# CESA Webinar

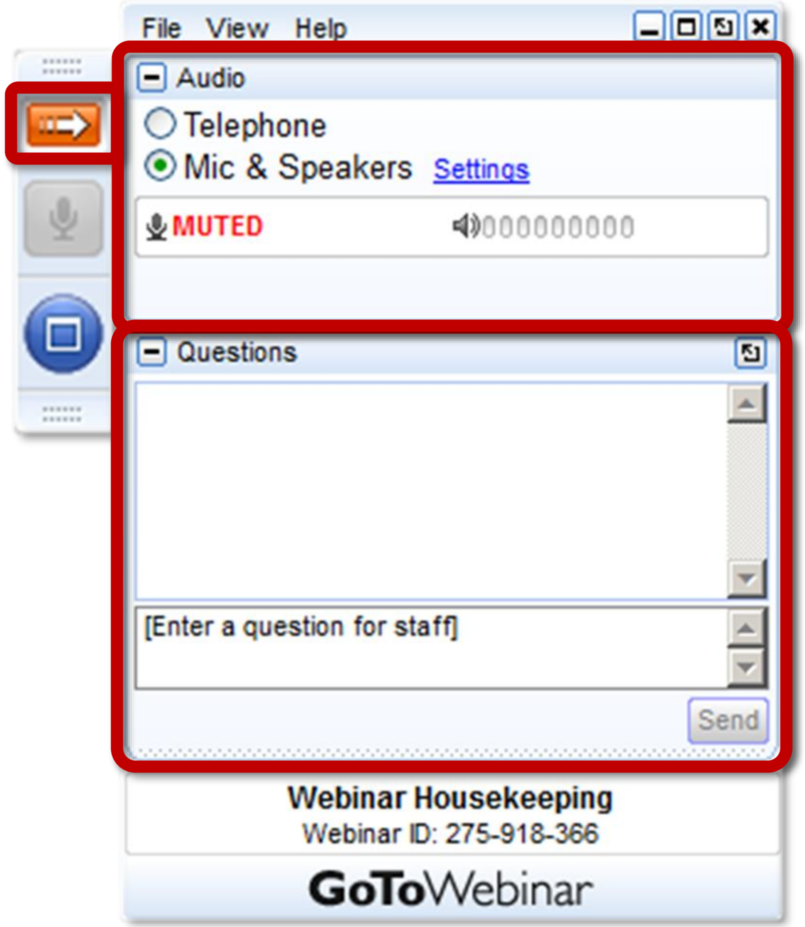
# California's Pioneering Policies for New Homes: Greater Efficiency with Required Solar Energy

Hosted by
Warren Leon, Executive Director, CESA

September 11, 2018

Clean Energy States Alliance

# Housekeeping

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# Webinar Speakers

**Maziar Shirakh**

ZNE Lead and Advisor for Building Energy Efficiency Standards, California Energy Commission

**Warren Leon**

Executive Director, Clean Energy States Alliance (moderator)

Building Energy Efficiency Standards

# The 2019 Building Energy Efficiency Standards ZNE Strategy

Building Standards Office:

**Mazi Shirakh, PE**
ZNE Lead and Advisor for Building Energy Efficiency Standards (BEES)

**Christopher Meyer**
Manager, Building Standards Office

**Bill Pennington**
Senior Technical and Program Advisor to the Energy Efficiency Division

**Payam Bozogchami, PE**
Project Manager, BEES

**Danny Tam**
Mechanical Engineer

**Clean Energy States Alliance**

September 11, 2018

# 2019 Standards Goals – Path to the Future

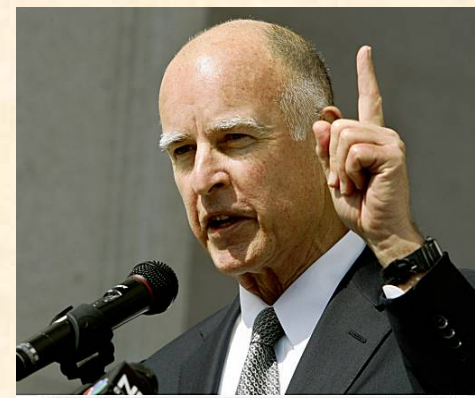
1. Increase building energy efficiency cost effectively
2. Contribute to the State's GHG reduction goals
3. Substantially reduce the home's impact on the grid through efficiency and PV
4. Promote grid harmonization and self-utilization of PV generation
5. Provide independent compliance paths for both mixed-fuel and all-electric homes
6. Provide tools for Part 11 Reach Codes and other beyond code practices

**The proposed 2019 Standards strategy will accomplish all of these goals listed above**

# California Dreamers

The ZNE Policy was initiated under the Schwarzenegger administrations and continued under the Brown Administration.  The following policy documents establish the goal for new building standards to achieve ZNE by 2020 for residences and by 2030 for nonresidential buildings:

- 2008 CPUC/CEC Energy Action Plan – Endorsement by both agencies of ZNE for Residential buildings by 2020 and nonresidential buildings by 2030
- 2008 CPUC California Long Term Energy Efficiency Strategic Plan
- 2008 CARB Climate Change Scoping Plan
- 2007 (and later) CEC Integrated Energy Policy Report (IEPR)
- Governor's "Clean Energy Jobs Plan"



# Investment in Change

Senate Bill 1 (SB 1, Murray, 2006) goals:

- 3,000 MW of installed Distributed Generation solar PV capacity
- Self-sufficient solar industry
- Solar installed on 50% of new homes

Programs:

- New Solar Homes Partnership (NSHP)
- California Public Utilities Commission

    California Solar Initiative

- Local Publicly Owned Utilities Programs

# New Solar Homes Partnership


Photo Courtesy of Sherrill Neidich

## Program Goals

Sustainable solar homes market; builder commitment to install solar energy systems

High-performing solar systems on highly efficient residential construction

Achieve 360 megawatts of installed solar electric capacity in California

Solar on 50%+ of new homes

Self-sufficient solar industry

# New Solar Homes Partnership


Photo Courtesy of Sherrill Neidich

## Program Success

### Participation:

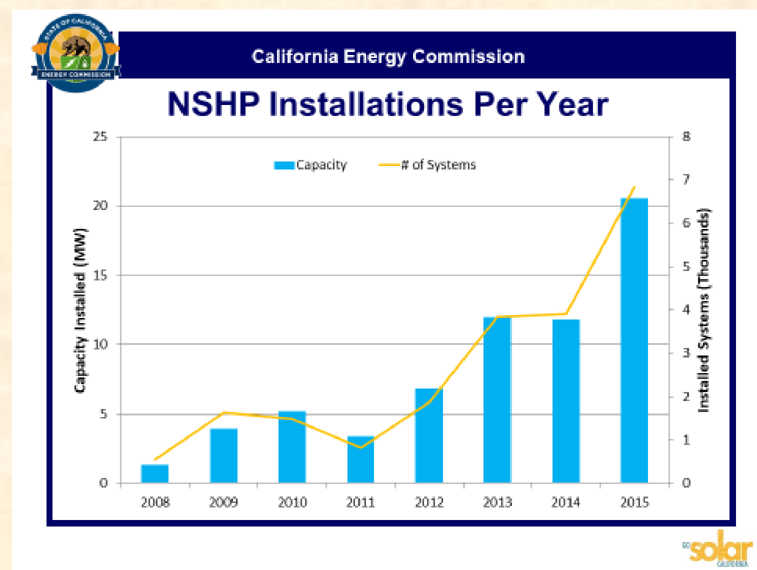
75+ Builders

30+ Retailers and Installers

### Installed and Reserved to Date:

113,857 Systems / 415.5 MW AC

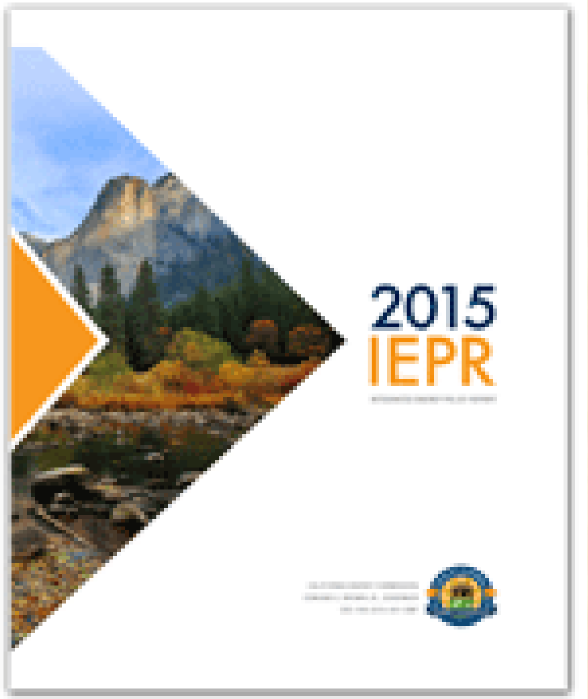
$353,200,000 million in incentives



# ZNE Strategy: the IEPR Vision

A decade ago when the ZNE goal was first set it was a simple idea: All newly constructed residential buildings by the year 2020 must be ZNE as defined by the IEPR (Integrated Energy Policy Report): improve building efficiency, deploy PVs, and:

> "…the value of the **net amount of energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building**, at the level of a single "project" …. using the California Energy Commission's **Time Dependent Valuation** metric."



# Lessons Learned

Reality turns out to be more nuanced – in the intervening years, new developments have had a significant impact on the ZNE approach, including:

- Large utility scale (50% RPS requirements) and buildings based PV deployment
- Net energy metering (**NEM)** rules and Time-Of-Use (**TOU**) compensation for residential customer-owned generation
- The current NEM rules treat the grid as "**virtual storage**" (or a bank), where the overgenerated kWhs can be "stored" and used later in the day, or another season

ZNE is a goal, NEM and life cycle costing are laws and we must operate within their confines.

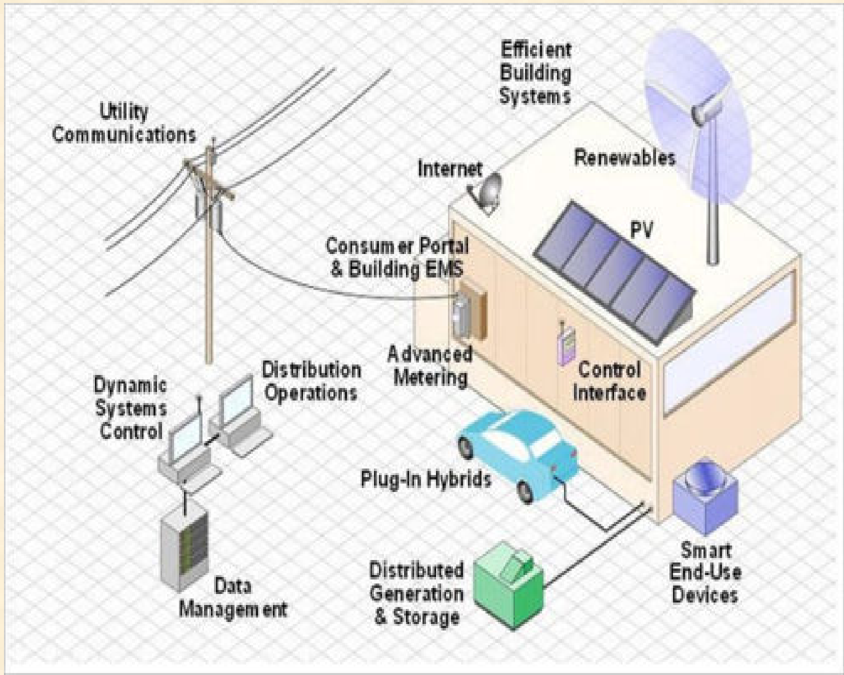
# Grid Harmonization

Grid harmonization strategies (GHS) when coupled with customer owned PV systems bring maximum benefits to the grid, environment, and occupants

Grid Harmonization Strategies Defined:

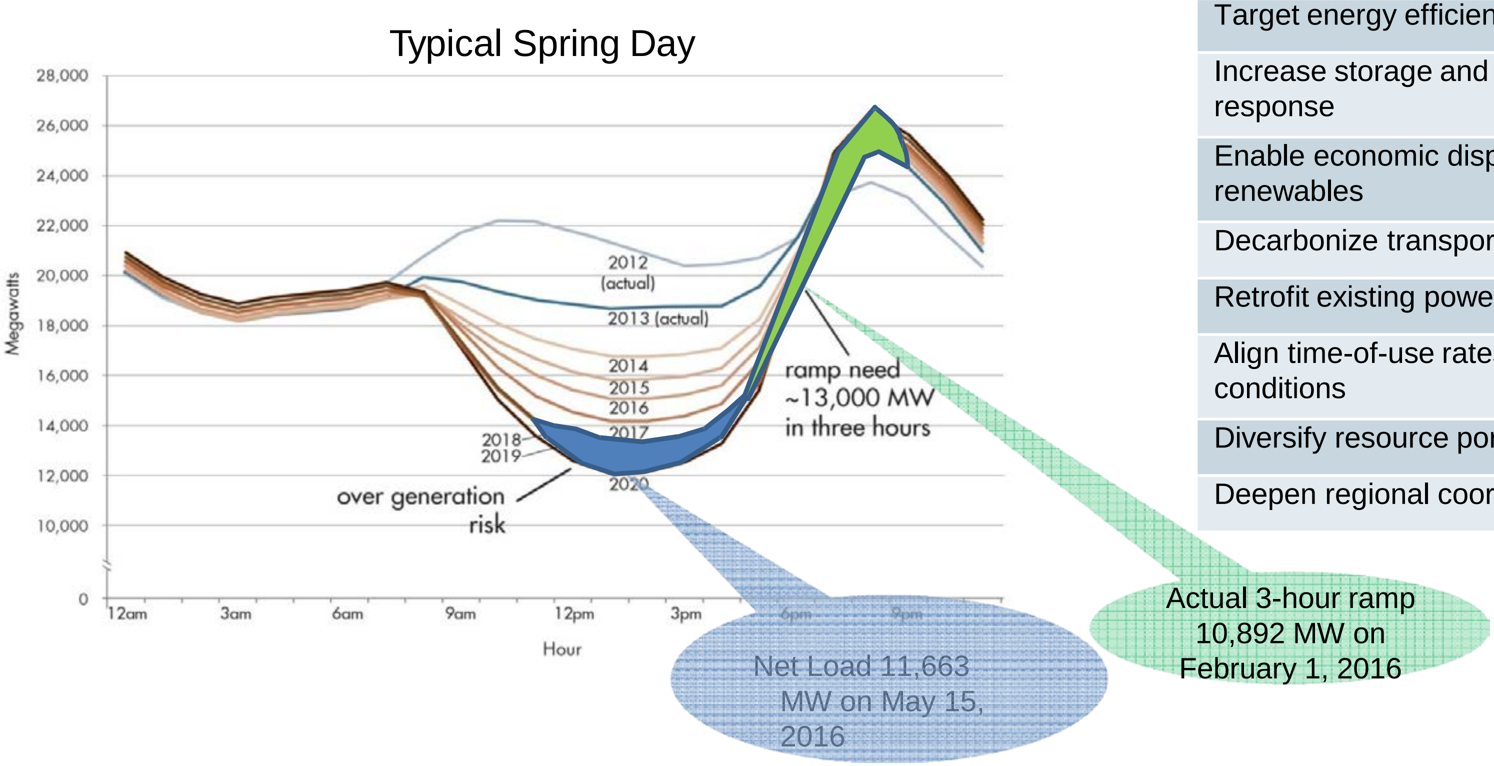
*Grid Harmonization Strategies are measures that harmonize customer owned distributed energy resources assets with the grid to maximize self-utilization of PV array output, and limit grid exports to periods beneficial to the grid and the ratepayer;*

*Examples of GHS include but are not limited to PVs in combination with battery storage, demand response, thermal storage, and in the future Electric Vehicle (EV) harmonization.*



