Energy+Environmental Economics

# Update on Zero-Net Energy (ZNE) in California

October 25th, 2017

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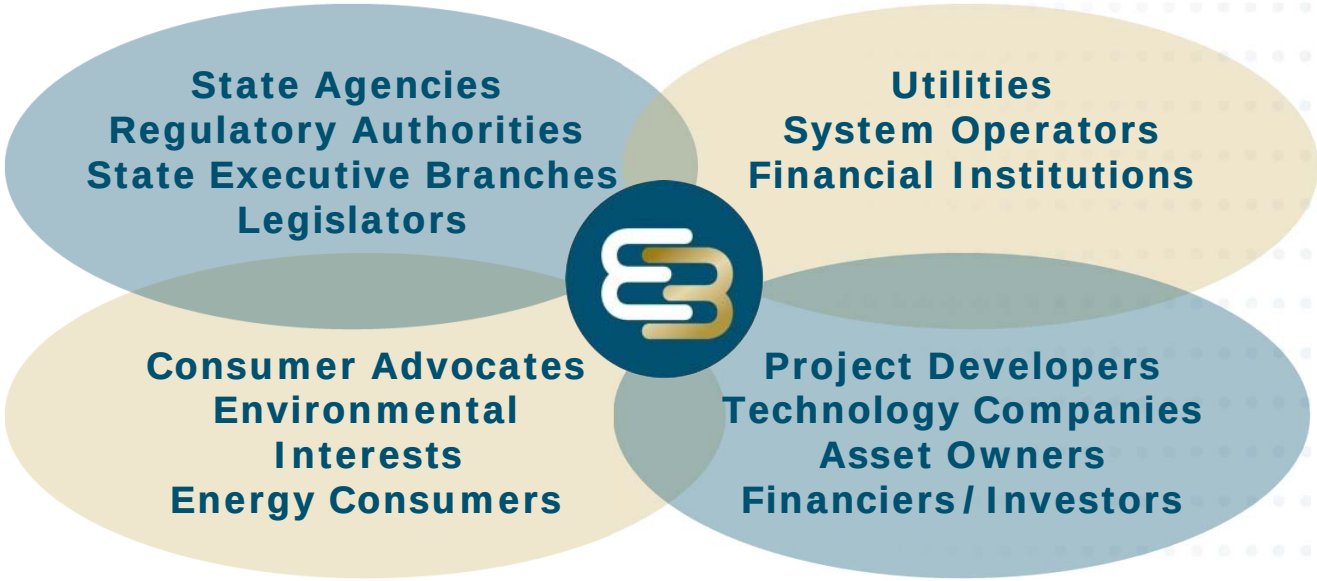
# About Energy and Environmental Economics, Inc. (E3)

- Founded in 1989, E3 is an industry leading consultancy in North America with a growing international presence
- E3 operates at the nexus of energy, environment and economics
- Our team employs a unique combination of economic analysis, modeling acumen, and deep institutional insight to solve complex problems and provide critical thought leadership for a diverse client base



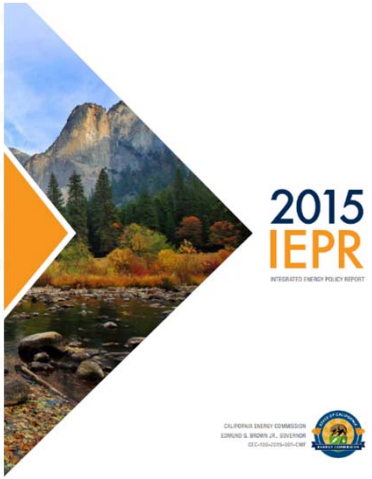
# California Background

- **Long track record of focused building efficiency progress**
- **Mild climate, robust economy**
- **Range of Policies Supporting Zero-net Energy Buildings**
  - SB32 GHG target in 2030
  - EO B-30-15 GHG target in 2050
  - SB350 50% renewable portfolio standard, doubling EE levels
  - EO B-18-12; ZNE state buildings (based on source energy)
  - California's integrated energy policy report (IEPR) requires ZNE Residential by 2020 and Non-residential by 2030 (based on a time-dependent valuation 'TDV' metric)

# California Policy for ZNE

## + 2015 IEPR clarified the definition of ZNE

- *A ZNE building is one where the value of the energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building… measured using the California Energy Commission's Time Dependent Valuation metric*[1]




## + ZNE goal applies to low-rise residential buildings by 2020 and commercial buildings by 2030[2]

## + Alternative compliance and community solar[1]

- Approaches need to be identified to make it administratively workable and cost-effective
- Must allow for building department verification to ensure that identified resources exist and are the correct size for offsetting energy use

[1] http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf
[2] http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF-small.pdf

