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# Codes for Loads

Bringing Energy Codes into the 21<sup>st</sup> Century  
with Time-of-Use Efficiency



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into the 21<sup>st</sup> Century with  
Time-of-Use Efficiency



Alexi Miller

NBI Senior  
Project Manager



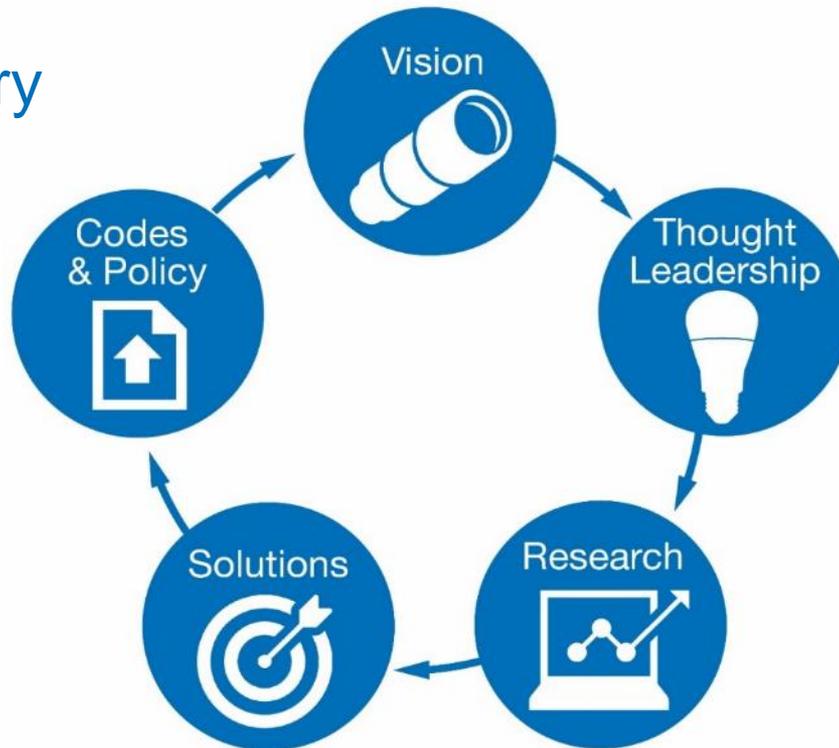
Jim Edelson

NBI Director of  
Codes & Policy

# Efficiency delivered.

NBI is responding to increasing urgency to reduce carbon emissions and increased demand for improved energy performance of new and existing buildings.

NBI's Theory of Market Change:



## Our Program Areas

(1) Building & Program Innovation

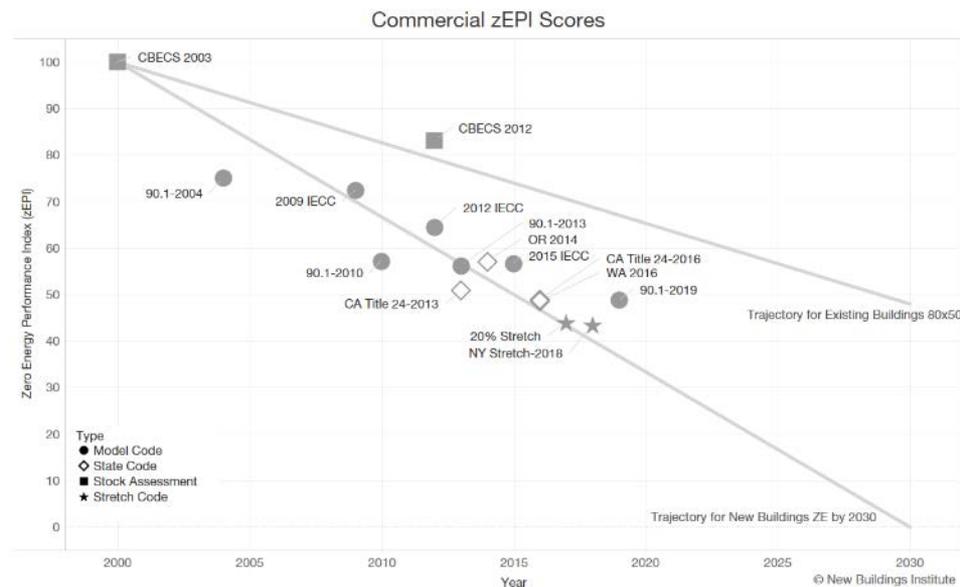
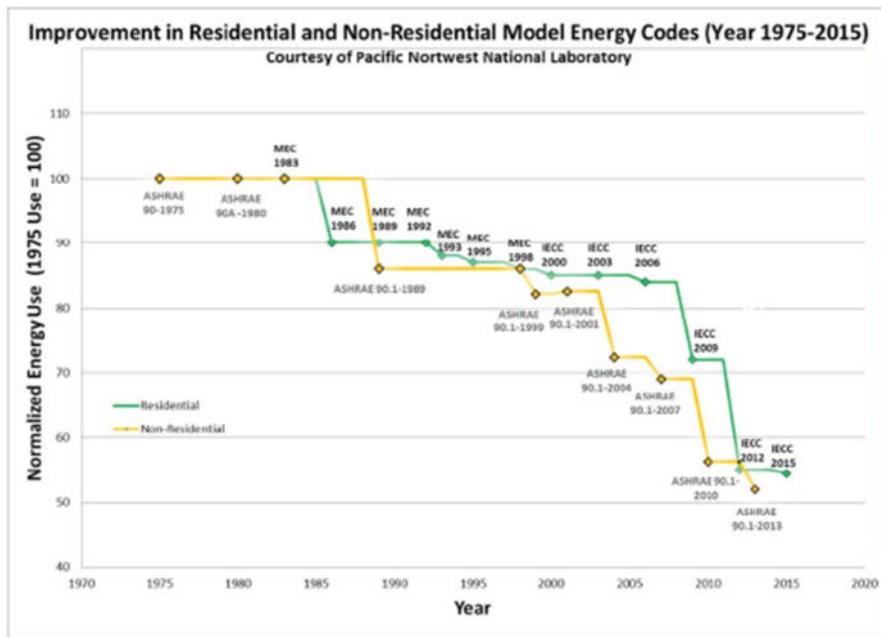
(2) Zero Energy Leadership & Market Development