# Bad Duck

## Oversupply and ramping: A challenge as more renewables are integrated into the grid

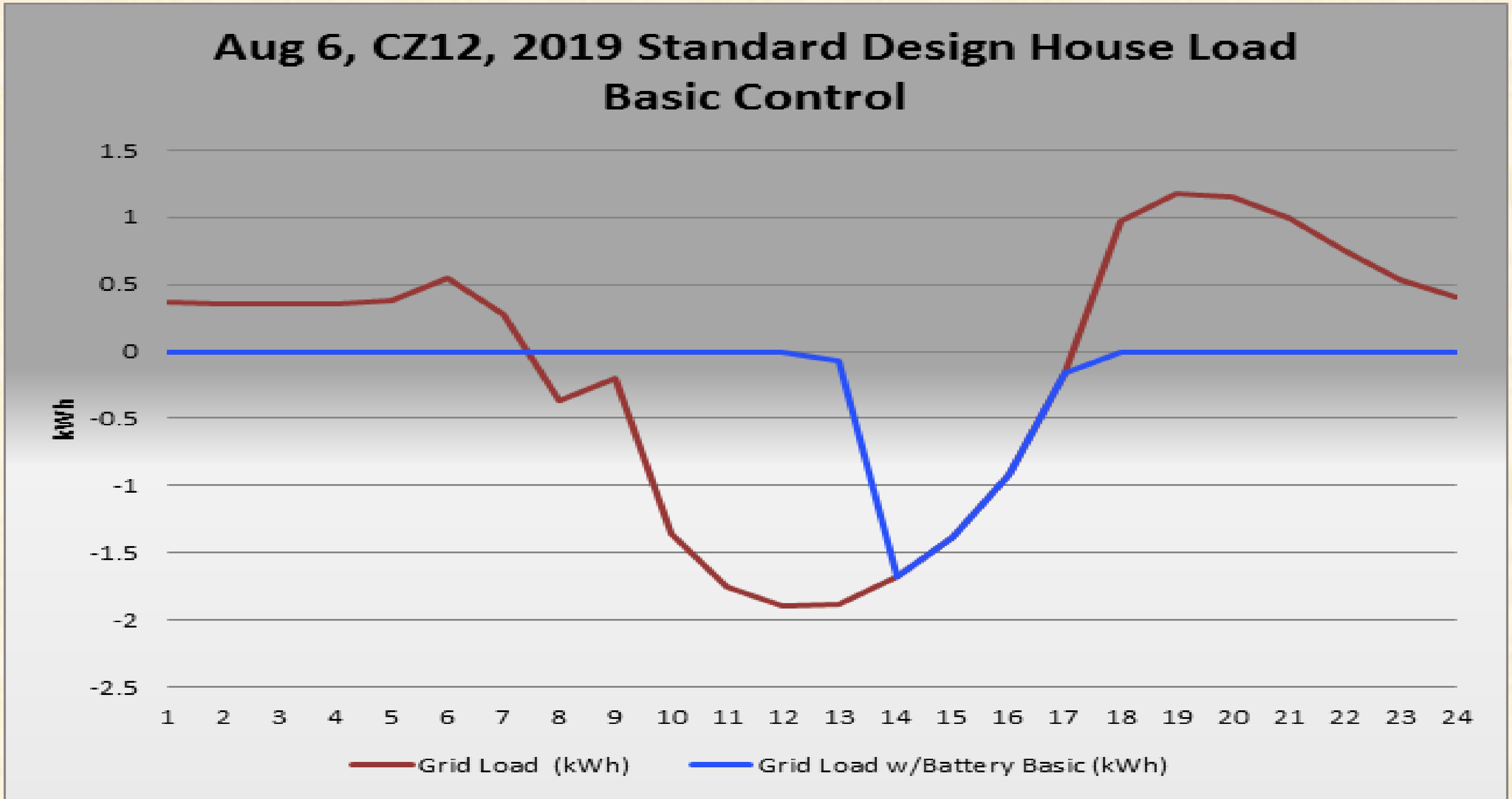



| Solutions |
| --- |
| Target energy efficiency |
| Increase storage and demand response |
| Enable economic dispatch of renewables |
| Decarbonize transportation fuels |
| Retrofit existing power plants |
| Align time-of-use rates with system conditions |
| Diversify resource portfolio |
| Deepen regional coordination |

# Good Duck

**The Invisible House - PV Plus Basic Battery – A "Mild" Summer Day**

Temporal netting assumes all hours of the day have the same emission and energy cost values, not a correct assumption - Blue line smooths out the belly of the duck and achieves zero carbon and zero energy without resorting to netting



# 2019 Standards Approach

The 2019 Standards recognize following efficiency and generation resources priorities:

1. Envelope efficiency: High performance attic (HPA) R-19 between rafters, high performance walls (HPW) U-factor 0.048, Quality Insulation Installation (QII), better windows with 0.30 U-factor and 0.23 SHGC
2. Appropriately sized (right-sized) PV systems,
3. Level playing field for all-electric homes, and
4. Grid harmonization strategies that maximize self-utilization of the PV output and limit exports to the grid

PV are a prescriptive requirement, but batteries are only a compliance option

# PV Cost Effectiveness

All Standards measures, including  efficiency and renewables, must be cost effective using life cycle costing (LCC)

Must comply with NEM sizing rules – Offset the annual kWh of the building, overgeneration compensated at wholesale ~ 3 cents/kWh

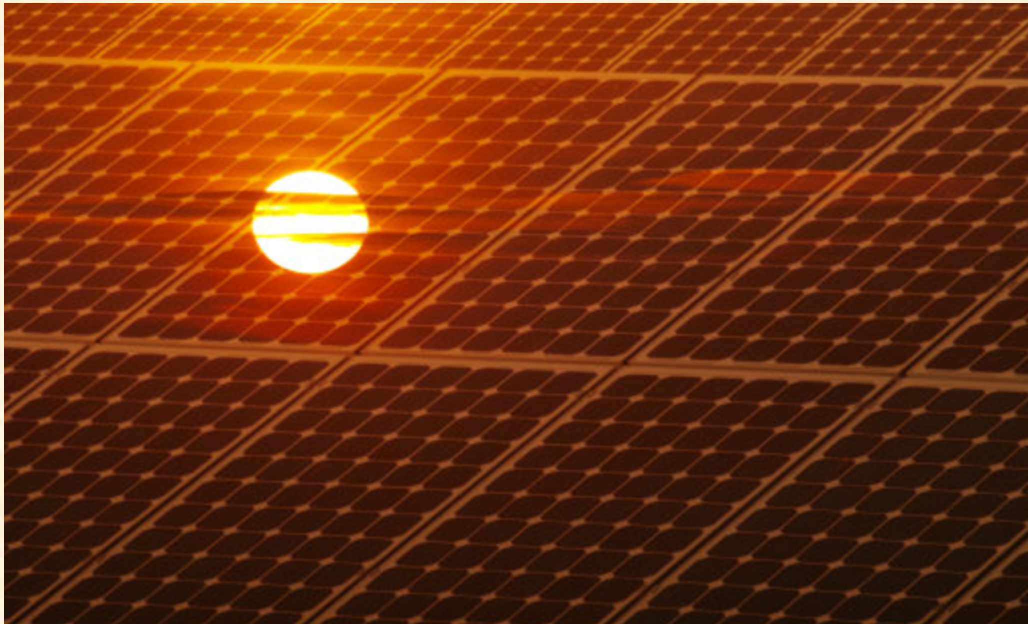
PVs are sized to displace annual kWhs are found to be cost effective in all 16 climate zones

# Here Comes the Sun…

**For the first time, 2019 Standards include prescriptive solar PV systems,** sized to displace the annual kWhs of a mixed-fuel home

There are several Exceptions, including:

- Shading due to external barriers
- Building plans approved prior to 1/1/2020
- Variance for multi-story buildings with limited roof space



# I'll Follow the Sun

## Options for PV Compliance

The building Standards allow different options for high performance walls and attics, similarly, there will be several different options for meeting the PV requirements:

- Rooftop installation
  - ✓ Outright purchase – larger initial investment by home owner, larger monthly savings
  - ✓ Lease and PPA options – little or no initial investment, smaller monthly savings
- Community Solar – If and when approved and become available, will be an alternative to rooftop PVs

# Community Shared Solar/Renewables

Community Solar - Section 10-115 – Include shared PV and Battery Storage systems

Homes can instead be served by Commission approved community solar projects that provide equivalent benefits to the homes as onsite PV systems.