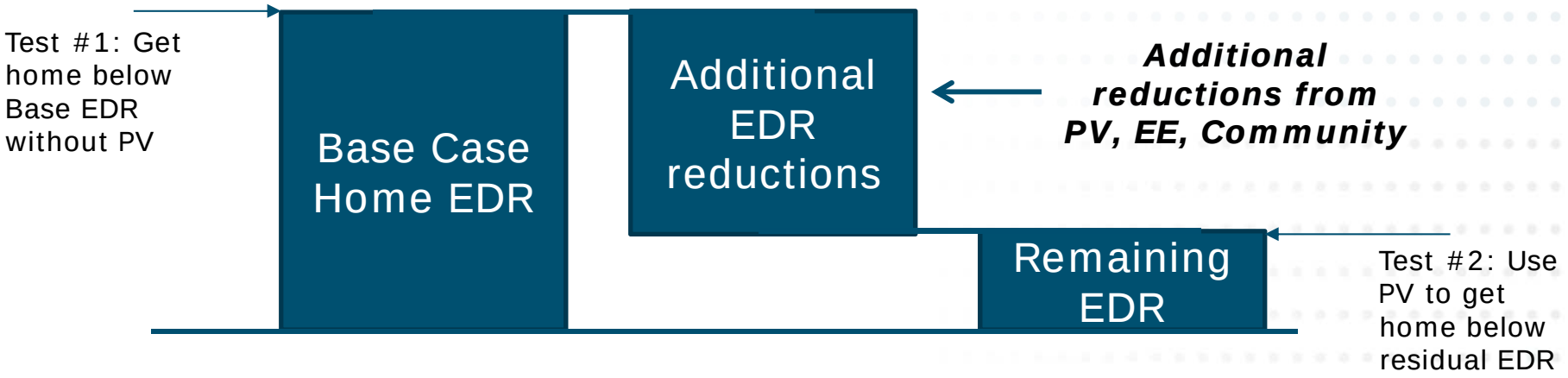
# Proposed Mechanism for ZNE

- **CEC has proposed a mechanism for ZNE in the 2019 code cycle[1]**

  1) CEC will calculate base EDR from prescribed energy efficiency[2] for each climate zone (Base Case Home EDR)

  2) CEC will calculation additional EDR reductions using PV size required to displace site kWh of base case home (Additional EDR reductions)

  3) New buildings must pass both 'tests'




[1] https://www.dropbox.com/sh/cqdmx9fvj3ncnqt/AAB88Wmr3ymYdlB_Hy-OWtqWa?dl=0&preview=Mazi+Shirakh+-+CEC_ZNE+forum_2016-11-29.pdf

