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Docket Number:	17-BSTD-01
Project Title:	2019 Building Energy Efficiency Standards PreRulemaking
TN #:	220876
Document Title:	Presentation - Proposed 2019 Building Energy Efficiency Standards ZNE Strategy
Description:	August 22, 2017 presentation of the Proposed 2019 Building Energy Efficiency Standards ZNE Strategy by Energy Commission staff.
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Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	8/24/2017 10:54:44 AM
Docketed Date:	8/24/2017

Building Energy Efficiency Standards

Proposed 2019 Building Energy Efficiency Standards ZNE Strategy

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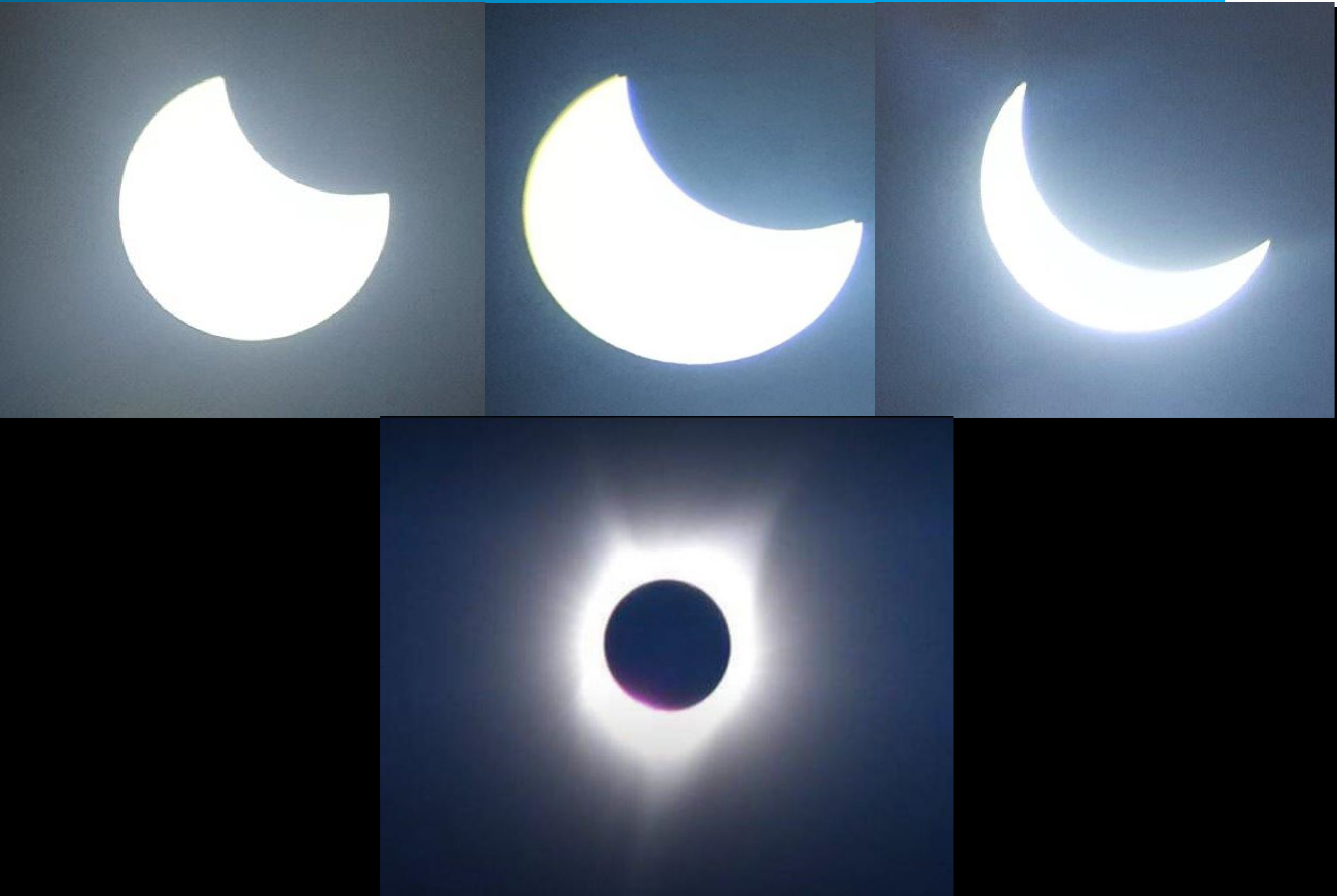
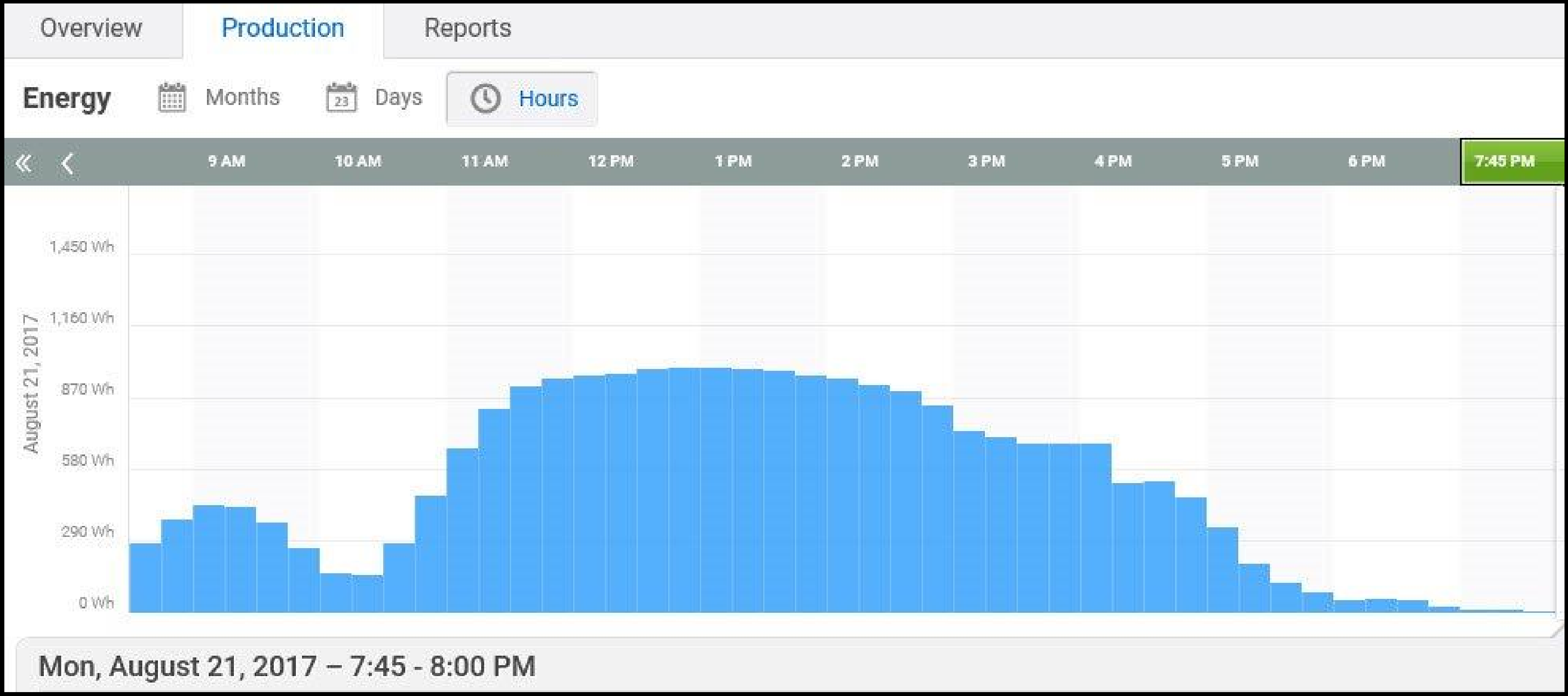
Countdown to 2020