(3) Advancing Codes & Policy

# NBI's Mission from the Beginning

1997: To Create a National Collaborative to Encourage and Support Workable Energy Codes and Design Guidelines

Today: We take leading-edge practices and technology applications for high performance buildings and translate them into innovative and practical solutions for the energy efficiency and commercial building industries.



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# Background and Context



# Energy Code Basis: History



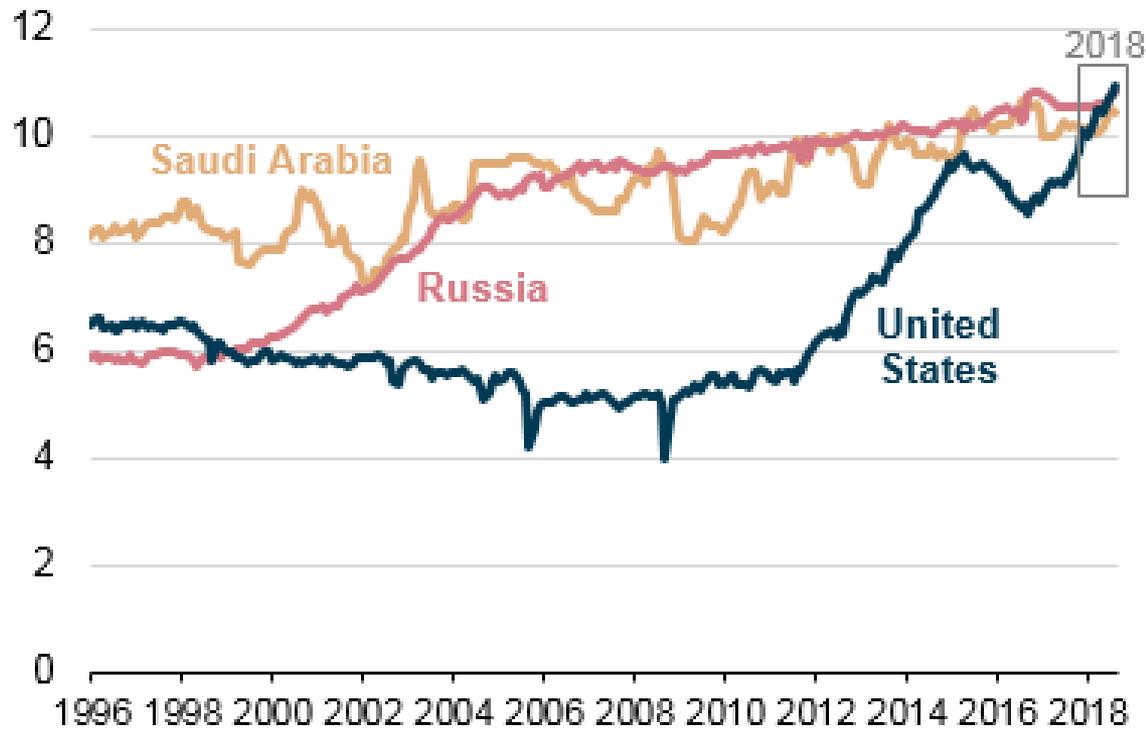
Image: © CORBIS

- Rooted in 1970s OPEC oil embargo
- **Resource conservation** focus: “Depletable Resources”

