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

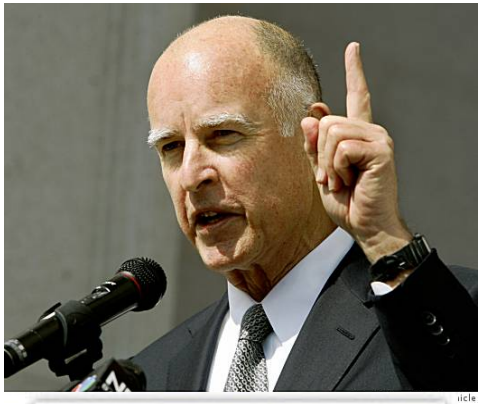
Payam Bozogchami, PE
Project Manager, BEES

Danny Tam
Mechanical Engineer

ZNE Policy Drivers

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:

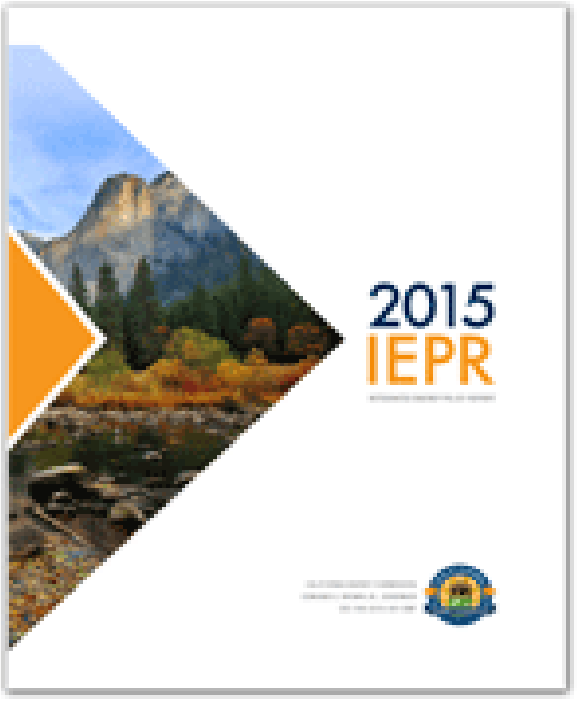
- 2008 CPUC/CEC Energy Action Plan – Endorsement by both agencies of ZNE for Residential buildings by 2020 and nonresidential buildings by 2030
- 2008 CPUC California Long Term Energy Efficiency Strategic Plan
- 2008 CARB Climate Change Scoping Plan
- 2007 (and later) CEC Integrated Energy Policy Report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



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

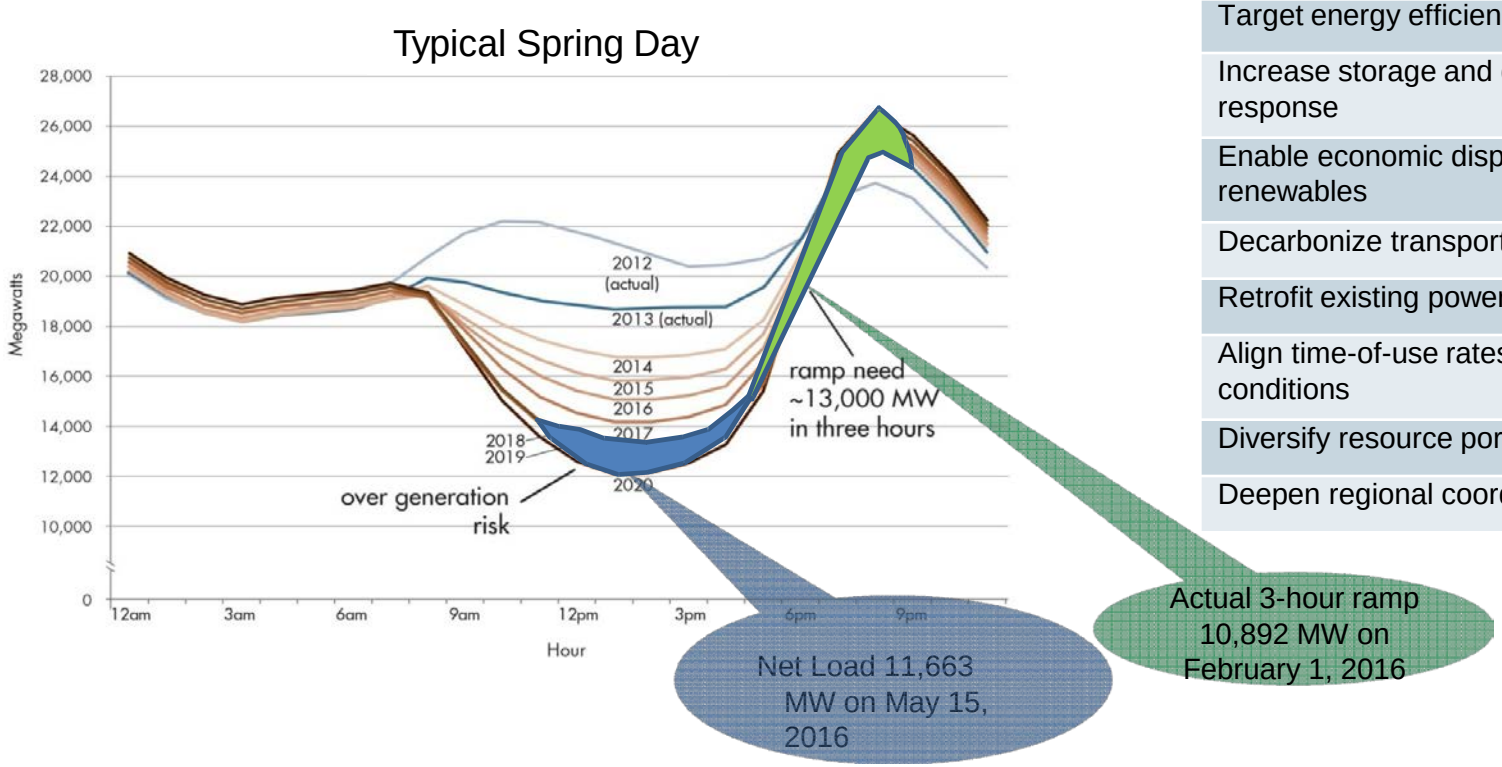
Reality turns out to be more nuanced – in the intervening years, new developments have had a significant impact on the ZNE approach, including:

- 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.

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

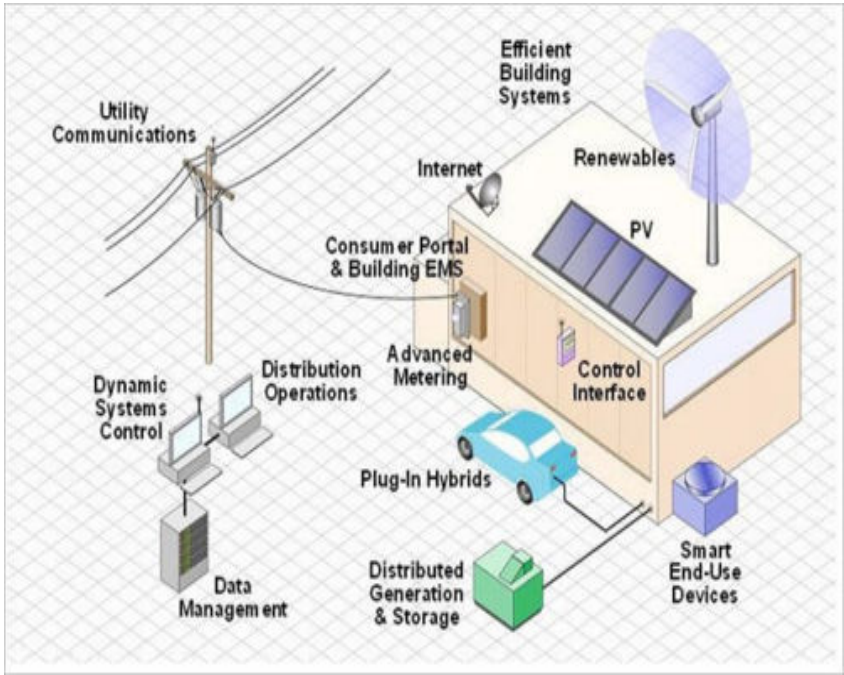
Grid Harmonization

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.



2019 Standards Approach

The 2019 Standards recognize following priorities for efficiency and generation resources:

1. Envelope efficiency: High Performance Attic (HPA) R-19 between rafters, high performance walls (HPW) U-factor 0.048, Quality Insulation Installation (QII)
2. Appropriately 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

§ 150.1(c)14–Photovoltaic Requirements

Add new prescription requirement for low-rise residential buildings to have a photovoltaic system. System output shall equal the dwelling's annual electrical usage and meets the requirements of JA11

1. Exception for limited solar ready zones less than 80 contiguous SF due to natural or manmade barriers
2. Reduced PV requirement for Climate Zone 15
3. Reduced PV requirement for 2 stories single and multifamily homes
4. Reduced PV requirement for 3 stories multifamily family and 3 or more stories single family homes
5. Accommodations for plans approved prior to Jan 1, 2020
6. Reduced PV size if installed in conjunction with a battery storage system