[2] Energy Design Rating (EDR) is defined as lifecycle TDV value

# System Perspective on Buildings

## + California Building

Stanford Huang Engineering Center
Credit Stanford Unofficial Blog

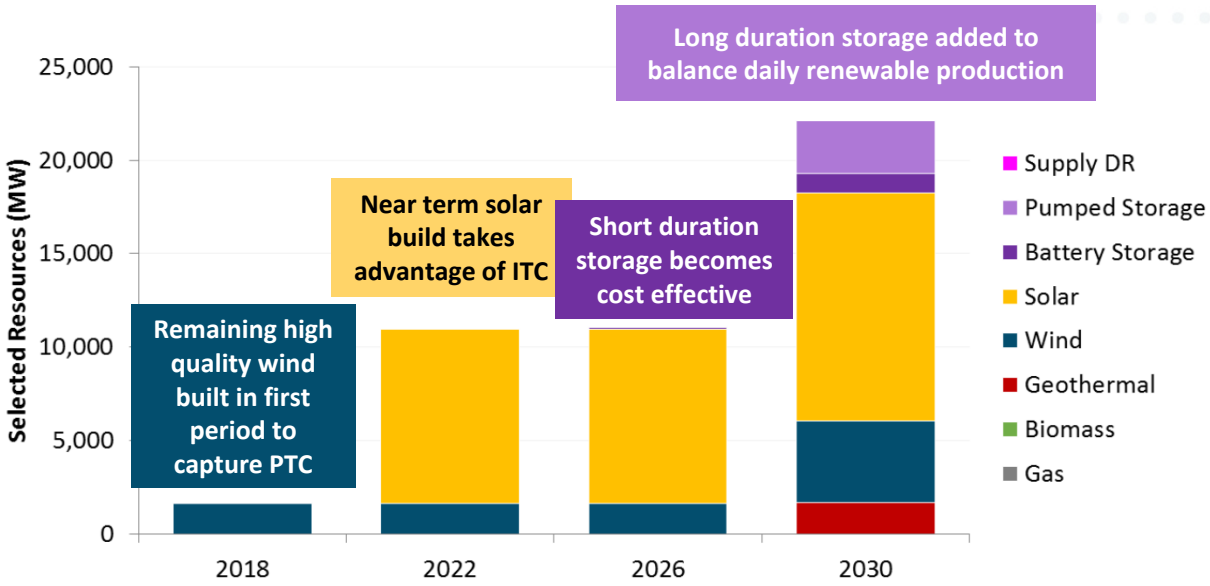
## + California Grid


CAISO System Map
Credit CAISO Website

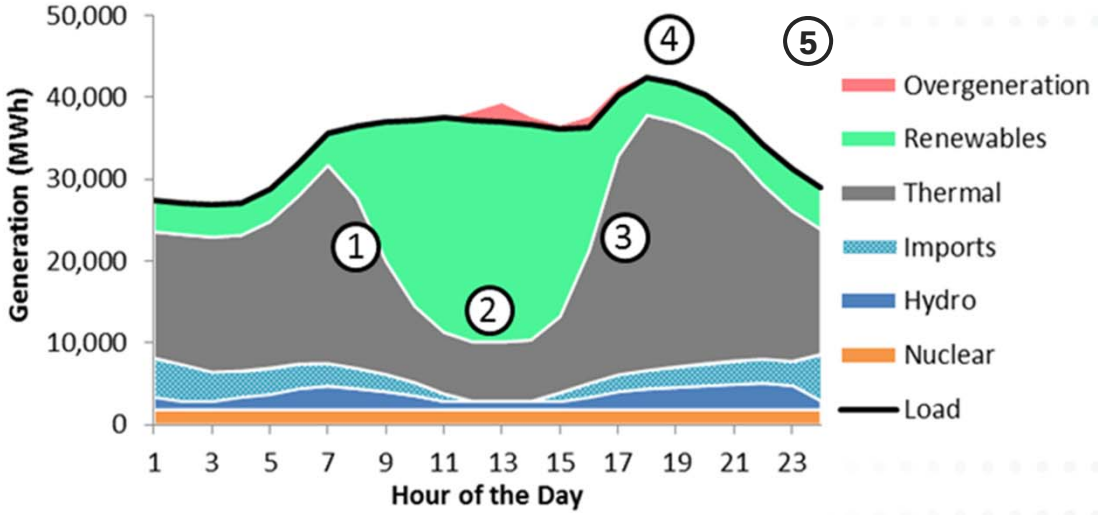
# California Grid is Changing

## California Integrated Resource Plan (IRP) 2017–2018

- Example IRP Results are Consistent with a 30MMt Electricity Sector by 2030



# Flexibility challenges for highly renewable systems – Spring Day




### 1. Downward Ramping

Thermal resources operating to serve loads at night must be ramped downward and potentially shut down to make room for a significant influx of solar energy after the sun rises.

### 2. Minimum Generation

Overgeneration may occur during hours with high renewable production. A system with more flexibility to reduce thermal generation will incur less overgeneration.

### 3. Upward Ramping

Thermal resources must ramp up quickly and new units may be required to start up to meet a high net peak demand that occurs shortly after sundown.

### 4. Peaking capability

The system will need enough resources to meet the highest peak loads with sufficient reliability.

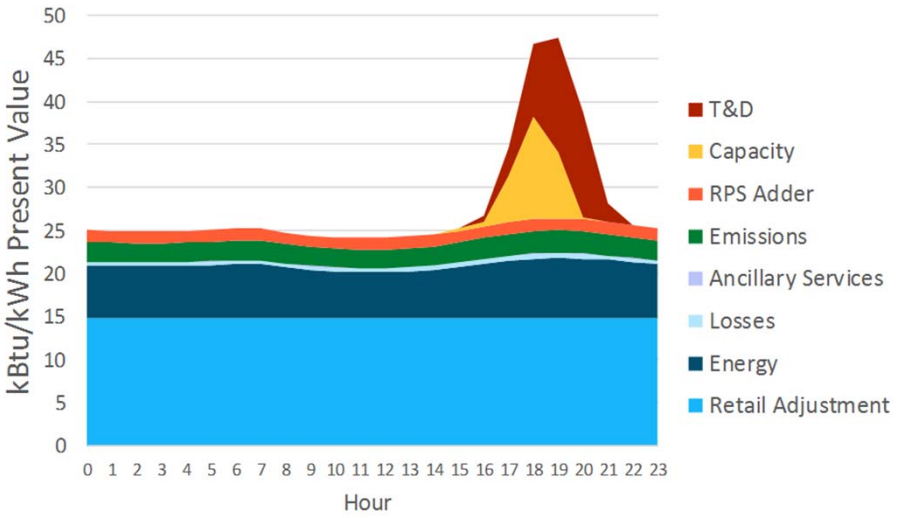
### 5. Ancillary Services

The system needs to be flexible enough to meet short-term balancing requirements at all times.

# What do we mean by ZNE?

- **Different ZNE metrics include site, source, GHG with varying and important details for each**
- **California uses Time-dependent Valuation (TDV) in Building Code (Title 24)**
  - Underlying cost of delivering electricity and natural gas that varies by area- and time- across California
  - Reflects 16 climate zones
- **Pro: Integrates grid-harmonization into the metric**
- **Con: Difficult to apply to existing buildings to get a TDV 'score' based on building energy usage**

