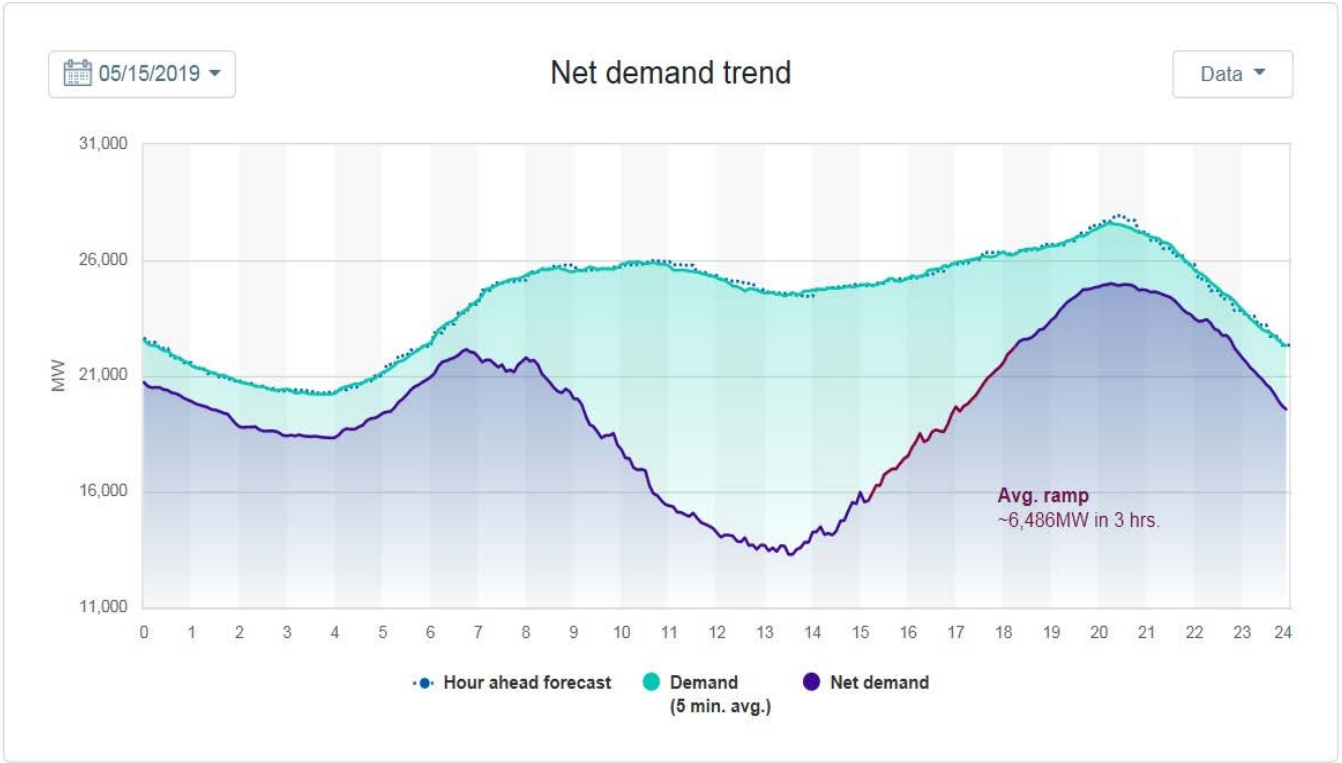
# California Spring Demand Profile- March 31