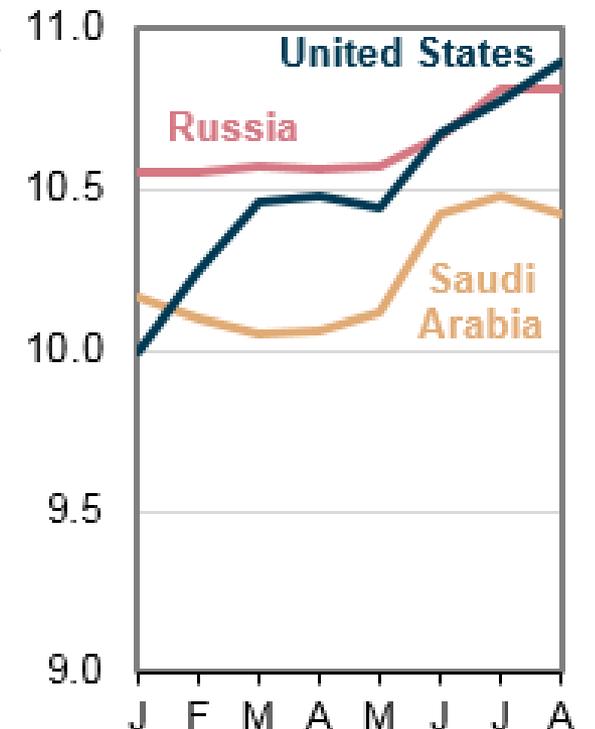
# We've Come a Long Way from 1974

Monthly crude oil production (Jan 1996-Aug 2018)

million barrels per day



million barrels per day 



Source: US EIA Short-Term Energy Outlook 2018

# New Considerations are Driving Policy



Image: Philip Spor / NOAA

# Energy Code Basis is Evolving

## *ASHRAE Standard 90.1, 2007*

- “**1. PURPOSE.** The purpose of this standard is to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings.”

## *International Energy Conservation Code (IECC) 2018*

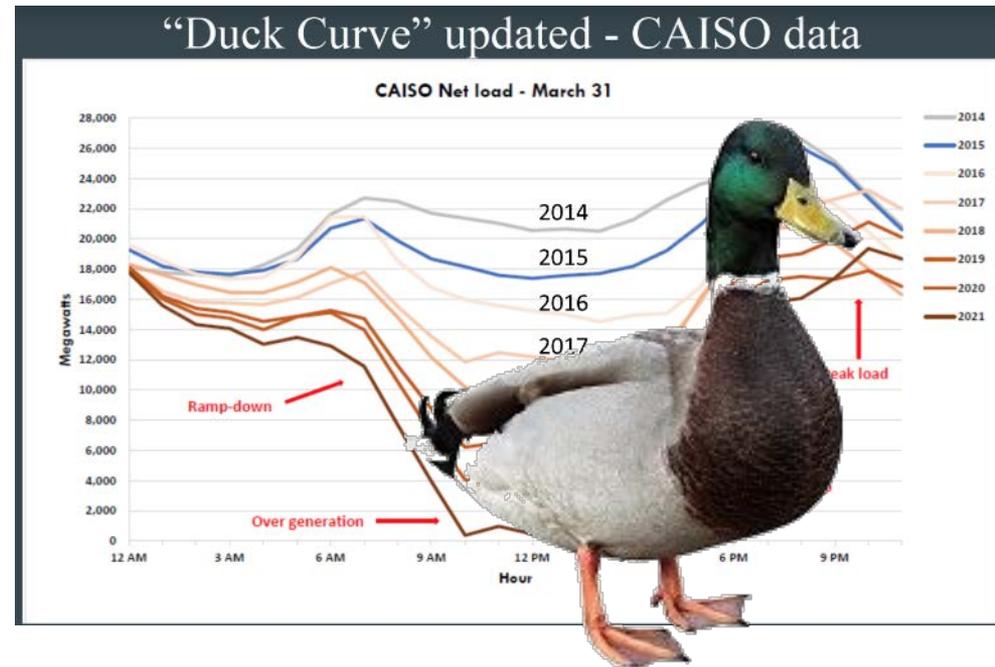
- “**C101.3 Intent.** This code shall regulate the design and construction of buildings for the use and conservation of energy over the life of each building.”

## *IECC 2021, Proposal CE7-19 (committee Approved in ABQ, May 2019)*

- “**C101.3 Intent.** This code shall regulate the design and construction of buildings for the effective use, conservation, production, and conservation storage of energy over the useful life of each building.”

# Which Came First? The Duck or the DR Egg?

- Demand Response was in energy codes before most of us had heard of the Duck Curve
- Today's fast-changing grid and building interactions drive the need for codes to get more comprehensive