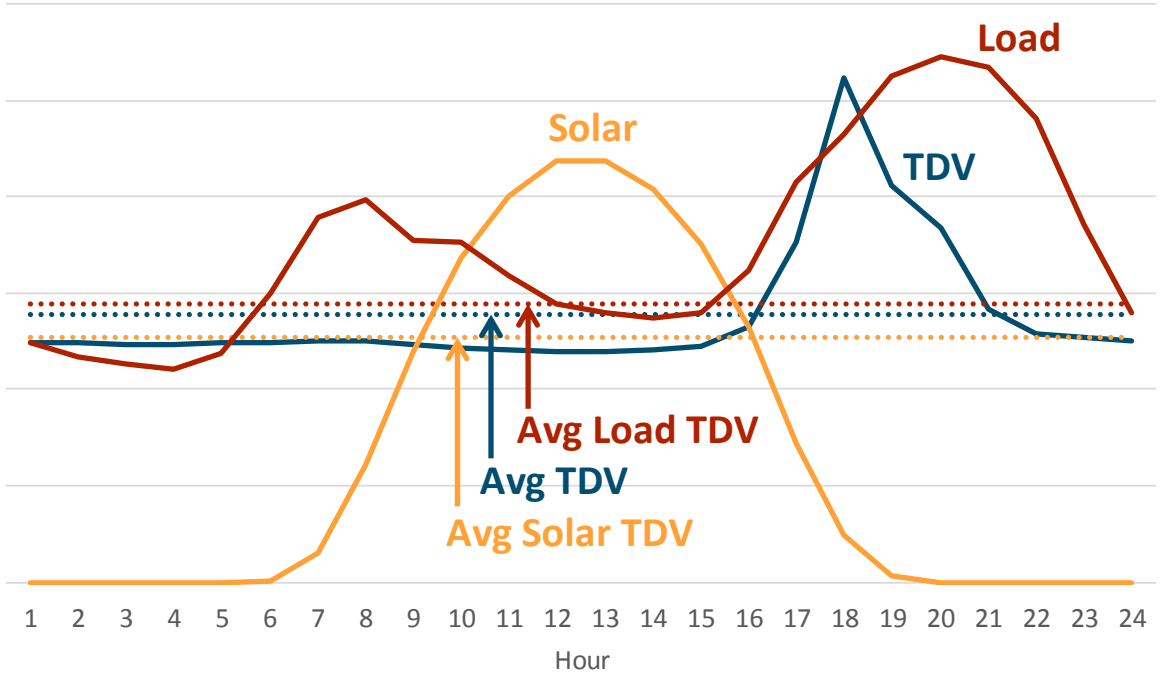
Example TDV Values – Average Day




Average Day 30-Year NPV TDV Values for San Francisco Bay Area (CZ3) for 2019 Title 24 Update

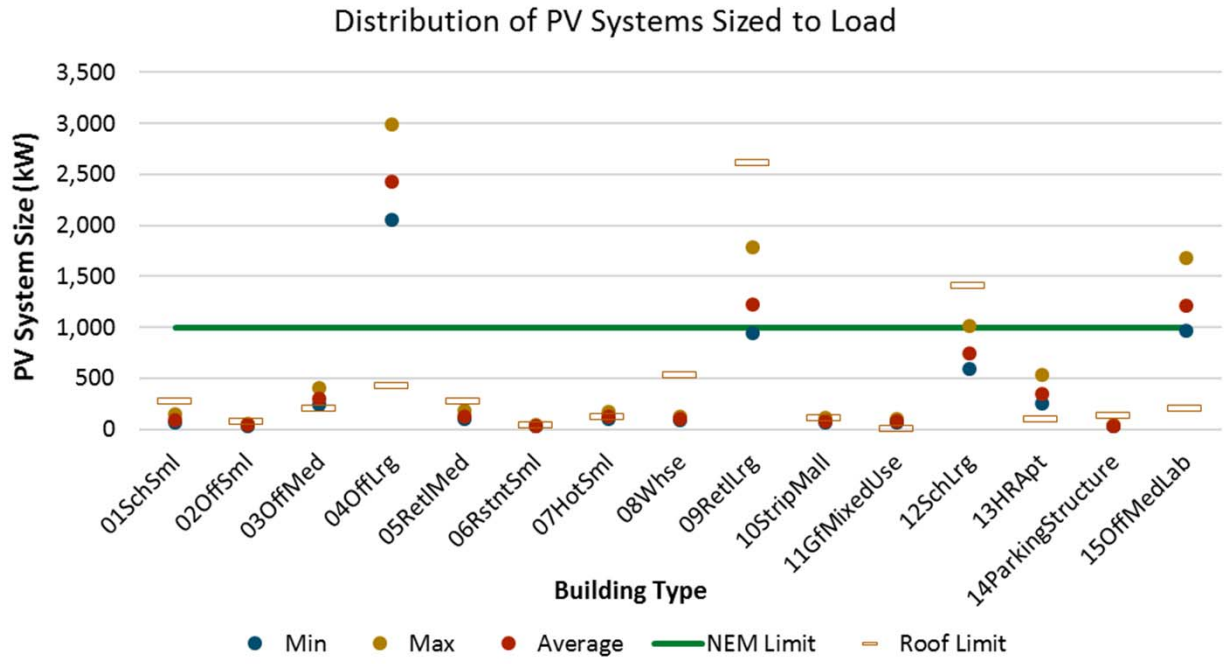
# Grid Harmonization - Solar Rooftop

- **Rooftop Solar <u>is not</u> coincident with high TDV hours because system solar is lowering value mid-day**
- **Results that solar is less valuable than average energy**
  - ZNE using TDV in California is a more stringent than an energy-based metric (source or site)