Figure 1: Net load on the CAISO system




Source: CAISO

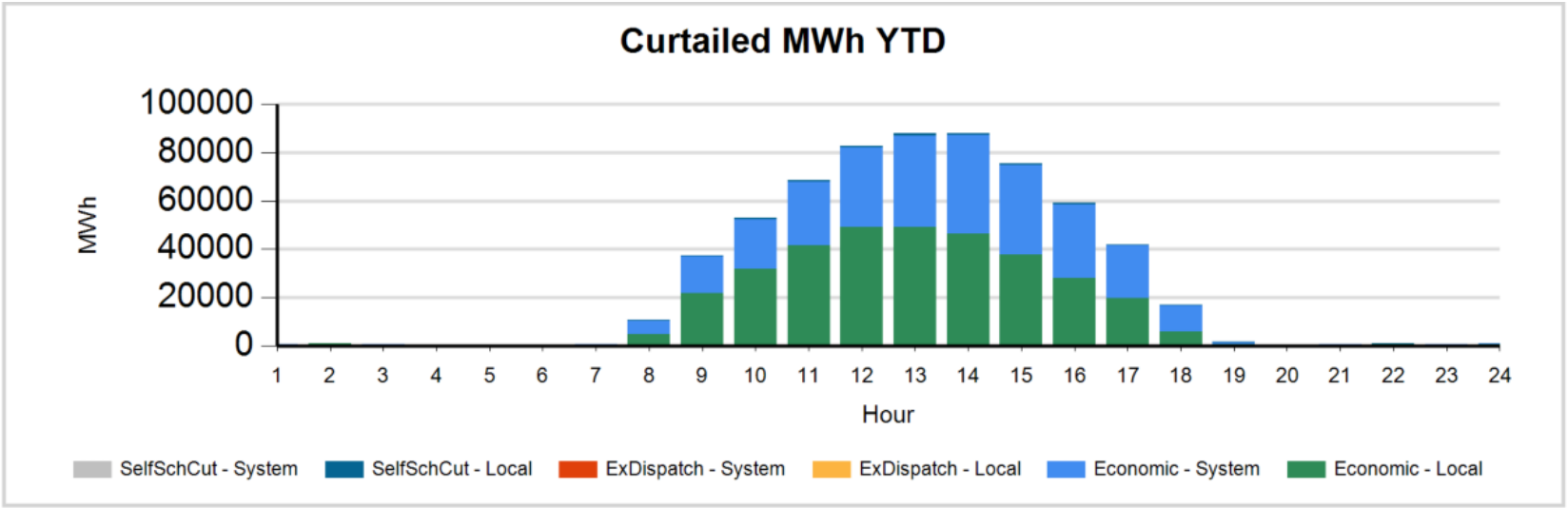
# Net Demand- May 15th 2019



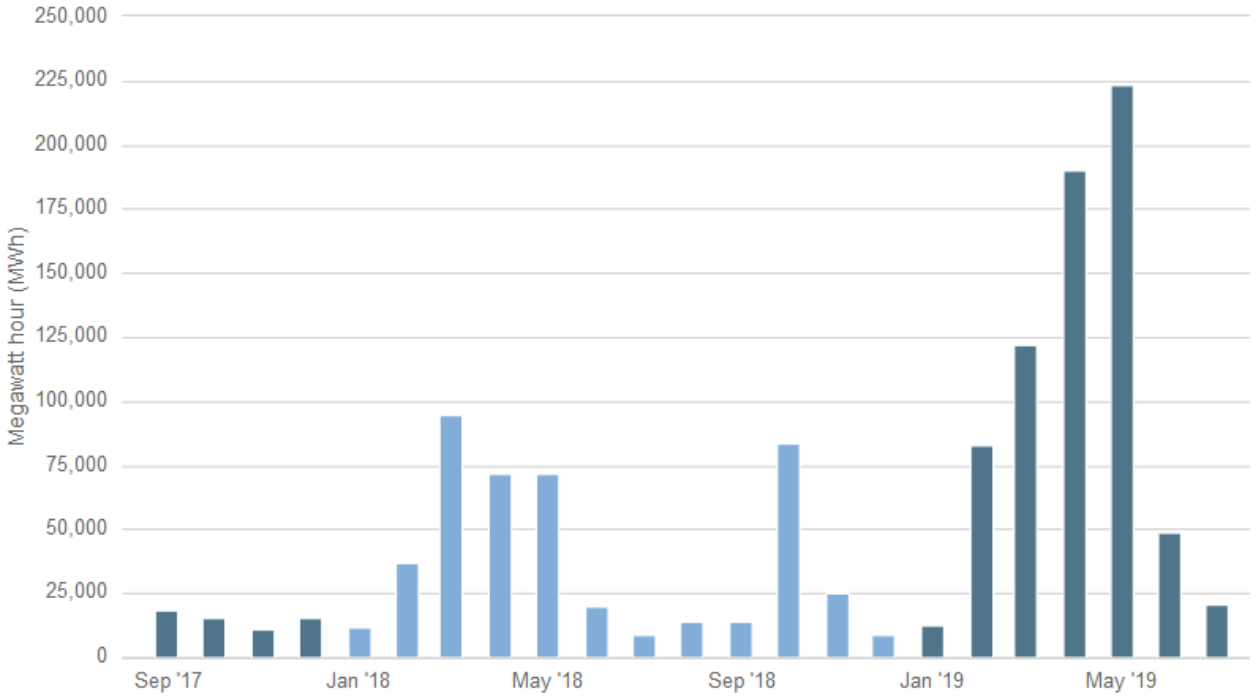
# Curtailment

- CA's abundant and growing supply of renewable resources can generate more electricity than is needed, resulting in curtailment
- Curtailment is the shutting down of renewable generation resources for economic and/or system reliability purposes
- 631 gWh of wind and solar curtailed from Jan 1- May 31 2019
- Curtailment is most common in spring, when clear weather is combined with mild temperatures