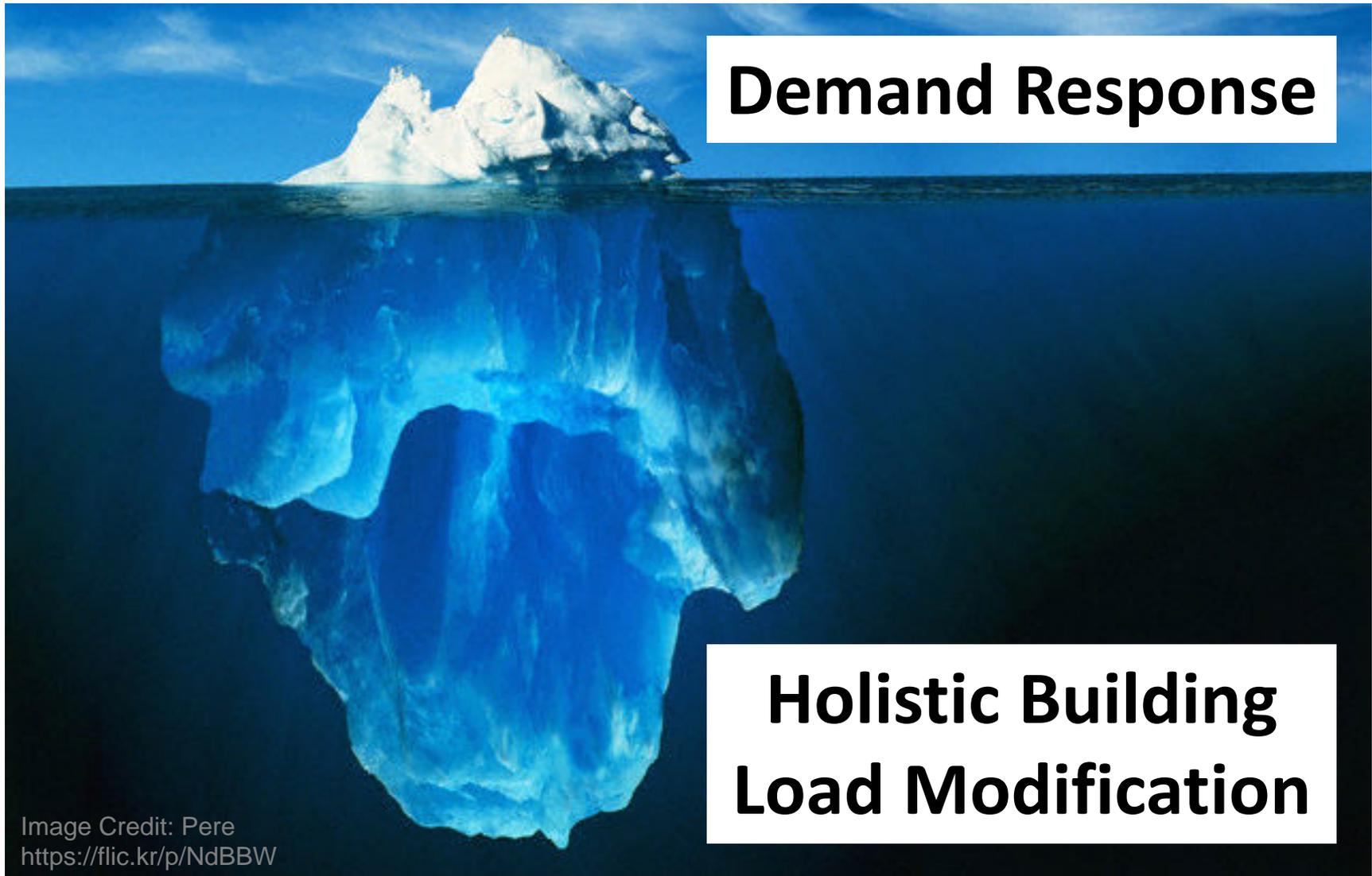


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# Drivers for Building-Grid Integration



# Building Responsiveness and Flexibility



**Demand Response**

**Holistic Building  
Load Modification**

Image Credit: Pere  
<https://flic.kr/p/NdBBW>

Energy Efficiency  
Optimization

“Future”  
Integrated  
Buildings

Renewable  
Energy  
Generation

Storage  
and Grid  
Harmonization

# GRIDOPTIMAL™

## BUILDINGS INITIATIVE

- Wrapping up Phase 1 currently
  - 2/28 Webinar: “Metrics, Modeling, and Momentum”
- Work Completed to Date:
  - Research: grid challenges and opportunities
  - Preliminary building modeling to define opportunity
  - First Pilot Project
  - Metrics framework development
- Phase 2: Metrics, Guidance, Pilots, Codes

[www.newbuildings.org/gridoptimal](http://www.newbuildings.org/gridoptimal)

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A Joint Initiative Of:

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Supporting Members:



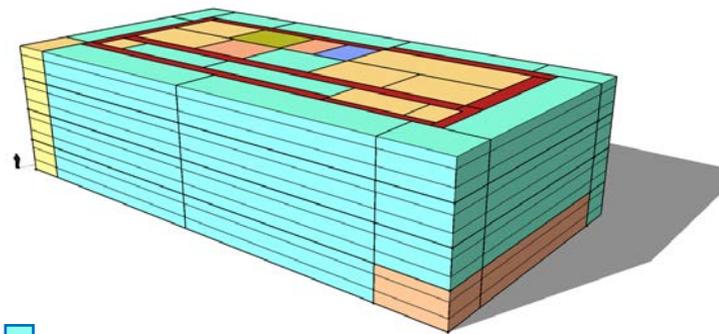
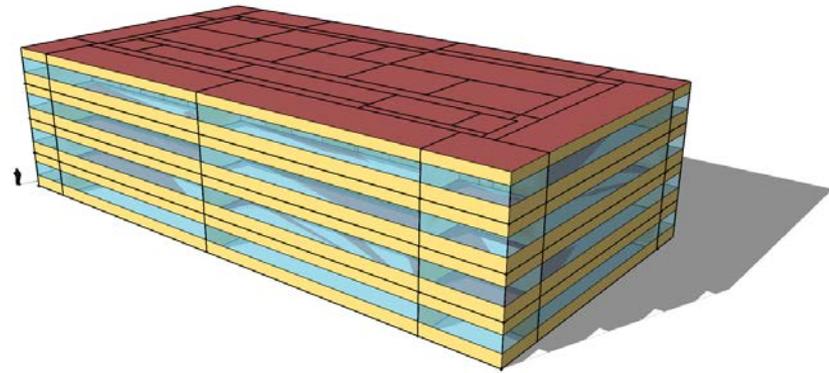
# How Much Can Buildings Modify Load Shapes?

## *Quantifying Impacts of Design Features*

- Preliminary modeling for GridOptimal Buildings Initiative
- Demonstrate potential power reductions or shifts in building design and control strategies.
- Provide an estimate of extreme power reduction potential for new buildings from a combination of measures.
- Create a set of simulated results of building load shapes for higher level research & analysis.
- Provides an initial framework for how to analyze future measures and building types

# Basis of Energy Model

- Detailed Medium Office Building
- Four (4) floor / 70,000 sf total
- 40% Window to Wall Ratio
- Electric Heating: Heat Pumps or VRF
- **Two Configurations:**  
Code Compliant, High Performance

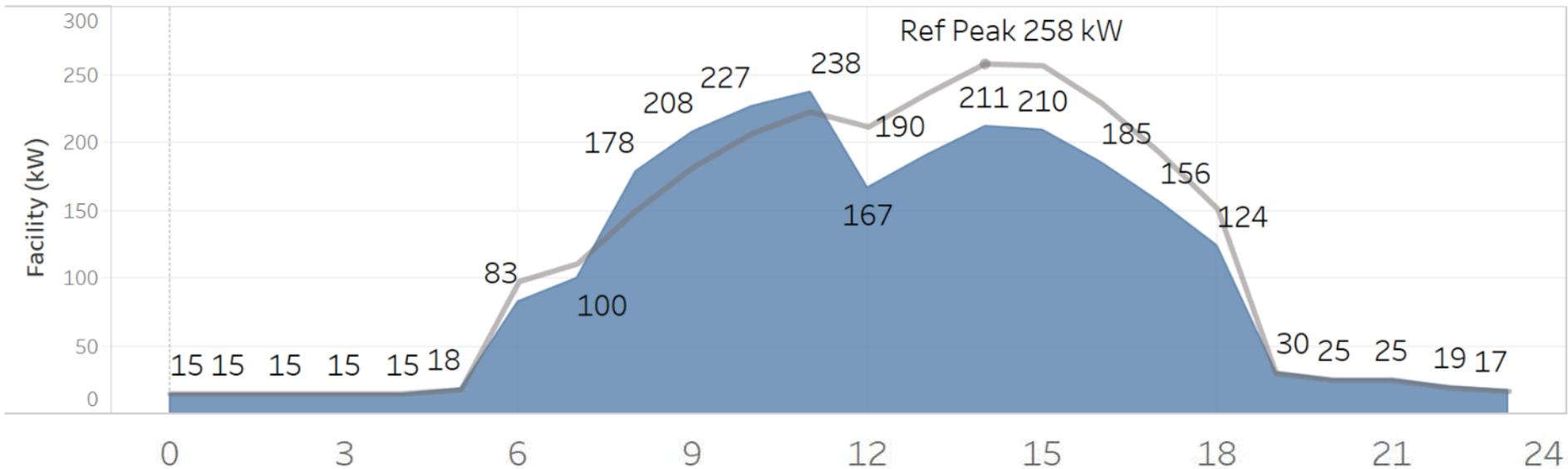


- Open Office
- Conference
- Breakroom
- Closed Office
- Stairs
- Corridor
- Lobby (flr 1)