# Rooftop limitation for non-residential buildings

- PV system size varies significantly depending on building type, panel orientation, and climate zone
- Regulatory (1 MW maximum size for net energy metering (NEM)) or physical (roof size) limits may prevent sizing PV to full load



# Relative Solar Costs

## + NREL Comparison

- Residential
  - Residential = $2.93/W-DC
  - NREL, 9/20/2016, U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016, available http://www.nrel.gov/docs/fy16osti/66532.pdf
- Community
  - Larger scale = $2.03/W-DC to $2.29/W-DC depending on size
  - NREL, September 2016, "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016," available at http://www.nrel.gov/docs/fy16osti/67142.pdf

**Other sources**

Brattle Report that compares residential to utility-scale prices puts utility-scale rate ~$60/MWh and Res at ~$140/MWh in 2019

Utility-Scale_and_Residential-Scale_PV_in_Xcel_Energy_Colorado's_Service_Area.pdf

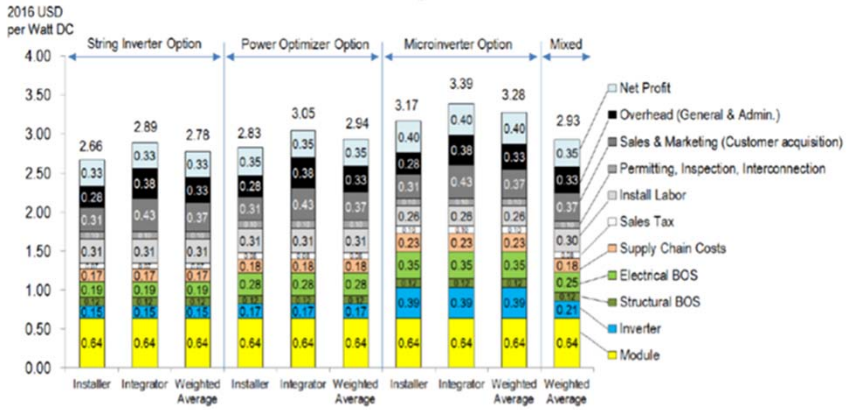



Figure 12. Q1 2016 U.S. benchmark: 5.6-kW residential system cost (2016 USD/Wdc)

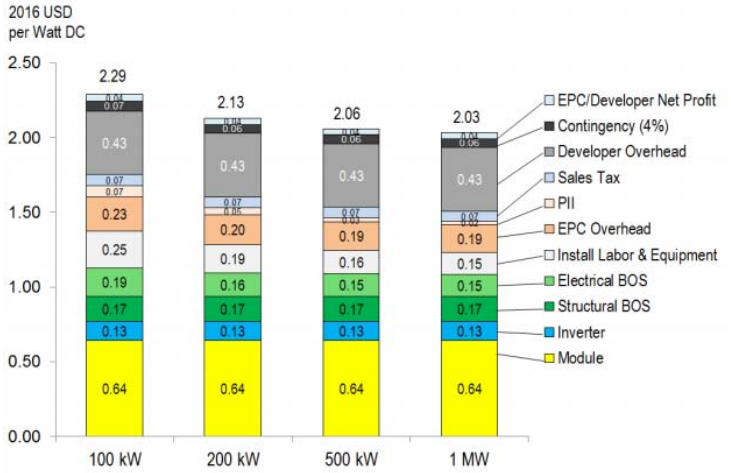
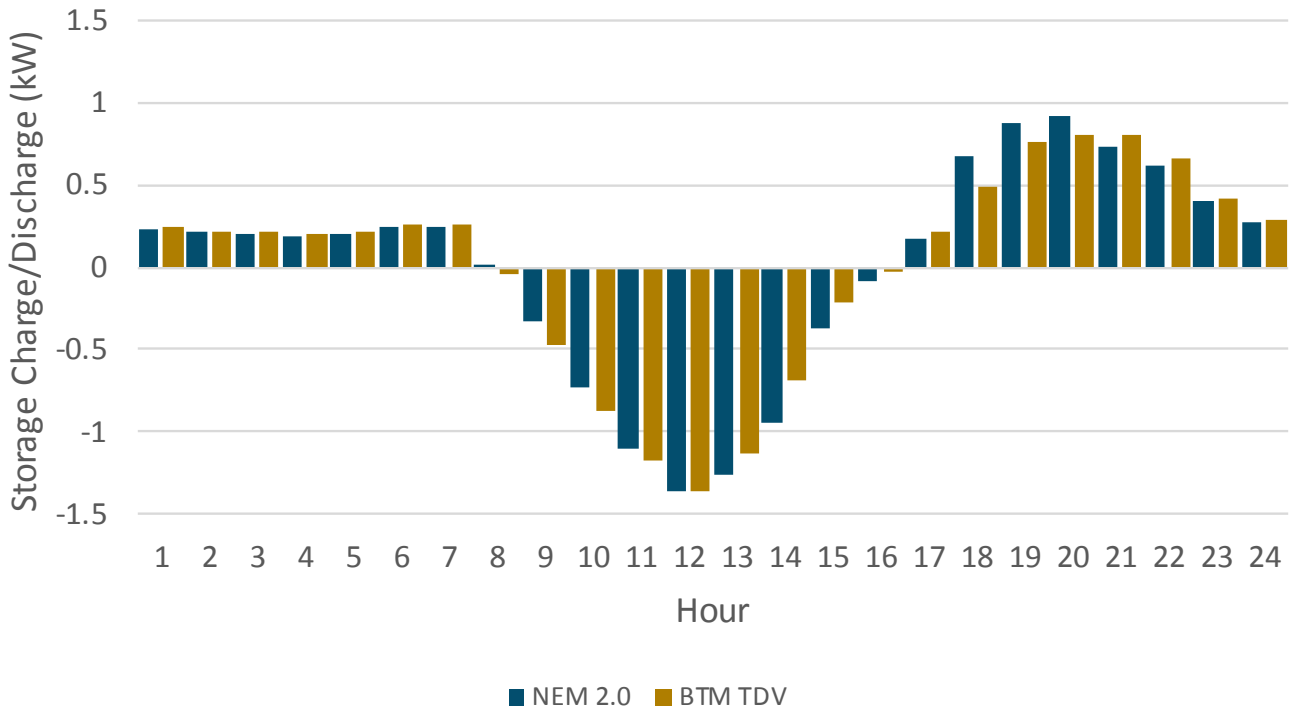