# Curtailment Amounts by Hour of Day



# Curtailment by Month



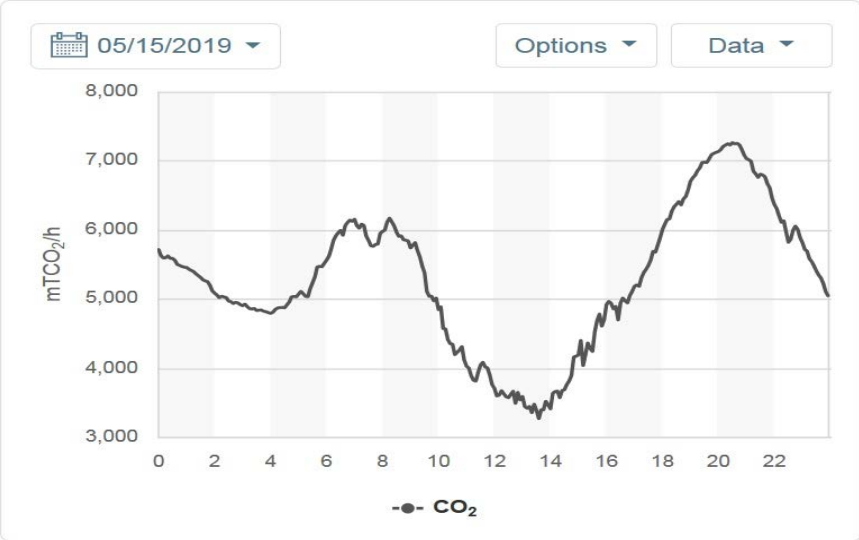
# Greenhouse Gases and the CA Energy Market

# Greenhouse Gases and Market Prices

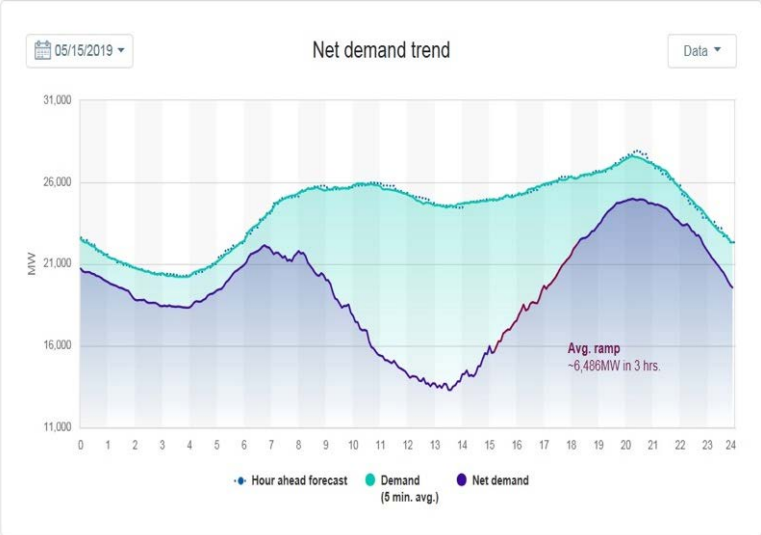
- **The California Independent System Operator (CAISO) manages an energy market to meet demand and to serve load efficiently**
  - The market forecasts the amount of supply needed at each hour of the following day (day ahead market)
  - Generators bid into the market to serve load and are dispatched in price order to meet demand at lowest cost