August 22, 2017

August 2017 Total Eclipse



August 2017 Total Eclipse



2019 ZNE Strategy

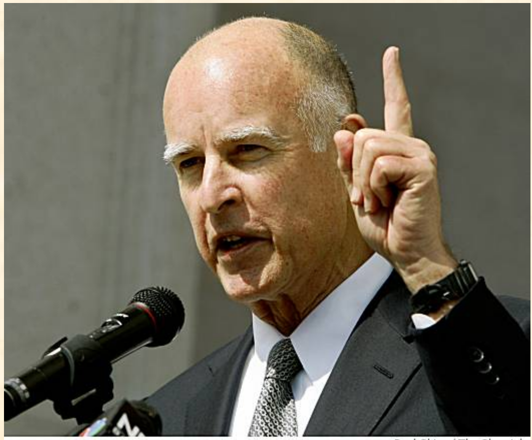
Content

1. Proposed ZNE Strategy – What is it and how we arrived there; explaining EDR
2. Cost Effectiveness for Prescriptive PV Requirements and NEM rules
3. Strategies for Reach Codes
4. CBECC-Res Software Tools for ZNE

Policy Drivers For ZNE

The following policy documents establish the goal for new building standards to achieve zero net energy levels 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"



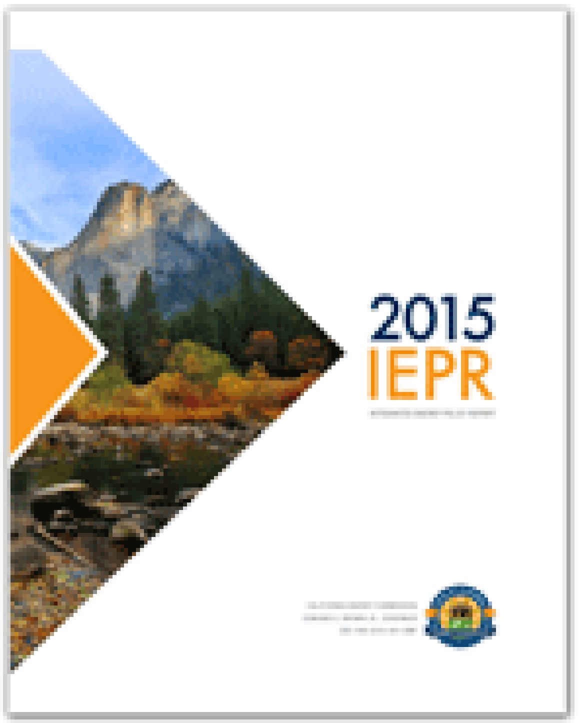
Paul Chinn / The Chronicle

ZNE Strategy: the 2015 IPER 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:

> "…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."

Improving building energy efficiency and deploying PVs were identified as the primary tools to achieve the ZNE goals



ZNE Goals – Lessons Learned

Reality turns out to be more nuanced - Since ZNE policy was first set we have learned about the impact of

- **50% RPS and** large scale PV deployment on the grid
- **large scale utility deployment of PVs** and to a lesser extent building-based PVs **lower the value of additional electricity around midday**
- Net energy metering (**NEM)** and Time-Of-Use (**TOU**) on **compensation for residential customer-owned generation and cost effectiveness of PVs**