Figure 16. Q1 2016 U.S. benchmark: commercial system cost (2016 USD/Wdc)

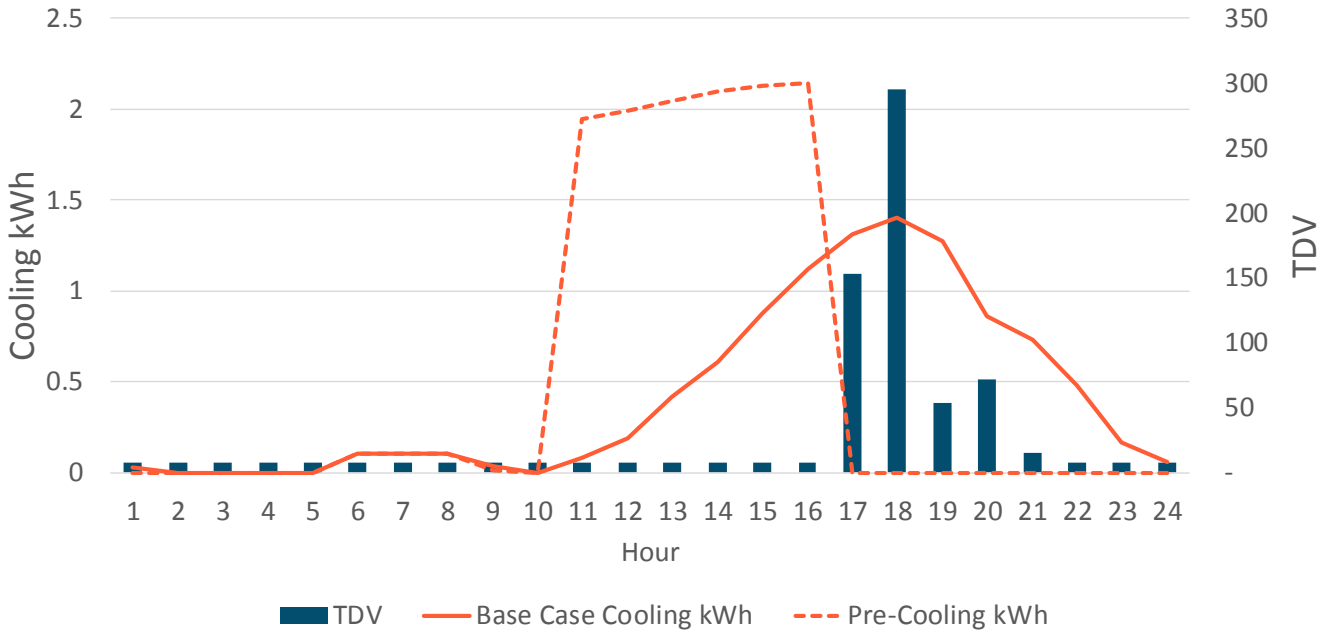
# Grid Harmonization - Batteries

- **Developed storage dispatch under different TDV assumptions**
- **Either way, charge during the day, discharge in evening**