- **The CAISO tracks the greenhouse gas emissions from the resources it dispatches and imports.**

# GHG Emissions



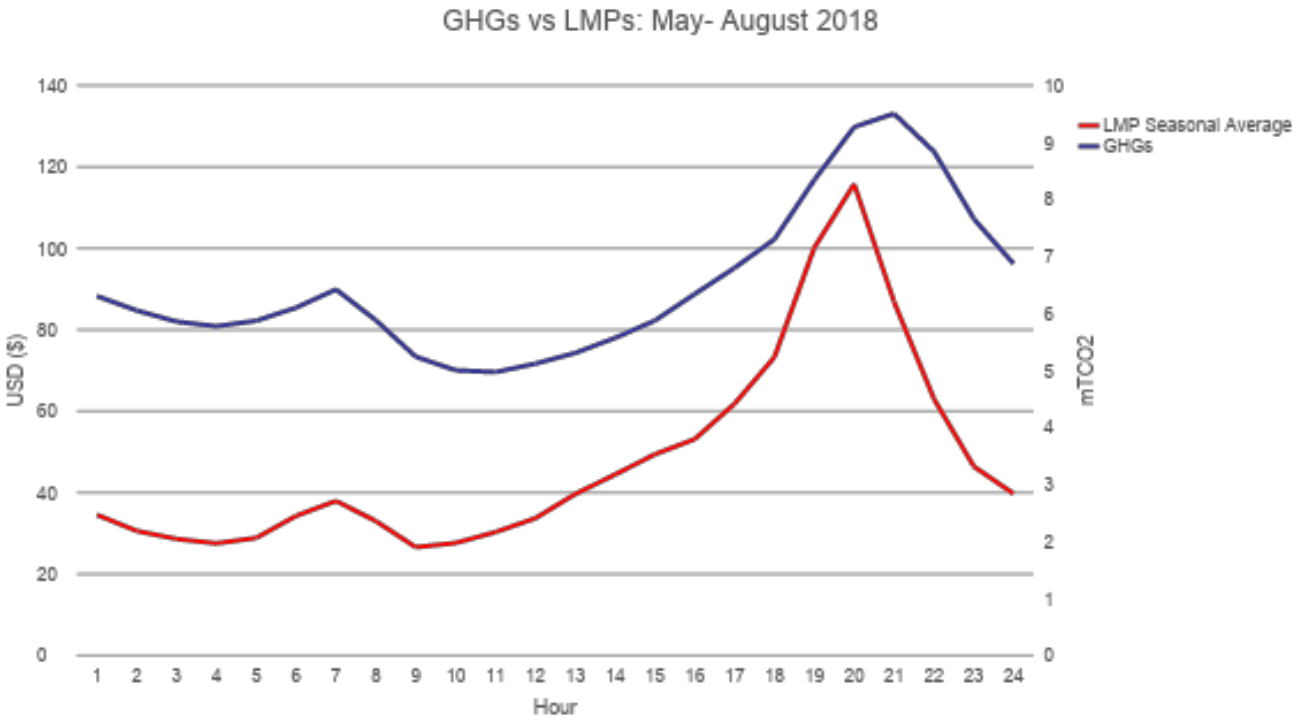

# Net Demand



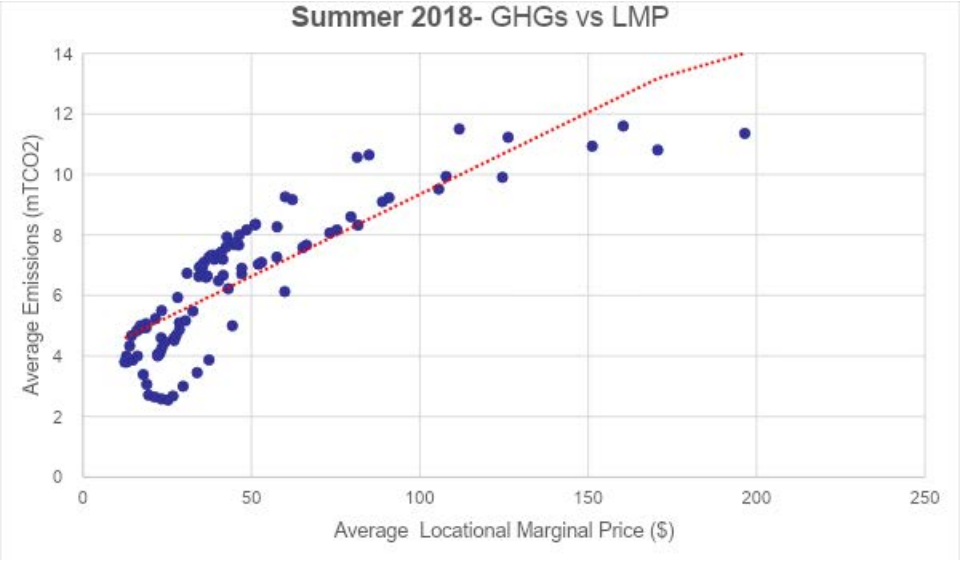
# Market Prices

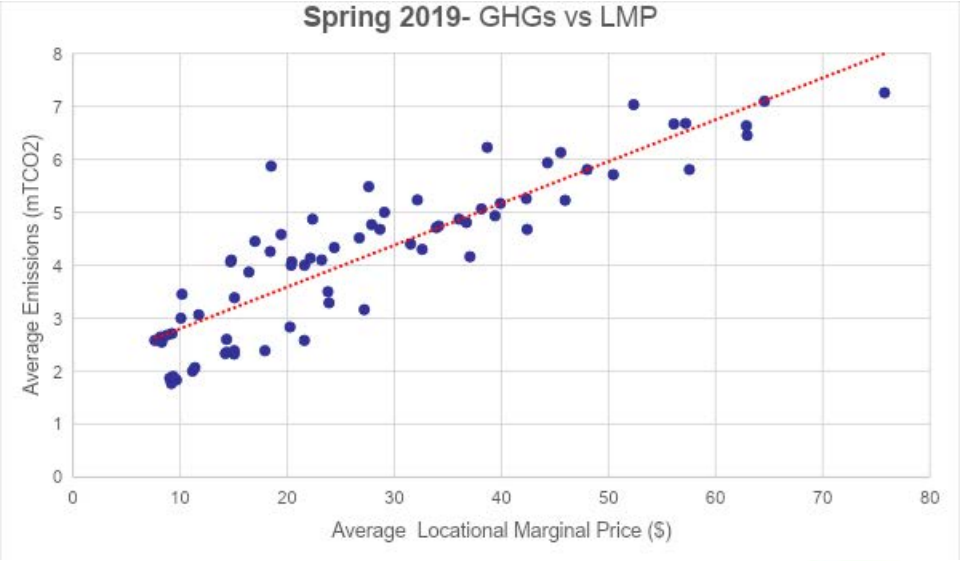
- **Hourly market data was measured from May-August 2018 (Summer) and March- May 2019 (Spring)**
- **14 energy price nodes were surveyed across 10 climate zones**
  - N= 266,365
- **Market prices appear to be correlated with GHGs; more expensive units tend to pollute more**