1. CS resources may include other shared renewables like wind and geothermal
2. Energy Performance – As if it is a rooftop PV systems
3. Energy savings dedicated to building for 20 years NOT occupants
4. Cost Savings – Cannot cost the occupants more than non-participants
5. Durability – Dedicated to the building for at least 20 years, like rooftop PVs
6. Additionality – CS resources must exclusively serve the building and not other buildings or purposes

# Joint Appendix 11 & 12

**JA11- Qualification Requirements for Photovoltaic System:**

1. The PV system must meet orientation and shading requirements
2. PV system must provide lifetime web & mobile based monitoring capabilities to allow occupants to monitor the performance of their systems

**JA12- Qualification Requirements for Battery Storage System:**

Turns the battery into a dynamic device that when coupled with a PV system brings maximum benefits to the environment, grid and the occupants

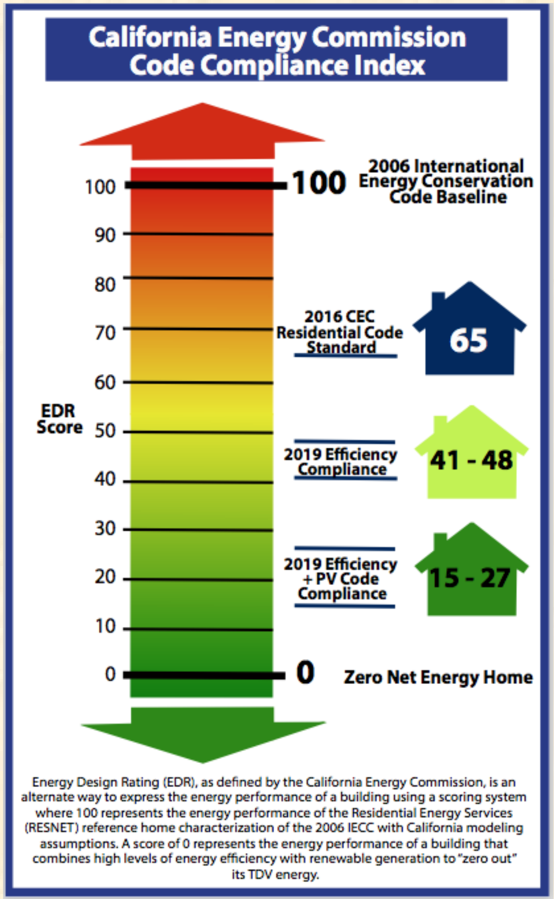
Three Control Strategies:

1. Basic – Charge when generation greater than load, discharge when loads greater than generation
2. TOU – Hold off discharge until the onset of highest TOU period
3. Advanced Demand Response – Charge/discharge in response to DR signal

Commissions may approve additional control strategies with similar benefits

# Builds on Commission's Energy Design Rating Tool

- **Energy Design Rating (EDR) score show how close a home is to the ZNE target**
  - ➢ Aligned with RESNET
  - ➢ Reference home  is a 2006 IECC compliant home, EDR=100
  - ➢ A score of zero means a ZNE building
- CEC's CBECC-Res software has the capability to calculate EDR scores for EE and PV
- EDR approach provides ultimate flexibility to achieve compliance
- Builders can use a combination of envelope energy efficiency features, storage, demand response, better appliances, PVs, and other strategies to get to the target EDR



# Target EDR and Compliance Tool

Here is an example of how CBECC-Res calculates the Target EDR for both EE and PV in climate zone for the 2,700 sq.ft house:

2019_CZ12_2700ft2_Std_ELEC - CZ12 STD2700 EGLASS20 ELEC

Compliance Summary | CO2 Emissions | Energy Design Rating | Energy Use Details | CO2 Design Rating

EDR of Standard Efficiency: 48.1 - EDR of Standard Design PV: 18.7 = Final Std Design EDR: 29.4

Std Design PV: 3.17 kW (not current)

EDR of Proposed Efficiency: 46.8 - EDR of Prop PV + Flexibility: 43.8 = Final Proposed EDR: 3.0

| End Use | Reference Design Site (kWh) | Reference Design Site (therms) | Reference Design (kTDV/ft²-yr) | Proposed Design Site (kWh) | Proposed Design Site (therms) | Proposed Design (kTDV/ft²-yr) | Design Rating Margin (kTDV/ft²-yr) |
|---|---|---|---|---|---|---|---|
| Space Heating | 5,107 | | 56.05 | 2,273 | | 25.01 | 31.04 |
| Space Cooling | 1,645 | | 61.06 | 353 | | 20.06 | 41.00 |
| IAQ Ventilation | 194 | | 2.28 | 194 | | 2.28 | 0.00 |
| Other HVAC | | | 0.00 | | | 0.00 | 0.00 |
| Water Heating | 2,924 | | 34.29 | 1,030 | | 11.14 | 23.15 |
| Grid Harmonization | | | | | | 0.00 | 0.00 |
| Photovoltaics | | | | -9,416 | | -95.35 | 95.35 |
| Battery | | | | 318 | | -19.94 | 19.94 |
| Inside Lighting | 2,615 | | 34.79 | 616 | | 8.01 | 26.78 |
| Appl. & Cooking | 2,596 | | 31.59 | 2,135 | | 26.07 | 5.52 |
| Plug Loads | 3,146 | | 38.73 | 2,371 | | 28.73 | 10.00 |
| Exterior | 328 | | 4.15 | 152 | | 1.87 | 2.28 |
| TOTAL | 18,555 | | 262.94 | 25 | | 7.88 | 255.06 |

Done

# The All-Electric Option PV Size

**What should be the PV sizing requirement be for All-Electric Homes (AEH)?**

Staff proposes that AEH PV size be the same as an equal sized mixed fuel home with similar features:

- Requiring a much larger PV system on an AEH to displace the larger annual kWh may disincentivize the AEH approach
- The larger PV needed to displace the AEH kWh, makes grid harmonization strategies more important

# Resistance Is Futile

Advances in **heat pump** water and space heating technologies **(no resistance heating)** has made all-electric homes a viable alternative to mixed-fuel homes

2019 Standards provide two parallel prescriptive paths for compliance for each of:

1. Mixed Fuel Homes
2. All-Electric Homes – All-electric homes have lowest GHG emissions, especially when coupled with PVs and storage

NEEA Tier 3 HPWH models can easily be used to meet or exceed standard design using the performance path

# Don't Judge Me By My Size

Lean and mean PV systems that work for the grid and home occupants. The average required PV size is 2.8 KW. The table below shows the PV sizes for a 2,700 sq.ft house in different climate zones. By comparison, the average existing home PV installation is 7.2 kW. PV sizes vary with house size and climate zone

**PV Sizes for Mixed Fuel Homes. 2700 SF Prototype**

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| **CZ** | **Efficiency EDR without PV, based on 2019 Efficiency Measures** | **Target Design Rating Score for Displacing kWh Elect with PV** | **kW PV Size for Displacing kWh Electric Only** |
| **1 - Humboldt** | **48.0** | **26.5** | **3.4** |
| **2 – Santa Rosa** | **41.2** | **18.0** | **2.9** |
| **3 – San Francisco** | **46.9** | **22.7** | **2.8** |
| **6 – Costal LA** | **48.0** | **20.9** | **2.9** |
| **7 – San Diego** | **48.0** | **14.9** | **2.7** |
| **8 - Disneyland** | **43.0** | **14.6** | **2.9** |
| **11- Redding** | **43.3** | **23.4** | **3.8** |
| **12 - Sacramento** | **43.1** | **24.5** | **3.1** |
| **13 - Fresno** | **44.8** | **22.1** | **4.0** |
| **14 - Palmdale** | **44.6** | **21.3** | **3.4** |
| **15 – Palm Springs** | **48.0** | **17.9** | **5.7** |
| **16 - Tahoe** | **46.3** | **27.5** | **3.0** |