# Grid Harmonization –Pre-Cooling

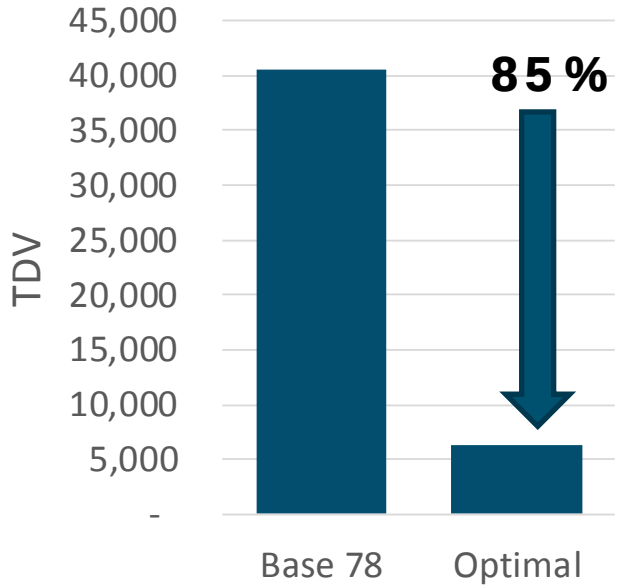
- Base case residential model assumes a cooling season set point of 78° F
- By pre-cooling the building with a communicating setback thermostat to below 78° before the highest TDV hours, the building can save TDVs by allowing the temperature to rise back to 78° during these highest hours
- Pre-cooling often means using more kWh than in the base case

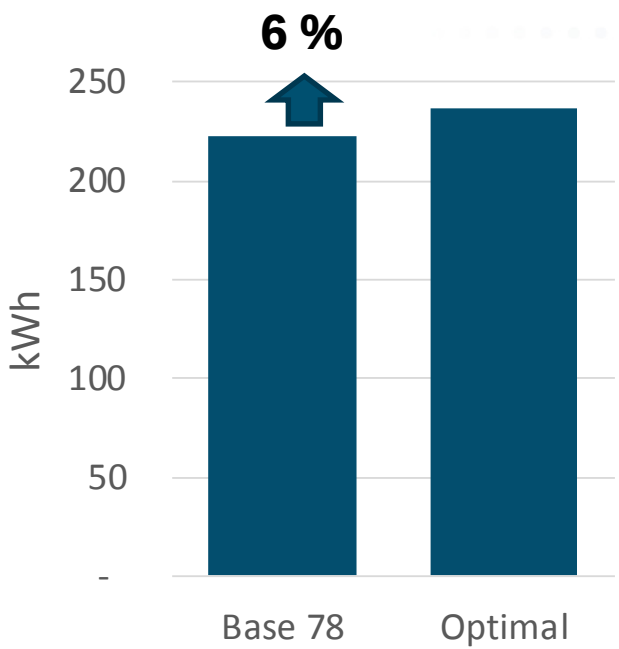


# Benefits of Pre-Cooling in Sacramento (Climate Zone 12)

## + By utilizing pre-cooling

- Cooling TDV consumption is reduced 84%
- Cooling kWh increased 19%

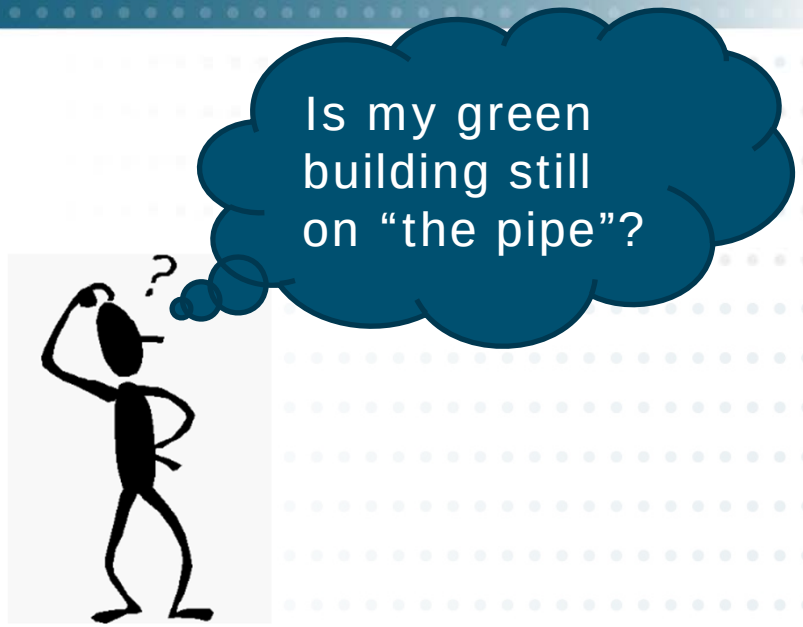



| | Days at Cooling Schedule |
|---|---|
| 75 for 2 hrs | 12 |
| 75 for 4 hrs | 13 |
| 75 for 6 hrs | 10 |
| 75 for 8 hrs | 2 |
| 75 for 10 hrs | 2 |
| 72 for 2 hrs | 2 |
| 72 for 4 hrs | 6 |
| 72 for 6 hrs | 28 |
| 72 for 8 hrs | 5 |
| 72 for 10 hrs | 9 |
| 75 for 6 hrs stop 2 | 23 |
| 75 for 10 hrs stop 2 | 7 |
| Const 78 | 246 |