ZNE Goals – Lessons Learned - Continued

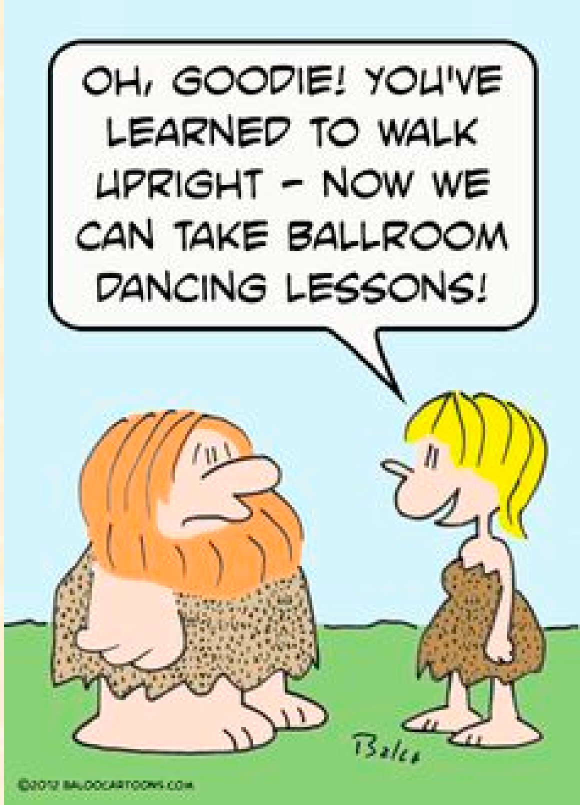
- The current NEM rules treat the grid as "**virtual storage**" (or a bank), where the overgenerated kWhs can be "stored" and used later in the day, or another season
- In reality, the **grid as it is now has very little capability** to store and effectively use overgenerated kWhs from PVs
- **Electrification of homes,** which results in a larger PV array**,** must be coupled with **grid harmonization strategies** to realize the expected environmental and home owner benefits
- Currently, customer-owned storage at about $500/kWh is still too expensive to be cost for the 2019 Standards, but this rapidly changing and can cost effective in a future cycle of Standards

Although ZNE is the goal for 2020, the 2019 Standards must operate within the confines of NEM and life cycle costing, which are the overriding factors for PV requirements

ZNE Goals – Lessons Learned - Continued

Grid harmonization strategies (GHS) must be coupled with customer owned PV systems to bring maximum benefits to the grid, environment, and the home owner

GHSs are strategies that maximize self-utilization of the PV array output and minimize exports back to the grid; examples of GHS include but are not limited to battery storage, demand response, thermal storage, and for some homeowners, EV grid integration.



2019 Standards Goals – Path to the Future

1. Increase building energy efficiency cost effectively
2. For Part 6, make **progress toward the ZNE** goal as possible within the **confines of NEM and life cycle costing rules**, while recognizing that Part 6 is an important but not the only tool for achieving ZNE
3. Contribute to the State's GHG reduction goals
4. **Promote self-utilization of the PV generation** by encouraging or requiring **demand flexibility and grid harmonization strategies**
5. Provide **independent compliance path** for both mixed-fuel and all electric homes
6. Achieve the above goals while ensuring real benefits for the building occupants with **positive benefit to cost ratios** for all efficiency and generation measures
7. Provide the tools for local governments to adopt **ordinances to achieve ZNE through** Part 11 Reach Codes, and other beyond code practices

The proposed 2019 Standards strategy will accomplish all seven goals listed above

Standards Goals – Beyond the 2019 Cycle

1. Extend the same seven goals from the previous slide to high-rise multifamily and nonresidential buildings
2. Improve integration of demand flexibility and grid harmonization strategies – consider making some measures prescriptive as technologies improve and cost effectiveness allows
3. Consider EV grid integration into the Standards - EV grid integration in nonresidential buildings offers huge potential for GHG reduction and self-utilization of PV generation