# Are Your PV Cost Numbers For Real?

The Commission's PV cost effectiveness is based on a system installed cost of ~ $3/w by 2020, for a ~ 2.8 kW system; but, are these numbers for real?

| California New Solar Home Partnership (NSHP) Program PV Installation Costs For New Buildings | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Number of Systems** | **Median PV Size** | **Average PV Size** | **Median Cost/Watt** | **% Reduction, Median** | **Average Cost/Watt** | **% Reduction, Average** |
| 2015 | 7,150 | 2.6 | 3.0 | $ 4.85 | 0% | $ 4.82 | 0% |
| 2016 | 5,924 | 2.7 | 3.3 | $ 4.31 | 11% | $ 4.30 | 11% |
| 2017 | 7,973 | 2.7 | 3.2 | $ 3.58 | 26% | $ 3.98 | 17% |
| 2018 | 2,922 | 2.7 | 2.9 | $ 3.00 | 38% | $ 3.66 | 24% |

This data is in-line with other sources we used to generate costs and savings estimates:

1. National Renewable Energy Labs (NREL)– Estimates a cost of $2.80/w in Q1 2017. See "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017" NREL Report: https://www.nrel.gov/docs/fy17osti/68925.pdf, and
2. SEIA, Solar Energy Industry Association, both national and California chapters, Estimate a cost of $2.94/w in Q4 2017

# Keep That Gas Out Of My Home

**$CO_2$ emissions reduced by 700,000 metric tons over three years, equivalent to 115,000 gas cars off the road.  California had one of the cleanest grids, $CO_2$ savings may be greater in other states.**

| 2700 sf prototype, CZ12 | | |
|---|---|---|
| **CO2 Impact of Housing Choices** | | **Metric mTons of CO2 Generated/Year - Including Exports** |
| Mixed Fuel | 2000 Compliant Building, No PV | **6.5** |
| Mixed Fuel | 2016 Compliant Building, No PV | **3.3** |
| Mixed Fuel | 2019 Standard Design, with 3.1 kW PV | **2.3** |
| Mixed Fuel | 2019 Standard Design, with 3.1 kW PV With Batt | **2.1** |
| All-Elect | 2019, 3.1 kW PV, No Batt | **1.1** |
| All-Elect | 2019, 3.1 kW PV, With Batt | **1.0** |
| All-Elect | 2019, 6 kW PV, With Batt | **0.2** |

# Keep That Gas Out Of My Car

## Combining 2019 Standards Compliant Homes with EVs Results in Very Low Emissions

| Combined $CO_2$ Impact of the 2700 Square Feet Home With Two Cars | | | |
|---|---|---|---|
| House Fuel Type | Scenario | Annual $CO_2$ Production - mTons per year | Percent Reduction |
| Mixed Fuel | 15 year old mixed fuel home with two 10 years old gasoline cars | **18.6** | 100% |
| Mixed Fuel | 2019 compliant mixed fuel home with 3 kW PV and two EVs | 3.8 | 20% |
| Mixed Fuel | 2019 compliant mixed fuel home with 8 kW PV and Batt and two EVs | 2.5 | 13% |
| All-Electric | 2019 compliant all-electric home with 6kW PV and Batt and two EVs | **2.1** | 11% |
| All-Electric | 2019 compliant all-electric home with 8 kW PV and Batt and two EVs | **1.1** | 6% |

# Optional Stretch Codes - CalGreen

CalGreen and other optional stretch codes may specify more aggressive performance targets than the base code, to achieve more energy savings and lower GHG emissions:

| Example CZs | Base Code EDR Target | CalGreen Tier 1 EDR Target | CalGreen Tier 2 EDR Target |
|---|---|---|---|
| CZ3-San Francisco | 23 | 10-14 | 0 |
| CZ12-Sacramento | 25 | 10-12 | 0 |

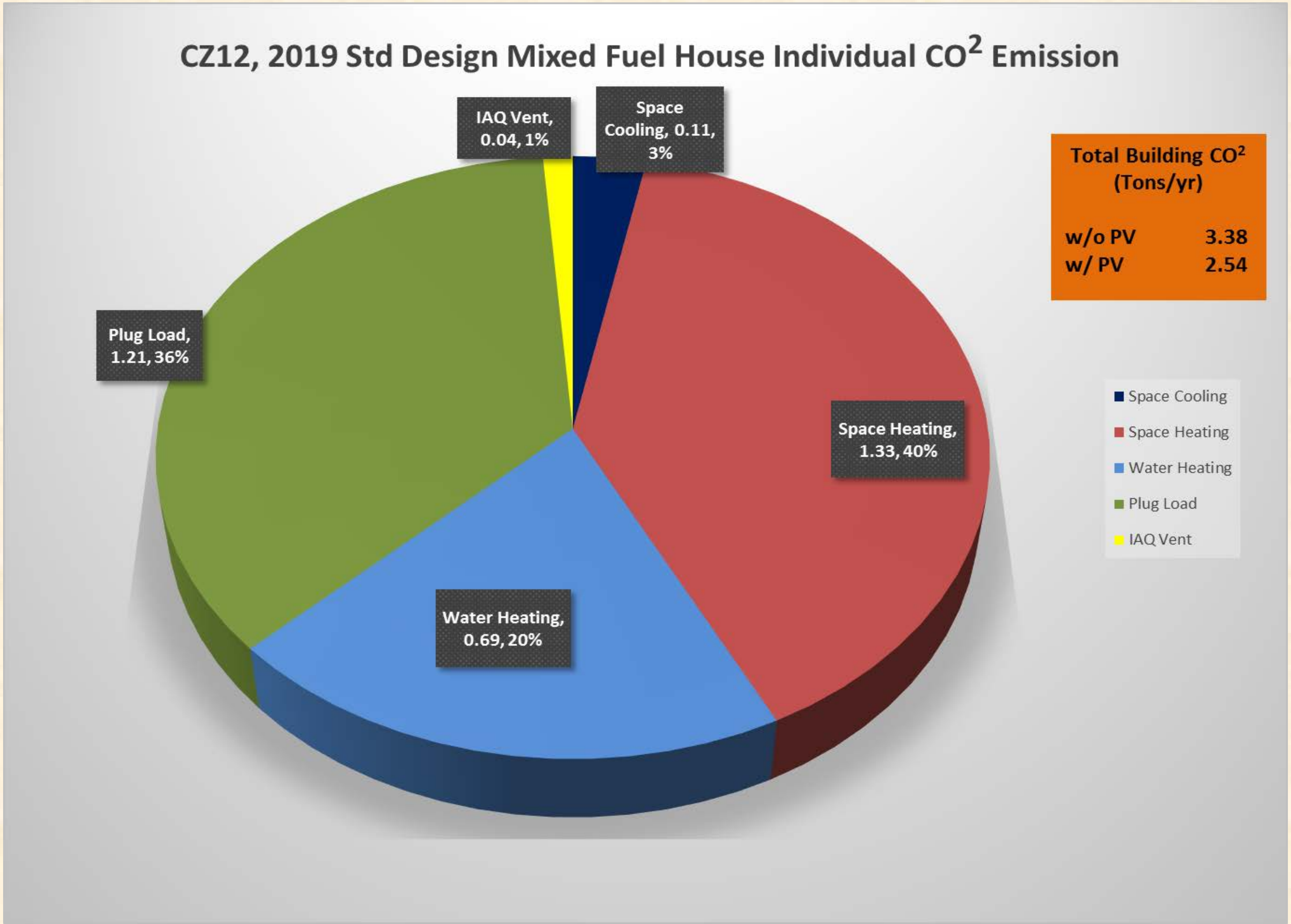
Tier 1 and Tier 2 targets can be reached by:

- More energy efficiency
- Larger PV systems that are coupled with at least 5 kWh battery storage system