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

§ 150.1(b)–Performance Standards

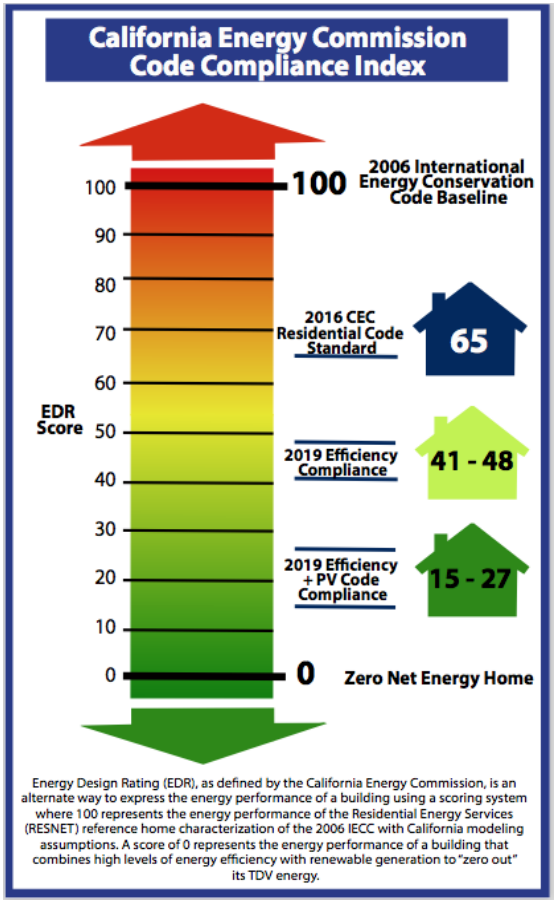
The Energy Budget for newly constructed buildings is now expressed as an EDR,

- Energy Efficiency EDR,
- Solar Electric Generation and Demand Flexibility EDR
- Combined to arrive at Total EDR

Energy Budget for additions and alterations continues to be expressed as TDV energy

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



Don’t Judge Me By My Size

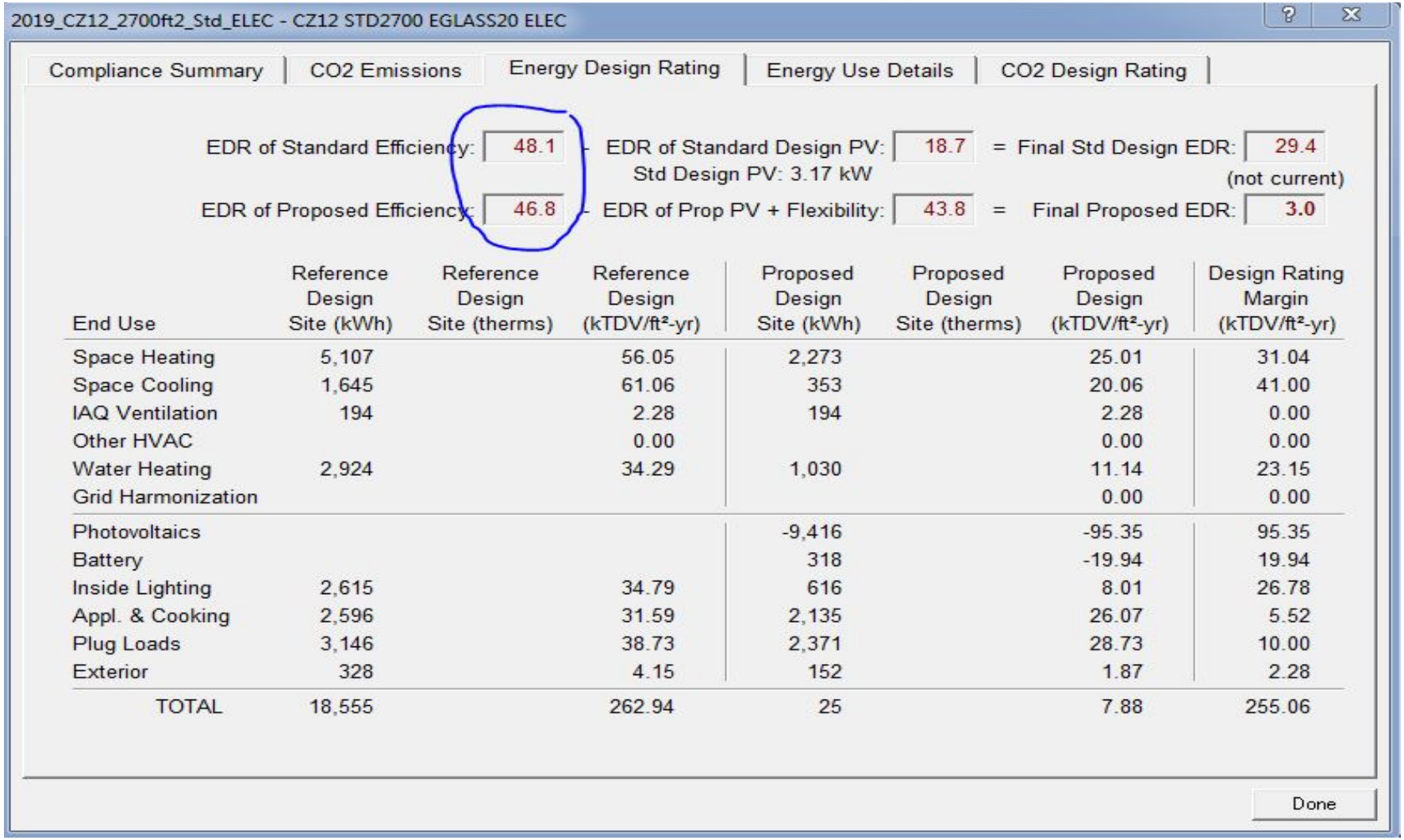
The PV requirement varies with the size of the house. The average required PV size is 2.8 KW. The table below shows the PV sizes for a 2,700 sq.ft house in different climate zones. By comparison, the average existing home PV installation is 7.2 kW

PV Sizes 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

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

Optional Reach Codes - CalGreen

CalGreen and other optional reach 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

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. Dedicated Building Energy Savings – Dedicated to the building 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

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

Questions?