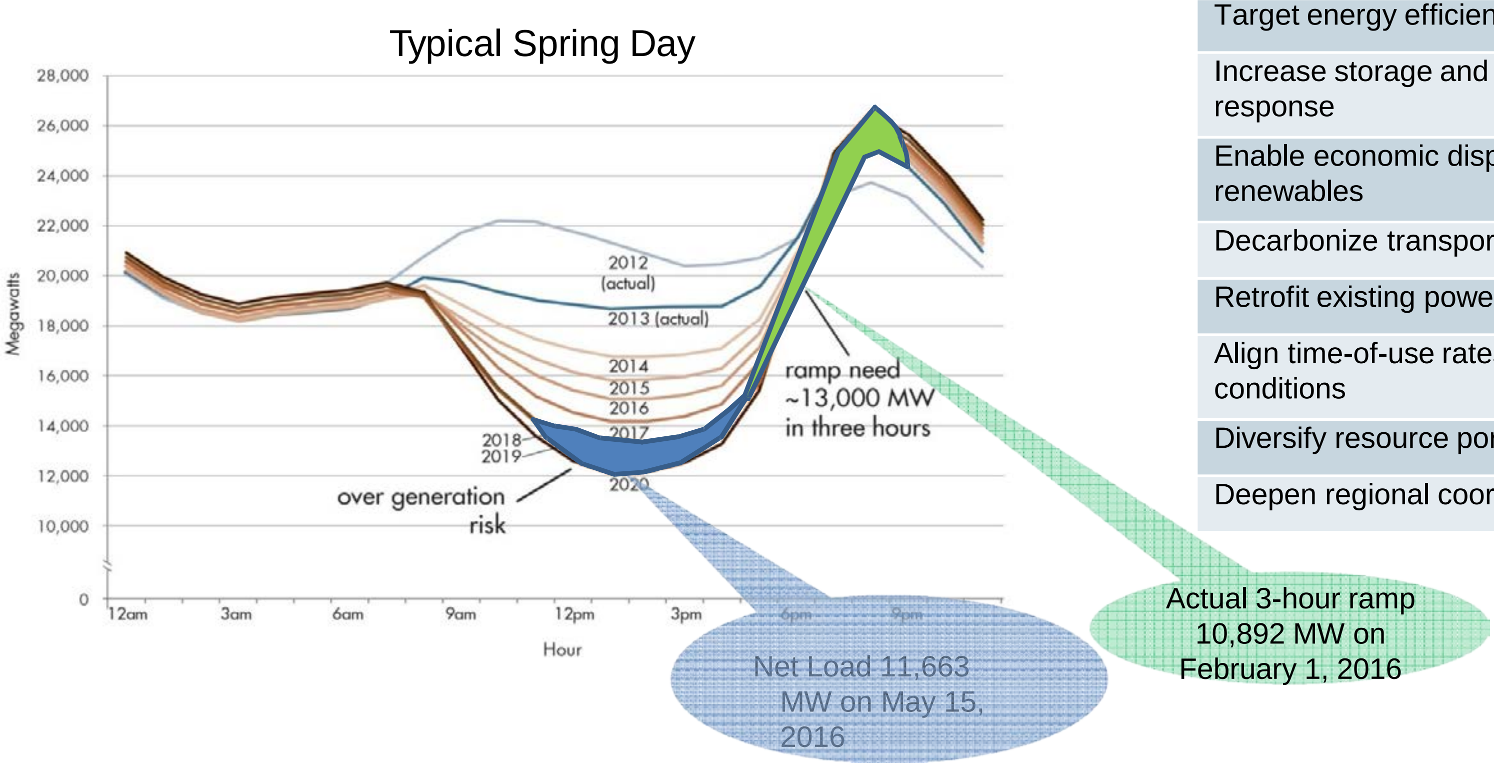
ZNE Goals – 2019 Standards Approach

The 2019 Standards will recognize the following priority for efficiency and generation resources:

1. Envelope efficiency, 2. Appropriately sized PVs, and 3. Grid harmonization strategies that maximize self-utilization of the PV output and limit exports to the grid

Further, the standards must be framed in a way to **encourage competition, innovation, and flexibility** to foster new solutions as the grid and technologies evolve.

Oversupply and ramping: A new 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

PV Cost Effectiveness - Findings

All Standards measures , whether efficiency or renewables, must be cost effective in each CZ, using life cycle costing

Using the 2019 TDVs which captures the impact of NEM rules, the LCC finds:

Complying with NEM rules, appropriately sized PVs that displace annual kWhs are found to be cost effective in all climate zones**, even if the NEM2 rules are changed in the future to compensate hourly exported kWhs at avoided cost**

Here Comes the Sun…

For the first time, 2019 Standards are proposed to have prescriptive PV requirements

Prescriptively, the PV system will be sized to displace the annual kWhs of the home

The prescriptive PV size will be calculated as follows:

Equation 150.1(c)14.1:
kWPV = (CFA x A) + B

Where:

kWPV is the kW DC size of the PV system
CFA is the conditioned floor area
A is the floor area adjustment factor from Table 150.1-2
B Is the dwelling type adjustment factor from 150.1-2

There will be look up tables for the Adjusters

For performance compliance, we'll use the Energy Design Rating (EDR) Tool

Proposed Exceptions to On-Site PV

Draft exceptions to part or all of the proposed residential PV requirement for consideration and refinement during the rulemaking process:

EXCEPTION 1 : Address where existing barriers external to the dwelling exist, including but not limited to trees, hills, and adjacent structures.