CBECC-Res can be used to demonstrate compliance with CalGreen

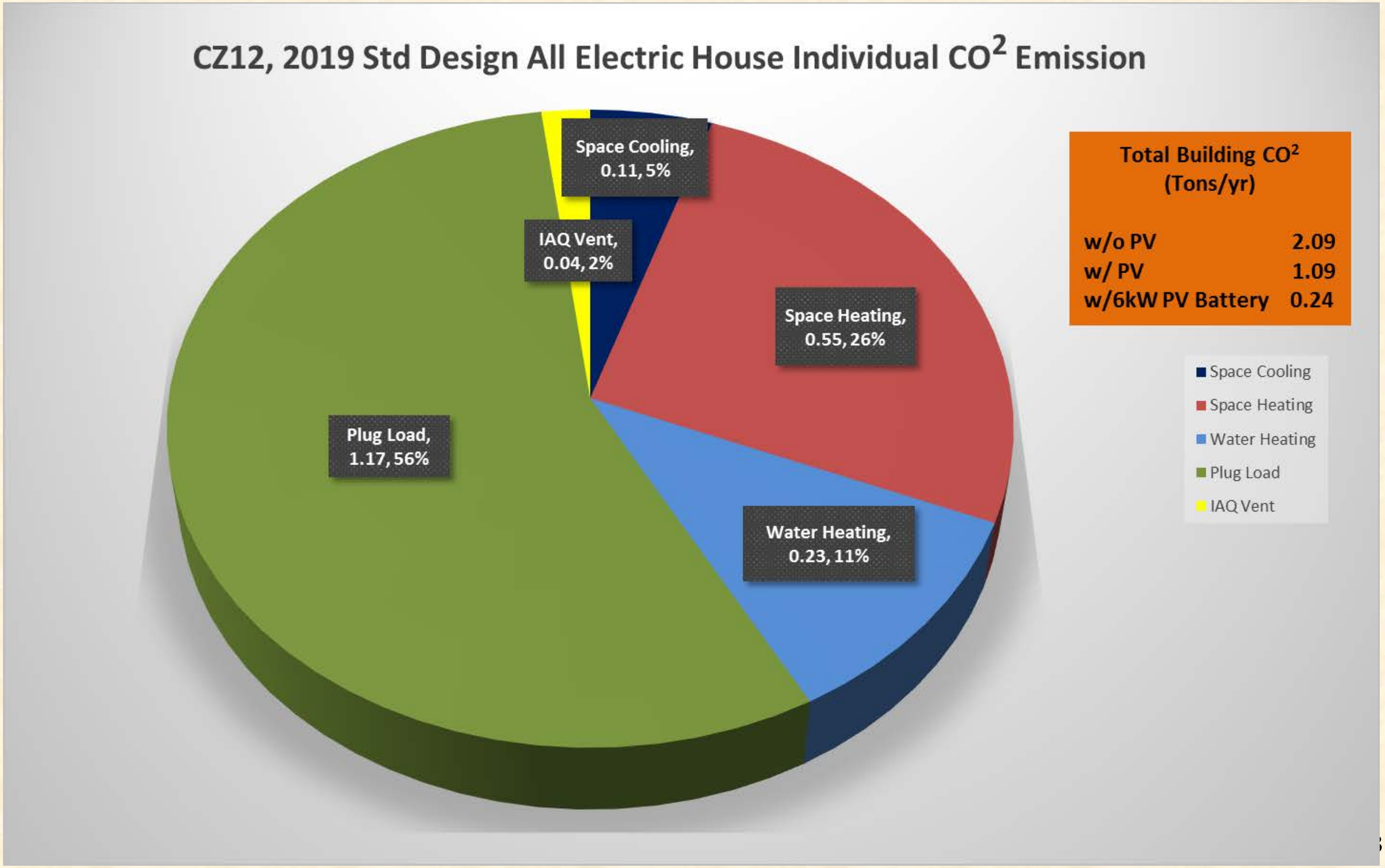
# CO2 Reduction in Buildings

## CO2 Emissions by Loads, Mixed-fuel Home, CAZ12, 2700 sf



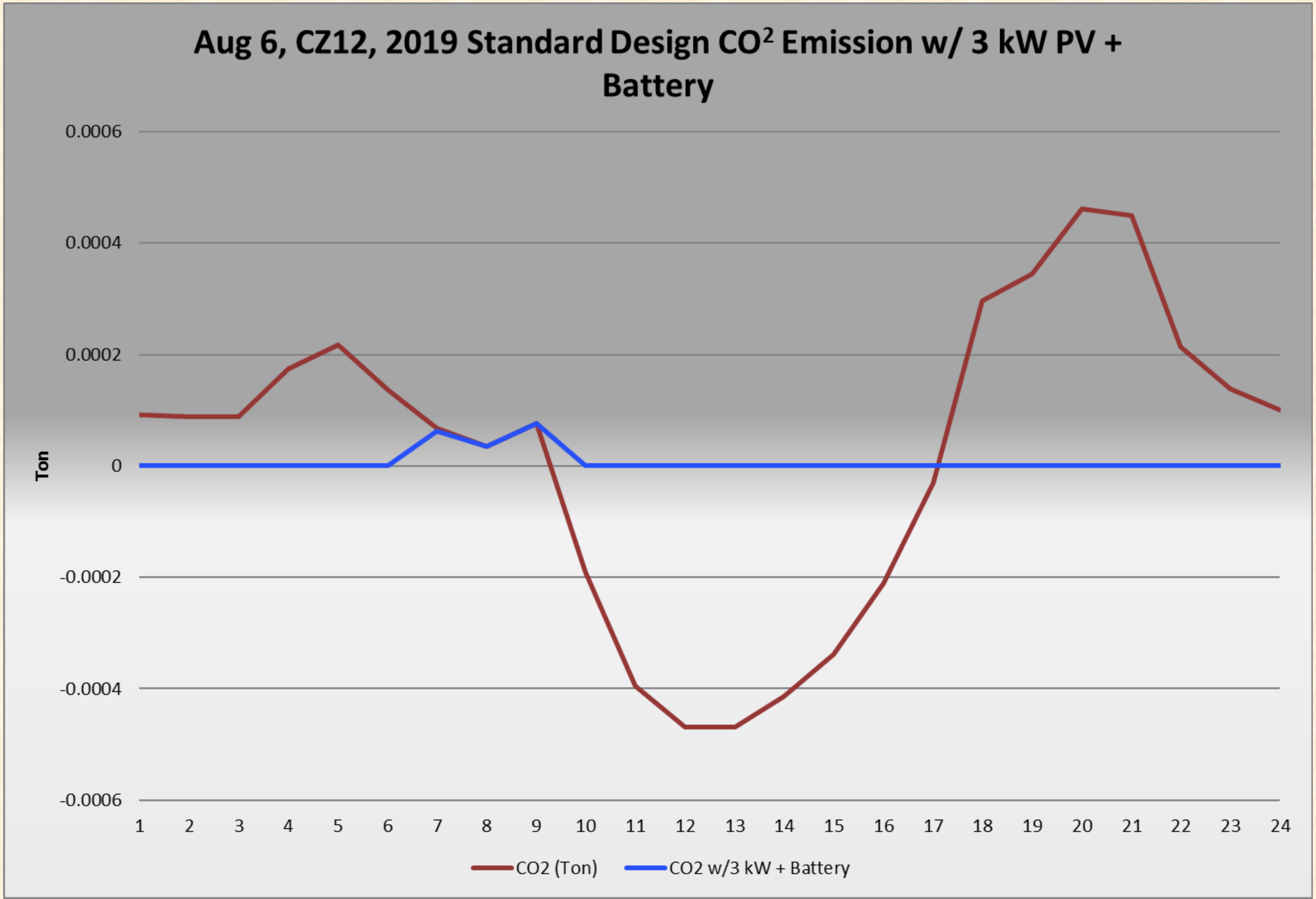
# CO2 Reduction in Buildings

## CO2 Emissions by Loads, all-Electric Home, CAZ12, 2700 sf



# CO2 Reduction in Buildings

## Daily CO2 Emission, all-Electric Home, CAZ12, 2700 sf, With and Without Storage



# Energy and $CO_2$ Savings

**Residential – For Single Family Homes:**

- Average 30-year cost of $9,500 and Savings of $19,000
- Monthly mortgage increase of $45 and energy bill reduction of $80
- Energy savings of 7% without PVs and 53% of entire house with PVs

**Percent Savings Between 2005 and 2019 Standards Cycles**

| Statewide Average | Residential Energy Savings | Residential CO2e Reduction |
|---|---|---|
| | 68% | 52% |

**Nonresidential:** LED lighting will save > 480 gigawatt-hours in the first year

**Combined:** The efficiency improvements save over 650 GWh for all buildings, enough to power 250,000 electric cars

# Utility Scale PVs Versus Rooftop PVs

**Question:** The larger utility-scale PV systems cost about half as much as onsite PV systems. Would it be more cost effective to achieve the state's policy goals with the less expensive utility scale PV systems?