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

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

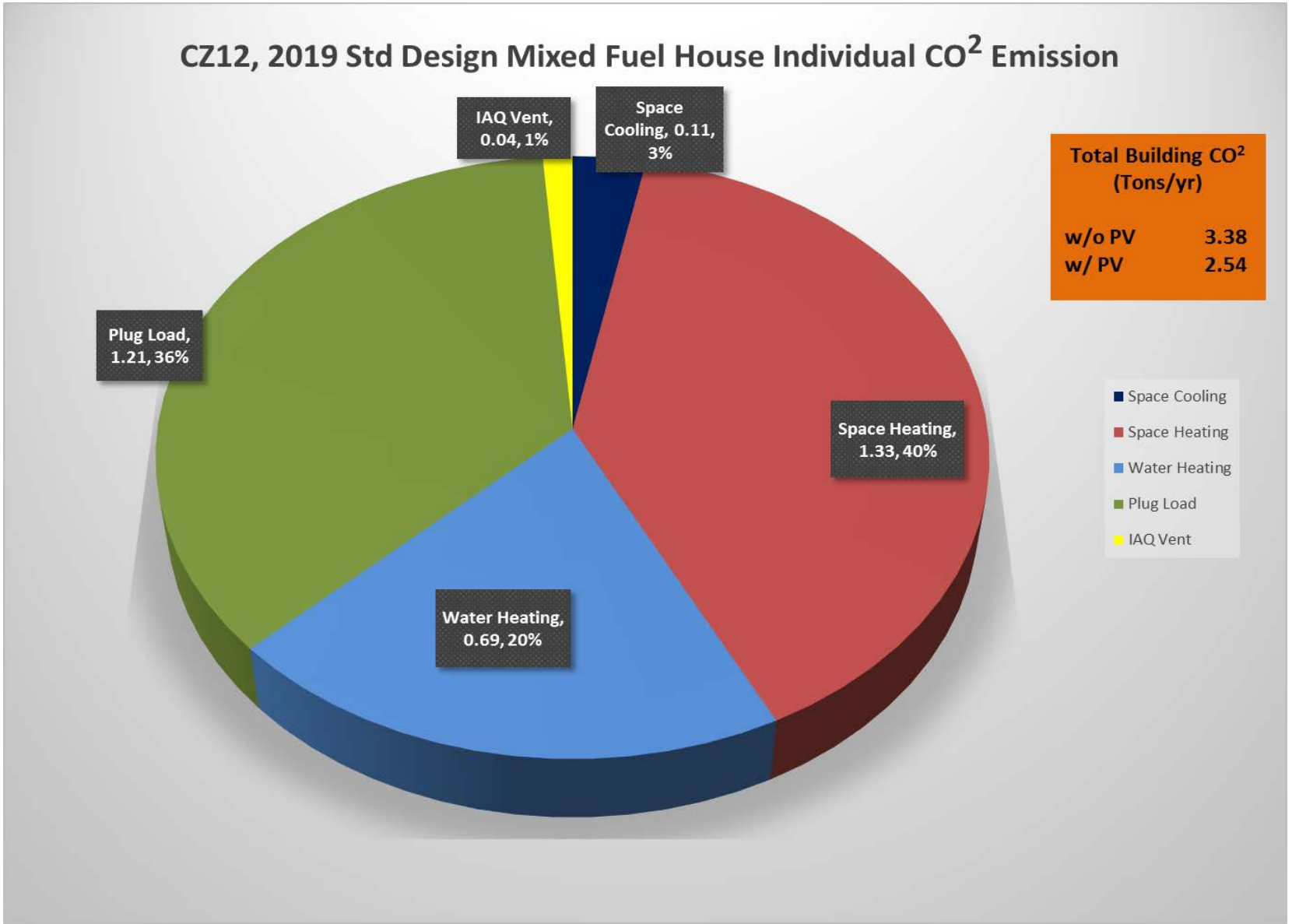
Keep That Gas Out Of My Home

CO2 emissions reduced by 700,000 metric tons over three years, equivalent to 115,000 gas cars of the road. California had one of the cleanest grids, CO2 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**