EXCEPTION 2 : Allow for a reduced PV size in climate zone 15 that can be accommodated by the solar access requirements of the solar ready zone.

EXCEPTION 3 : Allow for a reduced PV size for single family homes with three stories.

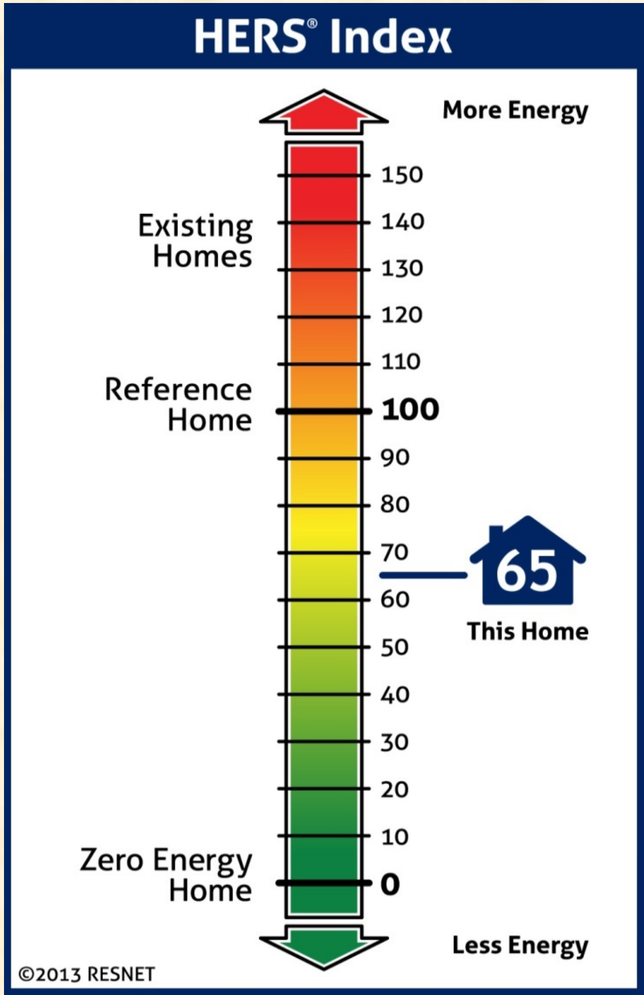
EXCEPTION 4 : Address dwelling unit plans that were approved by planning departments prior to January 1, 2020.

EXCEPTION 5 : Allow for a reduced PV size if installed in conjunction with a battery storage system.

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 the house is a ZNE building

- **CEC's CBECC-Res software has the capability to calculate EDR scores for EE and PV**
- **Builders can use a combination of envelope energy efficiency features, better appliances, PVs, and other strategies to get to the target EDR**



Download CBECC-Res here for free:

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

Proposed 2019 Standards Approach

Energy Design Rating (EDR) targets for each climate zone:

1. An EDR level for energy efficiency features based on 2019 prescriptive measures – This EDR target can only be met using energy efficiency measures, i.e., no PV tradeoff
2. An EDR Contribution for the PV system that is sized to displace the home's annual kWhs
3. Subtract the PV EDR Contribution from the energy efficiency EDR to determine the final target EDR

Proposed 2019 Standards Approach

1. Maximize envelope efficiency as allowed by LCC and calculate EE EDR
    i. HPA to R19 in severe CZs – Currently R13
    ii. HPW to 0.043 ~ 0.046 U-factor in severe CZs – Currently 0.051
    iii. Windows U-factor of 0.30 and SHGC of 0.23 – Currently 0.32 and 0.25
    iv. QII as a prescriptive requirement

Establish an Energy Design Rating (EDR) for energy efficiency in each CZ **that can only be met with efficiency measures (no PV tradeoff against EE)**

2. Calculate EDR of PV system as follows:
    i. Calculate the PV size required to displace the kWh in each CZ
    ii. Calculate the EDR contribution of the PV array