# Load Modification Example: Package 1



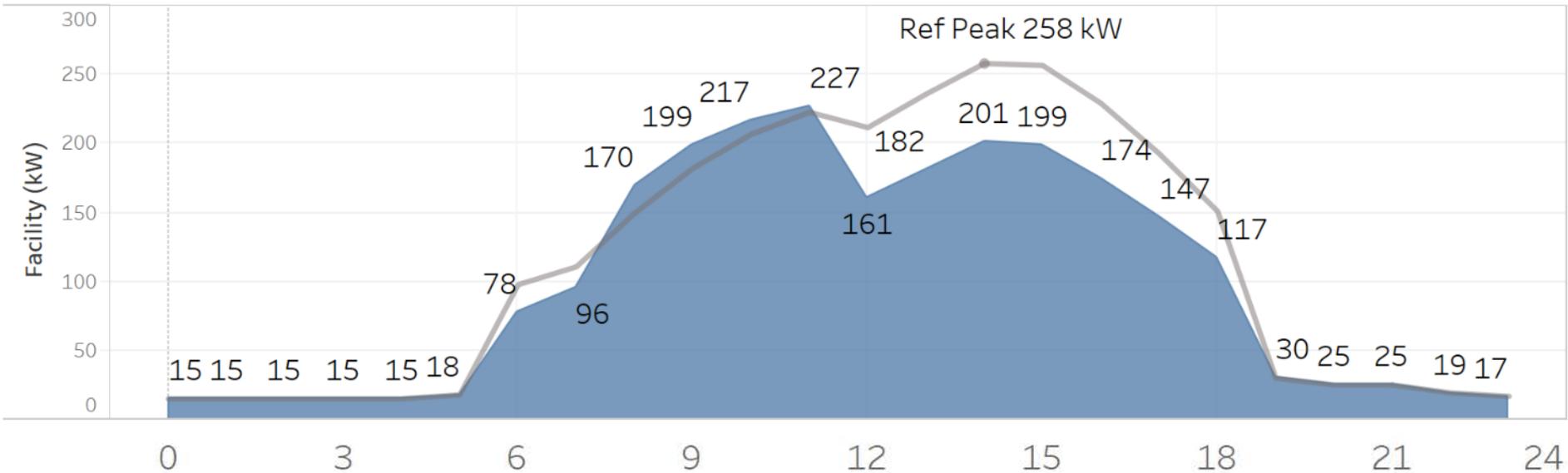
**Code Compliant Building**  
**Package 1: Thermal Mass with Three Temperature Controls**  
Typical August Day - Austin, TX



# Load Modification Example: Package 2



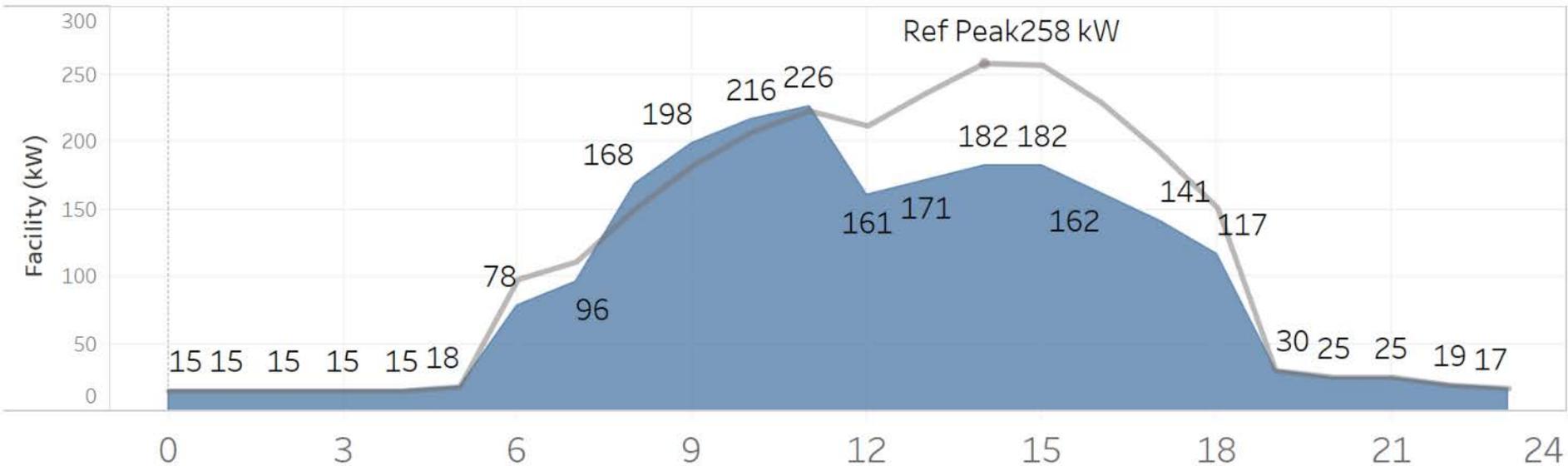
Package 2: Mass, Thermal Control, Interior Blinds