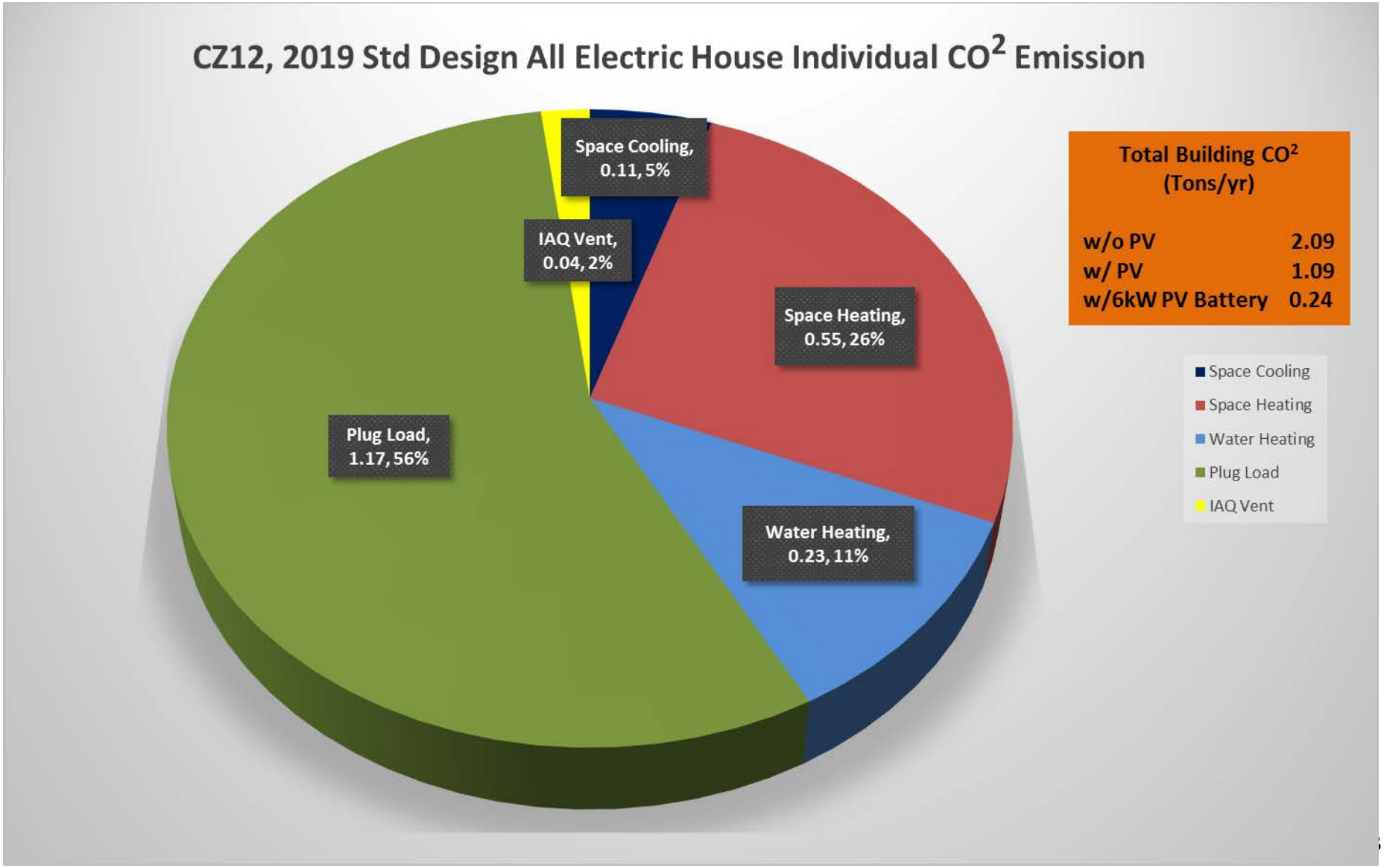
CO2 Reduction in Buildings

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



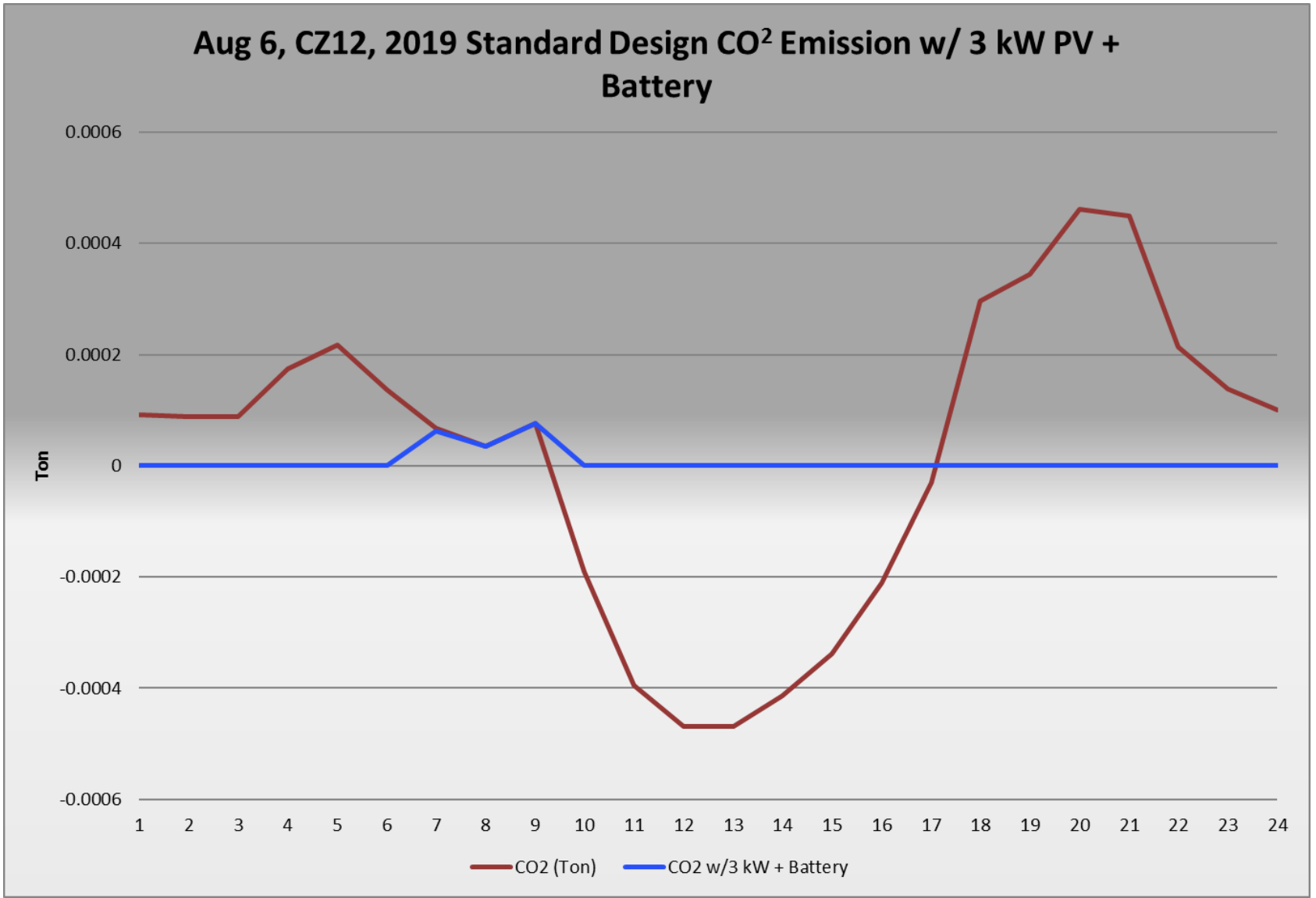
CO2 Reduction in Buildings