3. Subtract the PV EDR contribution from the EE EDR contribution to **establish the final EDR that the building must meet to comply in each CZ**

Note: Examples are presented in later slides

Target EDR's Many Advantages

1. A target EDR establishes a **performance benchmark that the building must meet to comply**; consistent with the Warren-Alquist Act performance standards expectation to provide builders with compliance flexibility
2. Target EDR allows the builder **to use more efficiency and less PV to get to the target**; such as **high performance glazing, Energy Star appliances, and higher than minimum HVAC systems** that we are prevented from requiring because of preemption issues
3. The EDR concept can be used to **right size the PV system for low EDR and ZNE goals by taking advantage of grid harmonization strategies including battery storage, thermal storage, and demand response and flexibility strategies**
4. Target EDR is fully **compatible with setting reach codes**, local jurisdiction simply identifies a lower target EDR (or zero) that can be met with a combination of additional EE, PV, demand response/flexibility, EV integration, or storage
5. Target EDR works well with **varying building sizes** – static PV size does not

Target EDR Advantages - Example

Here is an example of how CBECC-Res calculates the Target EDR for both EE and PV in CZ12 for the 2,700 sf house:

2019_CZ12_2700ft2 - v30 12 S27 G20 M01

Compliance Summary | Energy Design Rating | Energy Use Details

EDR of Proposed Efficiency: 41.9 - EDR of Prop PV + Flexibility: 19.1 = Final Proposed EDR: **22.8**

EDR of Standard Efficiency: 43.2 - EDR of Minimum Required PV: 18.5 = Final Std Design EDR: 24.7

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	584	486.0	45.09	187	217.2	19.51	25.58
Space Cooling	1,729		59.71	317		17.22	42.49
IAQ Ventilation	194		1.99	194		1.99	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		176.3	13.03		119.9	8.86	4.17
Photovoltaics				-5,022		-43.51	43.51
Battery						0.00	0.00
Inside Lighting	2,615		30.42	616		6.98	23.44
Appl. & Cooking	989	73.4	15.65	1,040	45.1	14.46	1.19
Plug Loads	3,267		35.06	2,371		25.03	10.03
Exterior	328		3.54	152		1.61	1.93
TOTAL	9,705	735.7	204.49	-146	382.3	52.15	152.34

Done

Parallel Prescriptive Paths

There will be two parallel prescriptive paths for compliance, one for each of:

1. **Mixed Fuel Homes**
2. **All-Electric Homes**

This allows the all-electric and mixed fuel homes to have their own prescriptive paths,

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

All-Electric Home Option

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

All-Electric Homes and GHG Goals

Home electrification when combined with PVs and demand flexibility strategies can result in environmental benefits as well as grid, and occupant benefits

Target EDR Examples by Climate Zone

Here is are examples of how Target EDRs might look for different scenarios in different CZs for the 2,700 sf Mixed Fuel Homes:

Note: At this time these numbers are examples only and may change as our tools evolve