# Greenhouse Gases vs. Locational Marginal Prices Summer 2018



# GHGs as a function of Market Prices: Spring vs Summer



**We've established that GHGs are correlated with**

**market prices  for electricity and amount renewables-**

**What does that mean for**
**HVAC program evaluation and policy?**

# Load Shapes

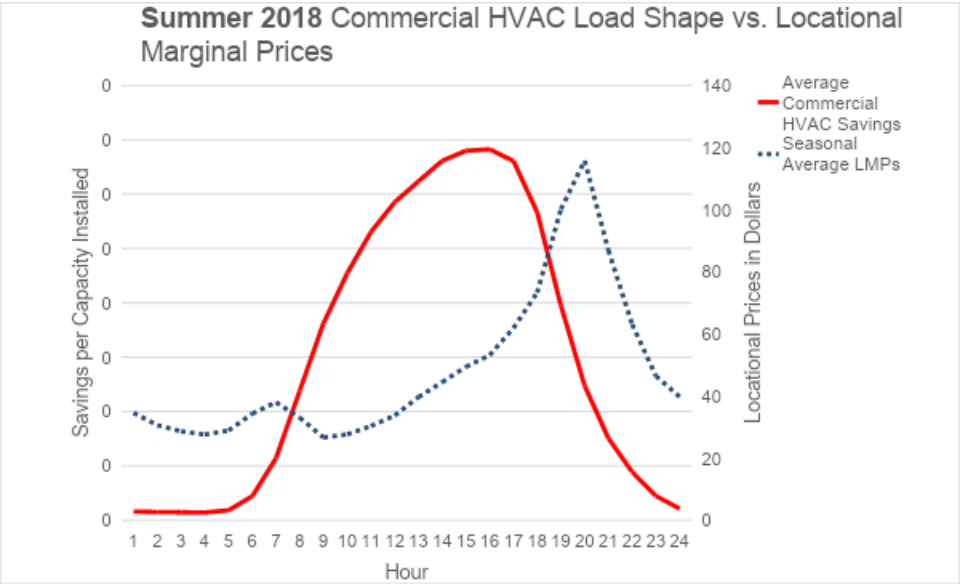
- **Load shapes help us to understand the costs and benefits of a program or individual measure**
- **The distribution of time-dependent savings derived from the installation of a measure is the measure's load shape**
- **This analysis used aggregated HVAC load shapes prepared for California's Energy Demand Forecast.**
  - Data combined from CA's Database of Energy Efficiency Resources (DEER) and modeling/simulations by Navigant Consulting
  - Based on load shapes also used by the CPUC's Avoided Cost Calculator
  - N= 30,252 Data Points

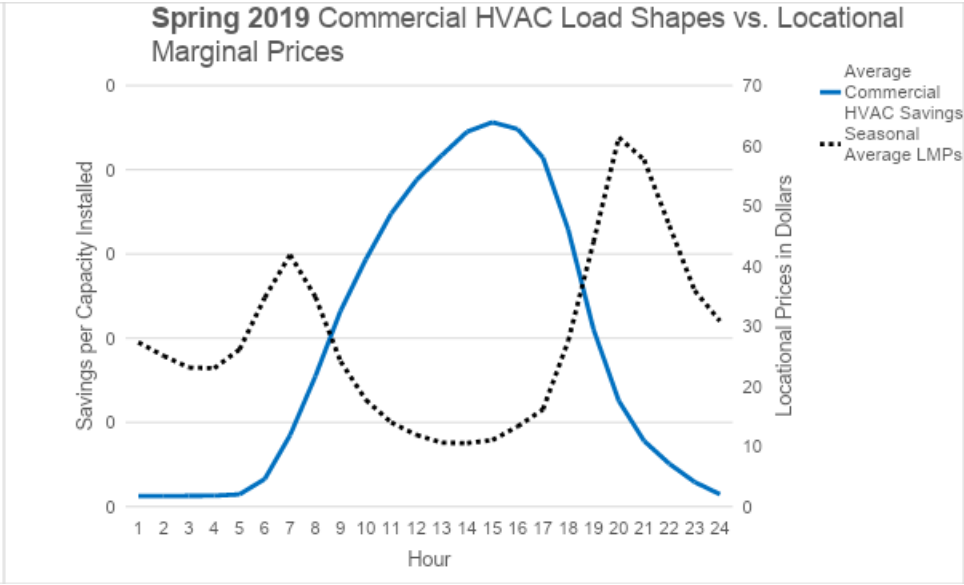
# Aggregated HVAC Measure Groups in Load Shapes

| | |
|---|---|
| **RESIDENTIAL** | DEER 2011- HVAC EFF AC (EQUIPMENT) |
| | DEER 2011- HVAC DUCT SEALING |
| | DEER 2011- HVAC REFRIGERANT CHARGE |
| COMMERCIAL | DEER 2011- HVAC CHILLERS |
| | DEER 2011- HVAC REFRIGERANT CHARGE |
| | DEER 2011- SPLIT PACKAGE AC |
| | DEER 2011- HVAC DUCT SEALING |
| | DEER 2011- HVAC SPLIT-PACKAGE HEAT PUMP (HP) |