**Response:**
The state is pursuing a diverse set of simultaneous energy and environmental policies including:

1. Reduce greenhouse gas emissions from all sectors, including buildings and transportation
2. Maintain grid reliability and resilience
3. Achieve cost-effective energy savings in buildings

To achieve these policy goals, the state must utilize both utility scale and onsite PV options. These approaches are complementary and are not mutually exclusive. Each presents its own unique opportunities, challenges, and environmental benefits.

# Utility Scale PVs Versus Rooftop PVs

**Utility scale PV systems** may be up to 500 MW or larger in size.

Benefits include:

- The installed equipment costs are less expensive per watt ($1.05 to $1.20 per watt) than an onsite rooftop system
- Reduce system-wide CO2 emissions

The challenges include:

- Require very large land acquisitions
- Long transmission, distribution, and transformer infrastructure development
- May negatively impact sensitive creature habitats
- Require time-consuming and expensive environmental impact report (EIR) process

It is important to include all of these costs and challenges when comparing a utility scale PV system to onsite solar.

# Utility Scale PVs Versus Rooftop PVs

**Onsite or rooftop PV systems** are generally only a few kW in size. The installed equipment costs are around $3 per watt. The benefits of these systems include:

1. No land acquisition required, the roof is already paid for
2. No additional transmission and distribution (T&D) infrastructure needed
3. Contribute to reduced CO2 emissions
4. No environmental impact reports needed

Additionally, as part of a local Distributed Energy Resource (DER) system and its proximity to the load it serves, an onsite PV system coupled with smart inverters, demand response and a battery storage systems, provide the following reliability and resilience benefits:

1. Improved ancillary services - Frequency and voltage regulation
2. Improved response to duck curve and evening ramp issues
3. Improved reliability during grid failures, natural disasters and wildfires
4. Being less prone to cyber-attacks

Onsite efficiency and PV systems allow building occupants to save each month on their utility bills, making home ownership more affordable.

# What is in Store for 2022 Standards?

1. Switching to a $CO_2$ emission metric such as a variation of hourly source energy multipliers, rather than the Time Dependent Valuation (TDV); the new metric must support these policy goals at the same time:

    i. GHG emissions reduction (instead of ZNE goals)

    ii. Supporting demand responsive and grid harmonization signals

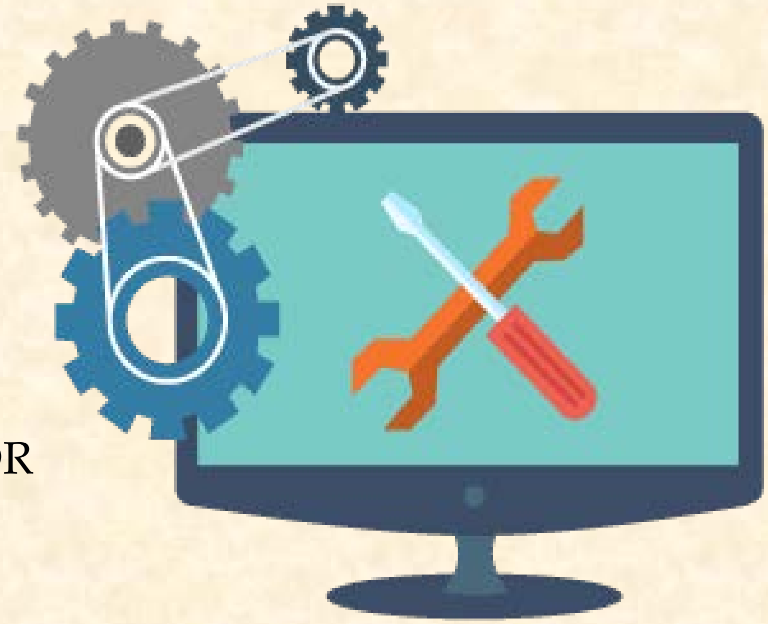
    - Getting away from annual netting and focusing on hourly netting for emissions and energy

2. Focusing on high-rise residential – 4 stories and higher, and hotel/motel
3. Selected nonresidential buildings – Retail, office, warehouse

# Software Tools

The CBECC-Res Compliance Software May Be Used For:

- Part 6 Compliance, and
- Part 11 (*CAL***Green**, Reach Codes, etc)



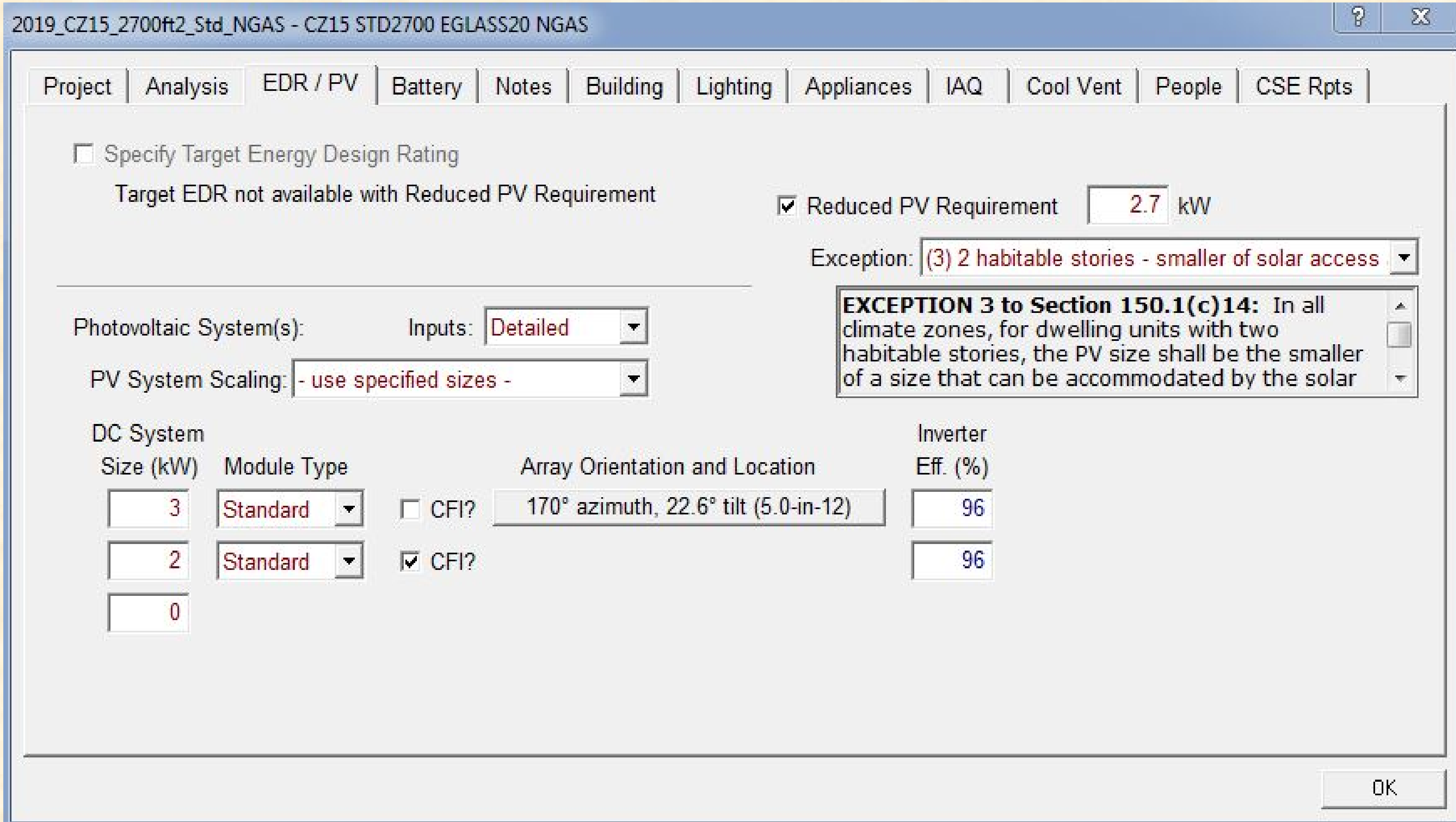
The Software can be used to:

- Size PV for Part 6 compliance or lower target EDRs for Reach Codes
- Assess the impact of battery storage on lowering EDR
- Assess the impact of precooling and other DR strategies on lowering EDR
- Assess the impact of HPWH DR on lowering EDR

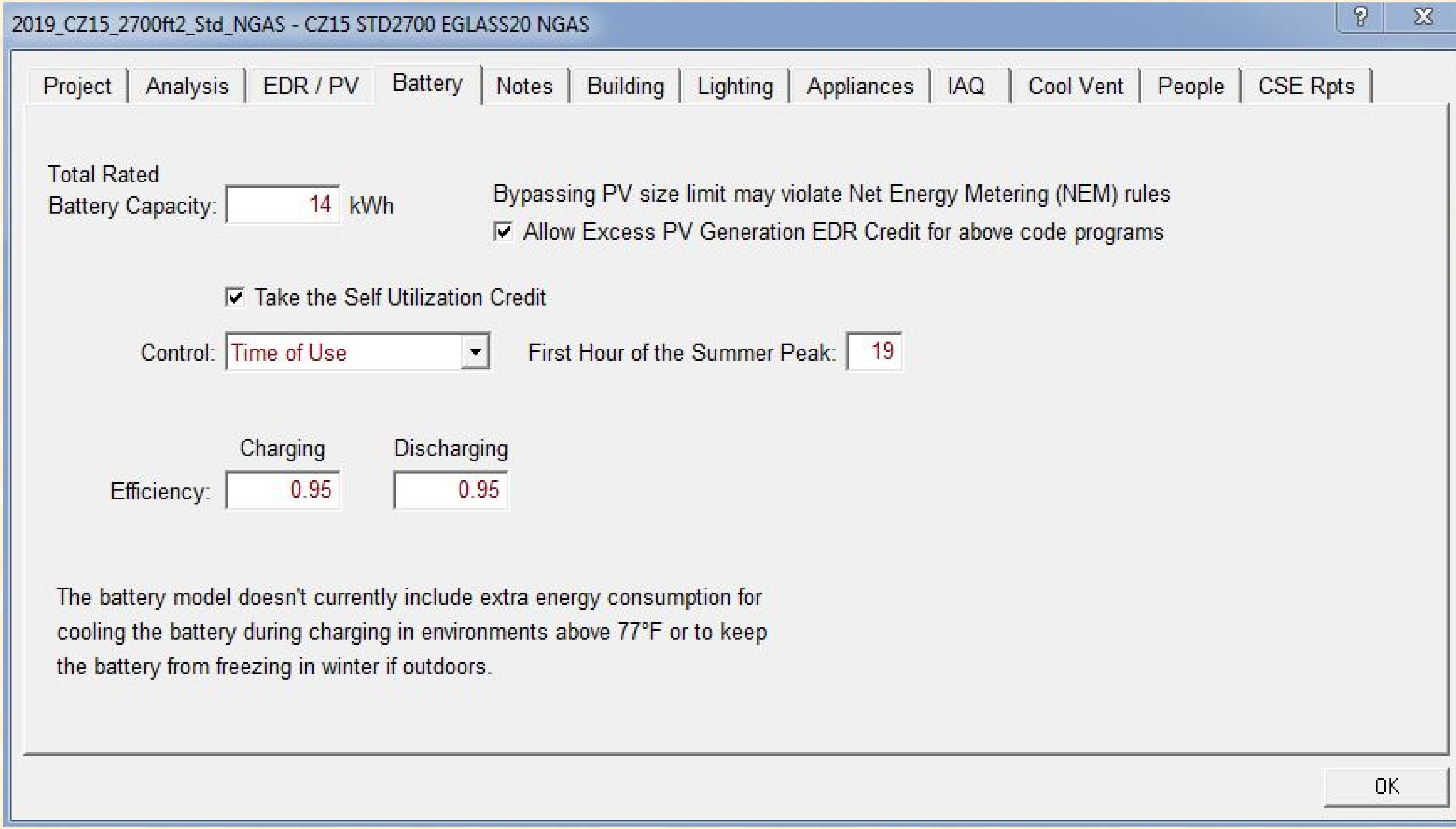
Download CBECC-Res for free:
**http://www.bwilcox.com/BEES/BEES.html**

# Software Tools – Input Screens

This screen can be used to specify an EDR target that may be required by reach codes to size the PV system



# Software Tools – Input Screens



# Software Tools – Output: $CO_2$

CBECC allows real time $CO_2$ emission implications of efficiency and PV choices

Largest Emission Source: Plug loads+appliances+lighting = 1060 kg/yr

2019_CZ12_2700ft2_Std_ELEC - CZ12 STD2700 EGLASS20 ELEC

Compliance Summary | CO2 Emissions | Energy Design Rating | Energy Use Details | CO2 Design Rating | CO2 Details

CDR of Standard Efficiency: 52.5 - CDR of Standard Design PV: 21.1 = Final Std Design CDR: 31.4

Std Design PV: 3.19 kW

CDR of Proposed Efficiency: 51.5 - CDR of Prop PV + Flexibility: 21.0 = Final Proposed CDR: 30.5

| End Use | Ref Design Electric CO2 Emis. (kg) | Ref Design Fuel CO2 Emis. (kg) | Ref Design Total CO2 Emis. (kg) | Prop Design Electric CO2 Emis. (kg) | Prop Design Fuel CO2 Emis. (kg) | Prop Design Total CO2 Emis. (kg) | Design Rating CO2 Emissions Margin (kg) |
|---|---|---|---|---|---|---|---|
| Space Heating | 1,087 | | 1,087 | 484 | | 484 | 604 |
| Space Cooling | 390 | | 390 | 92 | | 92 | 298 |
| IAQ Ventilation | 39 | | 39 | 39 | | 39 | 0 |
| Other HVAC | | | 0 | | | 0 | 0 |
| Water Heating | 262 | | 262 | 183 | | 183 | 80 |
| Self Utilization Credit | | | 0 | | | 0 | 0 |
| Photovoltaics | | | 0 | -758 * | | -758 | 758 |
| Battery | | | 0 | | | 0 | 0 |
| Inside Lighting | 567 | | 567 | 134 | | 134 | 434 |
| Appl. & Cooking | 531 | | 531 | 409 | | 409 | 122 |
| Plug Loads | 650 | | 650 | 484 | | 484 | 165 |
| Exterior | 79 | | 79 | 33 | | 33 | 45 |
| TOTAL | 3,605 | | 3,605 | 1,099 | 0 | 1,099 | 2,506 |

Done

# References and Contacts

2019 Building Energy Efficiency Standards:

http://www.energy.ca.gov/title24/2019standards/rulemaking/documents/2018-05-09_hearing/2019_Revised_EnergyCode.php

Joint Appendix (JA) 11, 12 and others:

http://www.energy.ca.gov/title24/2019standards/rulemaking/documents/2018-05-09_hearing/2019_Reference_Appendices.php

2019 Residential Compliance Manual:

http://www.energy.ca.gov/title24/2019standards/post_adoption/2019_Draft_Compliance_Manuals/Residential_Manual_PDF/

2019 and 2016 CBECC-Res:

http://www.bwilcox.com/BEES/cbecc2019.html

Mazi Shirakh, PE, Senior Engineer and ZNE Project Manager:

mshirakh@energy.ca.gov

Danny Tam, Mechanical Engineer:

dtam@energy.ca.gov

# Questions?

# Thank you for attending our webinar

Warren Leon
CESA Executive Director
wleon@cleanegroup.org

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