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



CO2 Reduction in Buildings

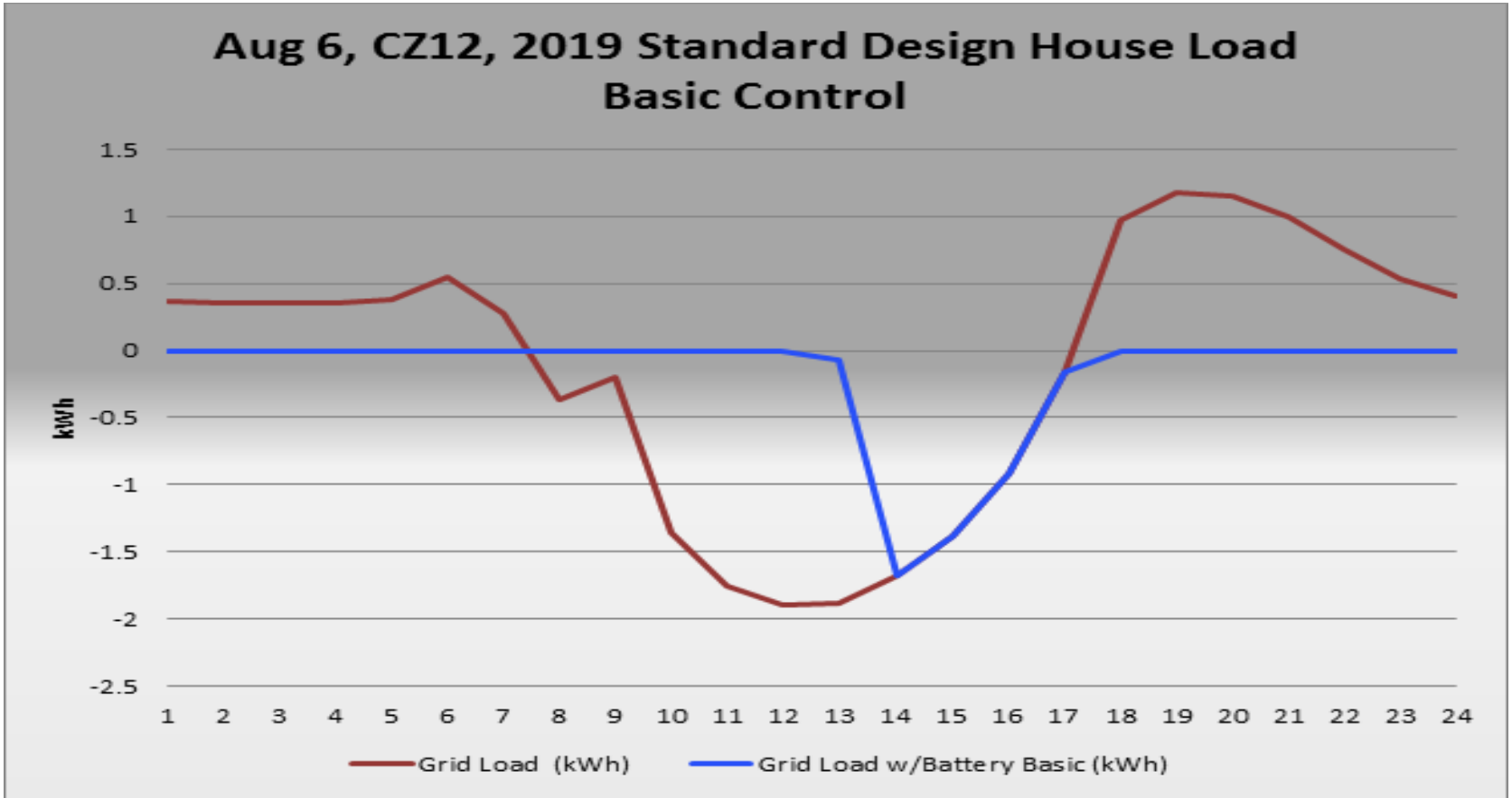
Daily CO2 Emission, all-Electric Home, CAZ12, 2700 sf, With and Without Storage