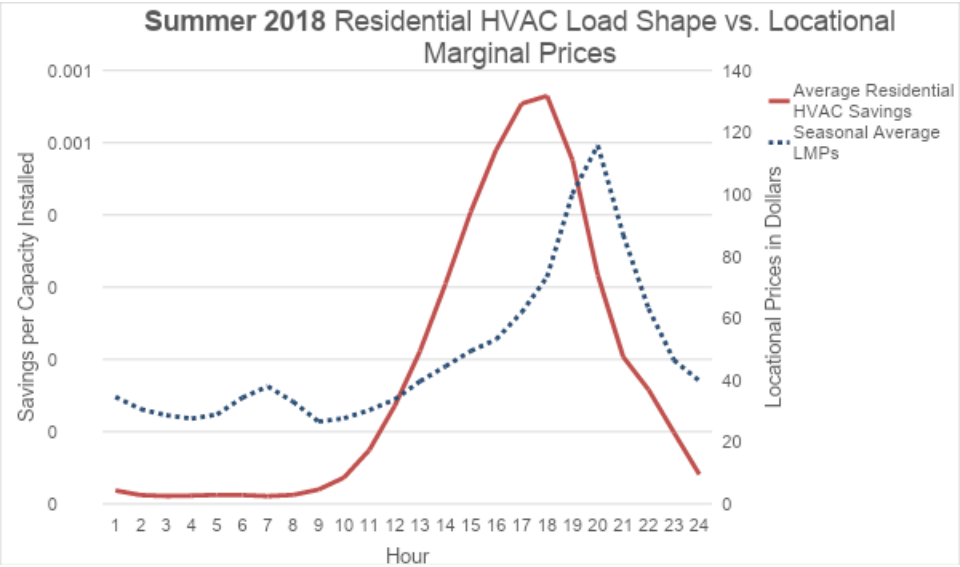
# Results: Comparing Load shapes to Prices and Emissions

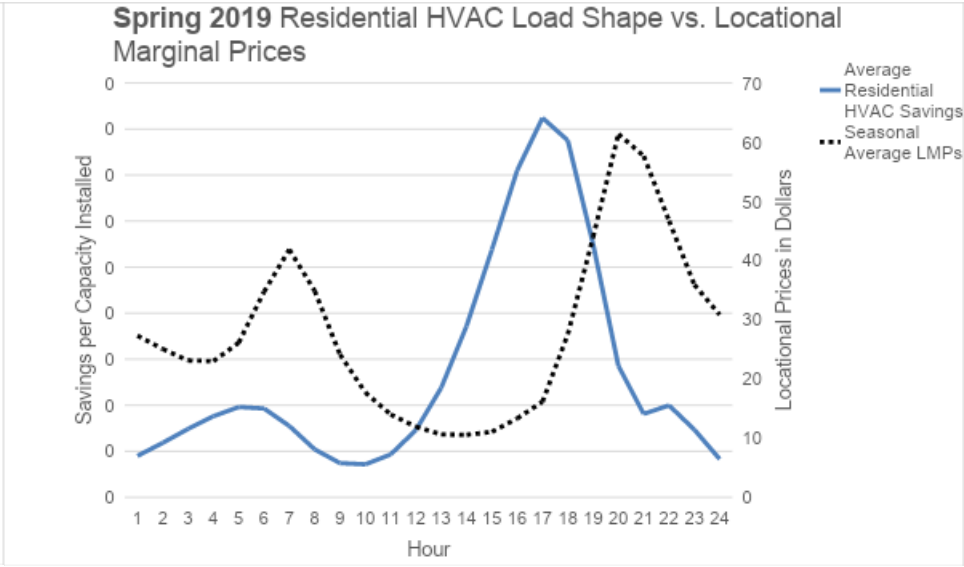
# Commercial HVAC Savings- Summer vs. Spring



# Residential HVAC Savings- Summer vs. Spring



# Takeaways

- **In the summer, renewables are rarely on the margin, e.g. HVAC efficiency measures are reducing market prices and emissions**

- **In the spring, when renewables are commonly on the margin during the solar peak, commercial measures may be increasing curtailment amounts by reducing load.**

- **Residential measures are closer to evening peak in both spring and summer, but decline as ramping increases**

# Policy & Evaluation Implications

- Future evaluations of HVAC programs could focus on providing data on load shapes and associated market and emissions impacts to support policy
- CA is in the process of moving to a “3rd Party”, statewide administration model. San Diego Gas & Electric is the lead program administrator
- Solicitations for innovative new HVAC programs may provide benefits to address this issue
- Measures which could provide the biggest peak-shaving impact include thermal storage cooling and water heaters, and sensor/control measures responsive to grid conditions

# Thank You!

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# Audience Questions?


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