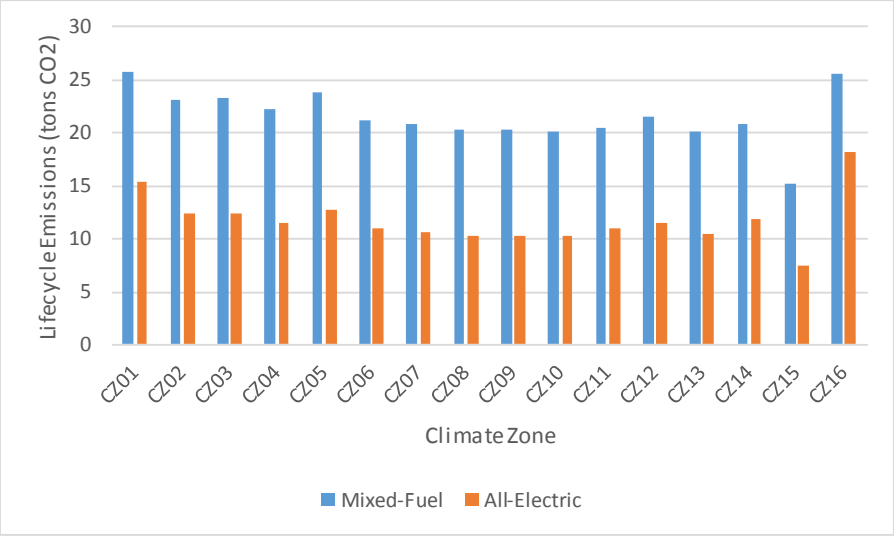
# Natural Gas Use in Buildings

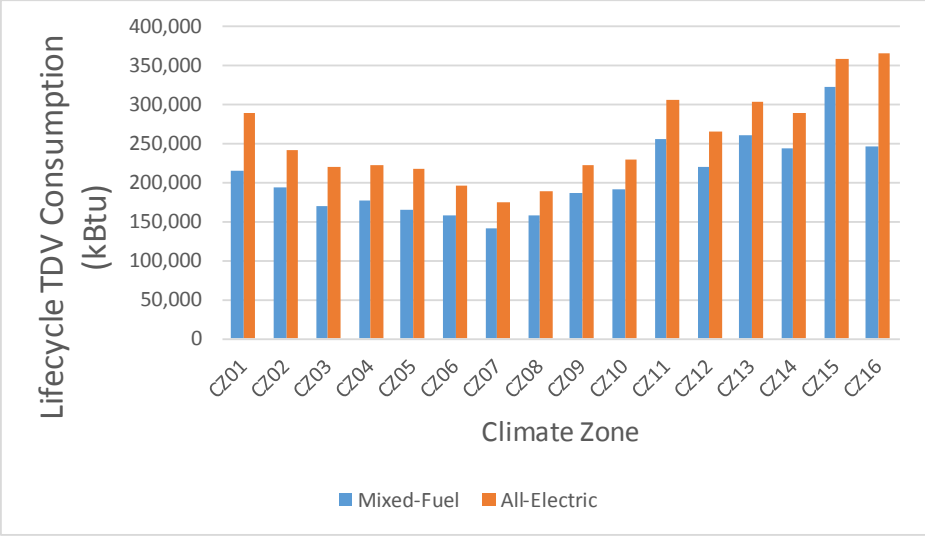
- The approach for ZNE buildings to address natural gas consumption is a crux issue for GHG emissions
- All-electric buildings with heat pump space and water heating reduce GHG emissions in California by about 50% over the life of the building
- What about biogas?




# Natural Gas and GHG Emissions

- **Results for 2,100 sqft residential prototype for emissions and lifecycle TDVs compared between mixed-fuel and all-electric prototype homes**
- **All-electric homes require more TDV (cost ~20% more to operate), but produce less GHGs (by ~50%) in California using the CEC Title 24 methodology**



# Summary Discussion

## + Positive things about the ZNE policy in California

- We will encourage design and construction of better buildings
  - innovation in building efficiency and design
  - demand for green, efficient buildings
  - solar roofs, an ideal place for solar from an environmental perspective
  - engage building owners in their energy use, and lower their operating costs
- The TDV metric embeds grid harmonization into the metric, rewards building features that are good citizens on the grid

## + However, the mandate for all buildings to be ZNE is sub-optimal from a systems integration perspective and GHG policy

- Doesn't align with California's primary goal on GHGs
- Relies on higher cost renewable generation and less diverse generation opportunities than on the grid
- Doesn't work for some building types with higher building density or smaller footprints without broadly redefining ZNE with off-site renewables
- A better policy would allow, but not require, the solar rooftop solar and focus on energy efficiency and grid harmonization

# CONTACT INFORMATION

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