# Load Modification Example: Package 3



Package 3: Mass, Thermal Control, Int. Blinds, Lighting Afternoon Reduction



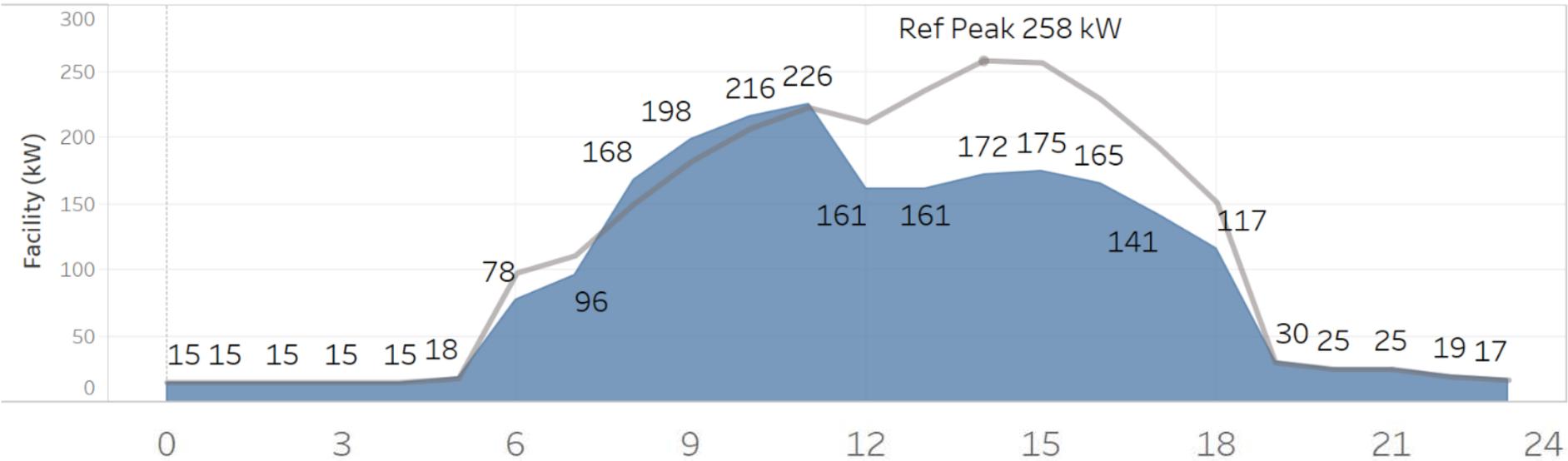
# Load Modification Example: Package 4



## Code Compliant Building

### Package 4: Mass, Thermal Control, Int. Blinds, Lighting + Grid Integrated Appliances

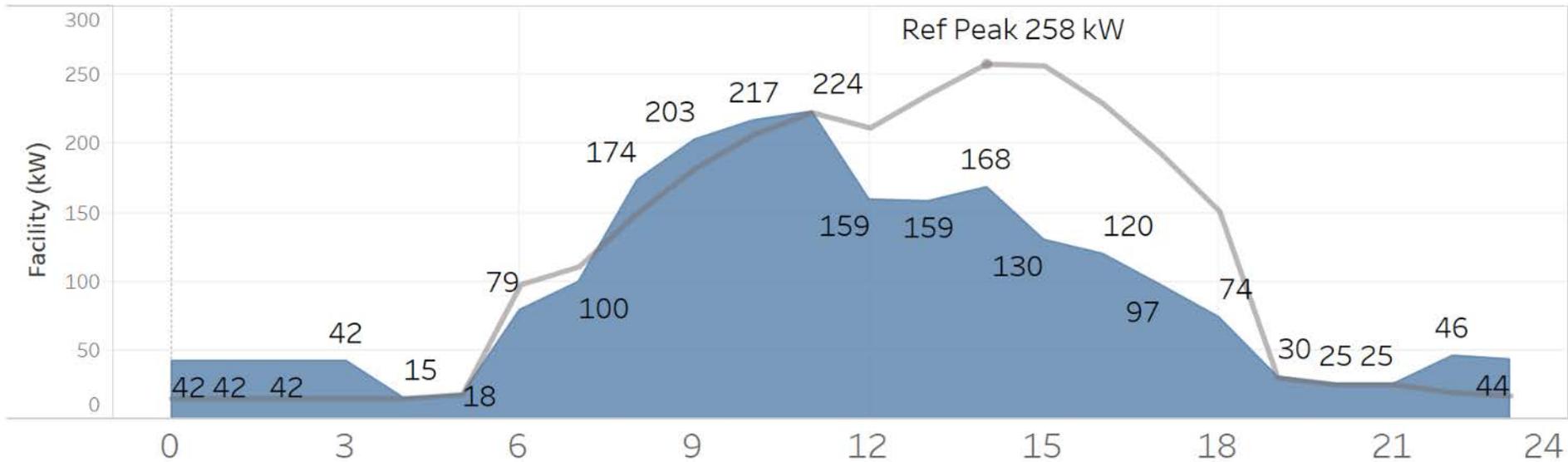
Typical August Day - Austin, TX



# Load Modification Example: Package 5 (w/ TES)



Package 5: Package 4 with Thermal Energy Storage



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# How Codes Account for Loads:

*Prescriptive,  
Performance,  
Commissioning*



# ASHRAE 189.1- 2017 / 2018 IgCC

**701.3.4 (7.3.4) Automated Demand Response.** *Building projects shall contain automatic control systems that have the capability to reduce building equipment loads to lower electric peak demand of the building. The building controls shall be designed with automated demand-response (DR) infrastructure capable of receiving DR requests from the utility, electrical system operator, or third-party DR program provider and automatically implementing load adjustments to the HVAC and lighting systems.*

1. HVAC Systems Zone Set Points (space setpoint controls)
2. Variable-Speed Equipment (HVAC motor controls)
3. Lighting (dimming controls)

# ASHRAE 189.1- 2017 / 2018 IgCC

**Gross conditioned floor area:** See ANSI/ASHRAE/IES Standard 90.1.

*Revise Section 7.3.4 as follows (sections not shown are not changed):*

**7.3.4** Where a demand response (DR) program is available to the building project, ~~Building projects shall contain automatic control systems that have the capability to reduce building equipment loads to lower electric peak demand of the building. The~~ the building controls shall be designed with automated demand-response (DR) infrastructure capable of receiving DR requests from the utility, electrical system operator, or third-party DR program provider and automatically implementing load adjustments to the HVAC and lighting systems.

**Exception to Section 7.3.4:** Buildings with a *gross conditioned floor area less than 5000 ft<sup>2</sup> (500 m<sup>2</sup>).*

# California Title 24

- **120.2(h) Automatic Demand Shed Controls.** HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for non-critical zones...
- **130.1(3) Demand Responsive Controls.** Buildings larger than 10,000 square feet, excluding spaces with a lighting power density of 0.5 watts per square foot or less, shall be capable of automatically reducing lighting power in response to a Demand Response Signal...
- **130.3(a)3 Demand Responsive Electronic Message Center Control.** An Electronic Message Center having a new connected lighting power load greater than 15 kW shall have a control installed that is capable of reducing the lighting power by a minimum of 30 percent when receiving a demand response signal.

# Prescriptive Code Framework (load curve matching)

- Can be proposed for an (informative) **appendix**
- Allows a jurisdiction to select most-critical load hours and credit targeted building load modifications during those hours
- **Framework**
  - Sum of LOAD CREDITS  $\geq$  Jurisdiction's threshold
    1. Formula for Load Credits
    2. Must be Commissioned
    3. Can be minimum requirement or Section 406 credit

# SAMPLE Formula for Load Credits

$$\begin{aligned} &1.0 * (\text{Dispatchable kW}) * V1 * t && \text{(eg. D.R. controlled setpoint)} \\ &+ 0.6 * (\text{Flexible kW}) * V2 * t && \text{(e.g. Ice Storage)} \\ &+ 0.4 * (\text{Permanent kW}) * V3 * t && \text{(e.g. Solar Heat Gain control)} \\ &= \Sigma(\text{Design Load Credits}) && \text{(each adjusted by its factors)} \end{aligned}$$

**Fixed factors** - reflect certainty of load management

**V1/V2/V3** - load shift valuation specific to location / service territory

**t** - length of load shift in hours

# Example: Thermal Energy Storage

- **Description** *This measure involves shifting cooling power demand from one time of day to another by supplying a storage tank with cooling medium (typically chilled water or ice) and discharging the tank at the time of day from where load is being shifted away.*
- **Modeling:** In Austin, the reduction (approximately 47 kW or 18% in Q3) is most significant at 4pm, when cooling loads are greatest.

# Example: Commissioning Load-Related Code Elements

- Add to Section 508 of IECC
- Add to mandatory requirements in ASHRAE 90.1
- Need to have a Cx Plan for Load Shift
- Require Functional Testing of capacity and duration
- Delivery of a Cx report (noted on plans)

# Section 406 – 2021 IECC (proposed) – C238-19

**C406.10 Electrical energy storage system (EESS).** EESS shall be controlled by an energy management system that is programmed to shift the load from on-peak to off-peak.

**C406.10.1 System storage capabilities.** The system shall be capable of storing the following:

1. Not less than 0.05 watts per square foot (0.54 W/m<sup>2</sup>) of conditioned floor area,
2. Not less than 10 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated in Chapter 4.

# Developing Simulation Protocols (Load Shift)

- KEY – identify load characteristics to target in simulation
- Quantify hourly kW modifications throughout 1 year
- Could be a trade-off or a minimum mandatory requirement
- Modeling software requires a baseline (eg. DOE prototypes)
- Could include mods to:
  - 90.1 Appendix G
  - CA T24 ACM manual

# Potential Next Steps

- GridOptimal developing further calculation methods and simulation-based results
- Creation of synthetic TOU rates for energy cost basis
- Evaluate impact of fixed rate vs time-value cost basis
- Prescriptive requirements in an informative appendix (90.1) or a jurisdictional appendix (IECC)
- Hold some informal conversations about specific code updates and modifications?

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GETTING TO  
**zero**  
FORUM 2019

October 9-11  
OAKLAND MARRIOTT  
Oakland, CA  
[gettingtozeroforum.org](http://gettingtozeroforum.org)



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# Thank you!

Keep the Conversation Going:

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