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



Energy and CO2 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

	Residential Energy Savings	Residential CO2e Reduction
Statewide Average	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

Software Tools

The CBECC-Res Compliance Software May Be Used For:

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

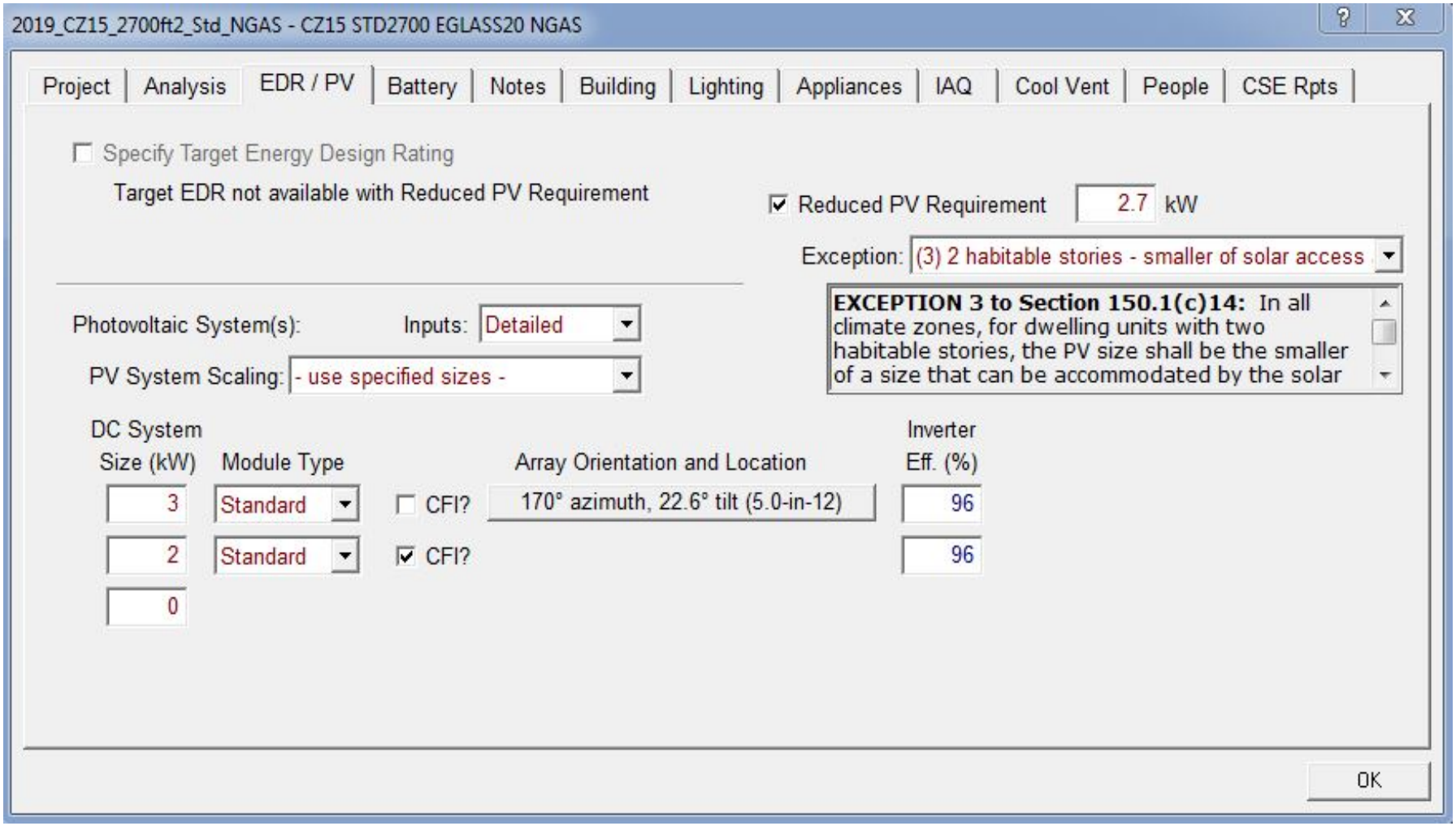
The Software can be used to:

- 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

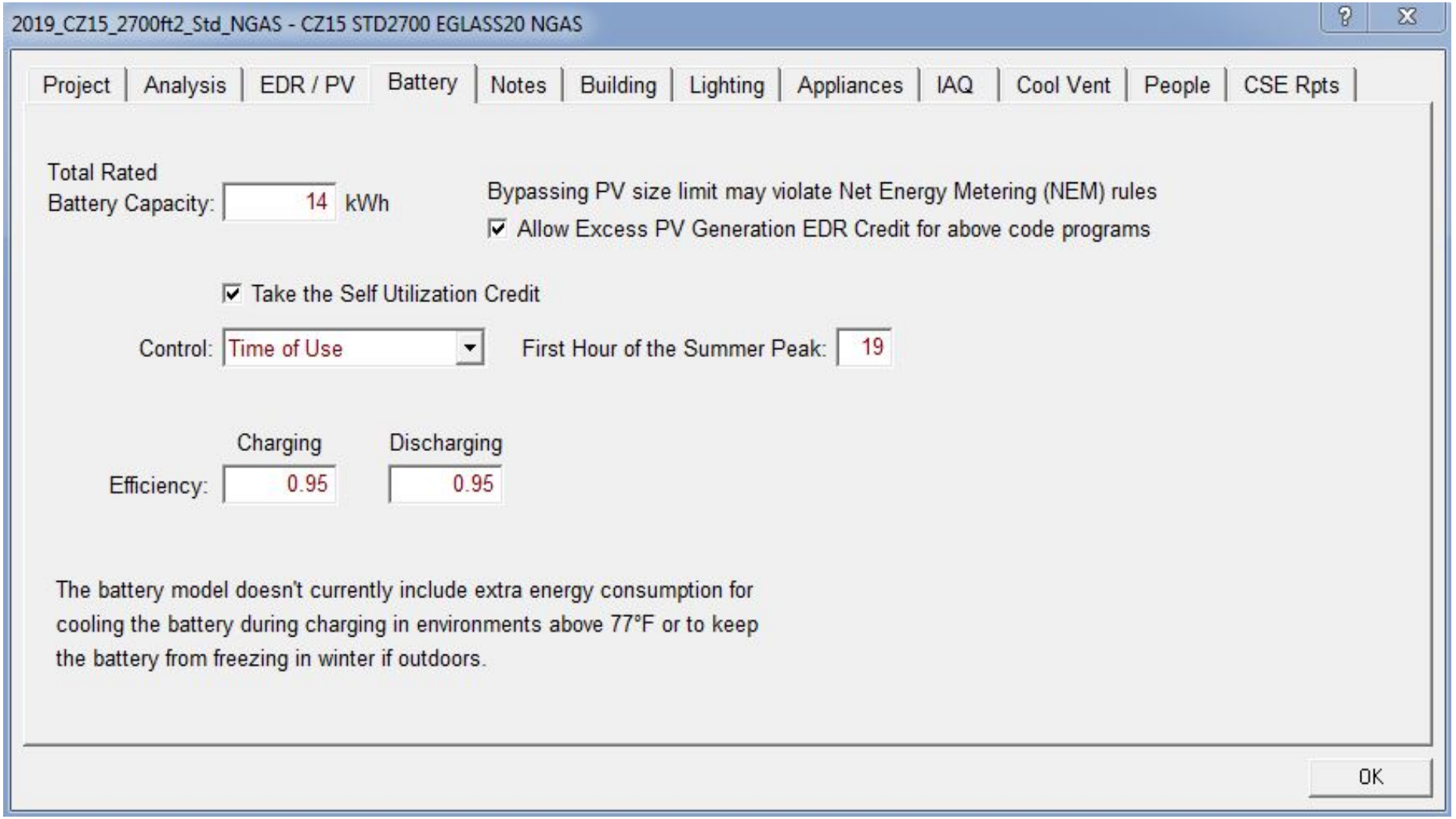
Download CBECC-Res for free:
http://www.bwilcox.com/BEES/BEES.html

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: CO2

CBECC allows real time CO2 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