NEM = Net Energy Metering; GH = Grid Harmonization; Dumb PV = No Battery Storage

1	2	3	4	5	6	7	8	9	10	11
CZ	Efficiency EDR without PV, based on 2019 Efficiency Measures	Target Design Rating Score for Displacing kWh Elect with PV from Col 4	PV Sized to Displace Annual kWh Electric – Cool with NEM, not so Cool with GH	Dumb PV Sized to Zero EDR – Violates NEM, Not Cool with GH	PV Size for Zero EDR with Basic Battery Controls – May Violate NEM, OK with GH	PV Size for Zero EDR with Optimum Battery Controls – Cool with NEM and GH	Similar to Col 7 But With 95 Furn, 0.95 WH – Real Cool with NEM and GH	Col 6 to 4 Ratio	Col 7 to 4 Ratio	Col 8 to 4 Ratio
1	48.0	26.5	3.4	7.7	6.9	4.6	4.1	2.0	1.4	1.2
2	41.2	18.0	2.9	6.1	5.5	3.1	2.8	1.9	1.1	1.0
3	46.9	22.7	2.8	5.8	5.3	3.2	2.9	1.9	1.1	1.0
6	48.0	20.9	2.9	5.3	4.5	2.9	2.8	1.6	1.0	1.0
7	48.0	14.9	2.7	4.6	3.9	2.4	2.3	1.4	0.9	0.9
8	43.0	14.6	2.9	5.3	4.3	2.7	2.6	1.5	0.9	0.9
11	43.3	23.4	3.8	8.5	6.5	4.4	4.2	1.7	1.2	1.1
12	43.1	24.5	3.1	7.0	5.8	3.8	3.5	1.9	1.2	1.1
13	44.8	22.1	4.0	9.0	6.2	4.9	4.6	1.6	1.2	1.2
14	44.6	21.3	3.4	7.4	5.4	4.4	4.1	1.6	1.3	1.2
15	48.0	17.9	5.7	10.5	8.1	6.9	6.8	1.4	1.2	1.2
16	46.3	27.5	3.0	7.6	6.5	4.8	4.3	2.2	1.6	1.4

Target EDR Examples by Climate Zone

Here is are examples of how Target EDRs might look for different scenarios in different CZs for the 2,700 sf All-Electric Homes:

Note: At this time these numbers are examples only and may change as our tools evolve

NEM = Net Energy Metering; GH = Grid Harmonization; Dumb PV = No Battery Storage

1	2	3	4	5	6	7	8	9	10	11
CZ	Target Design Rating Score for Displacing kWh Elect with PV Size from Col 3	PV Sized to Displace Annual kWh Electric in Mixed Fuel Homes–Cool with NEM not so Cool with GH	Dumb PV Sized to Displace Annual kWh in AEH – Cool with NEM, not Cool with GH	Dumb PV Sized for Zero EDR – Violates NEM, Not Cool with GH	PV Sized for Zero EDR with Basic Battery Controls – May Violate NEM, OK for GH	PV Sized for Zero EDR with Optimum Battery Controls – Cool with NEM and GH	Similar to Col 7 But With 14 EER HP, 3.5 COP HPWH – Real Cool with NEM and GH	Col 6 to 4 Ratio	Col 7 to 4 Ratio	Col 8 to 4 Ratio
1	33.9	3.4	7.7	9.4	8.4	5.6	5.3	1.1	0.8	0.7
2	29.6	2.9	5.9	7.2	6.5	3.9	3.7	1.1	0.7	0.6
3	32.1	2.8	5.4	7.0	6.0	3.8	3.6	1.1	0.7	0.7
6	26.6	2.9	4.6	5.9	4.9	3.2	3.0	1.1	0.7	0.7
7	26.0	2.7	4.1	5.3	4.4	2.7	2.6	1.1	0.7	0.6
8	26.0	2.9	4.6	6.1	4.8	3.1	2.9	1.0	0.7	0.6
11	31.4	3.8	6.6	9.9	7.6	5.9	5.3	1.2	0.9	0.8
12	30.0	3.1	5.9	8.4	6.7	4.8	4.4	1.1	0.8	0.7
13	30.8	4.0	6.7	10.3	8.0	6.5	5.8	1.2	1.0	0.9
14	33.3	3.4	5.9	8.6	6.7	5.8	5.3	1.1	1.0	0.9
15	26.2	5.7	7.0	11.5	9.2	8.0	7.0	1.3	1.1	1.0
16	48.3	3.0	7.7	10.2	8.9	7.0	6.9	1.2	0.9	0.9

Extreme Efficiency and ZNE

Can extreme energy efficiency regardless of cost achieve full ZNE (EDR of 0)?

- Even if we eliminate all heating, cooling, hot water, and IAQ loads, we'll still end up with an EDR score of 25-30, the theoretical limit for efficiency EDR!
- That is because in most climate zones plug loads are now the dominant loads and they are unaffected by efficiency measures, extreme or not
- 2019 Standards efficiency EDRs are in the 43-48 range depending on the CZ
- "Practical" efficiency measures – without renewables and demand flexibility - can move the EDR score by no more than 7-9 points in severe CZs, less in milder CZs to ~34-41 range!

Conclusions:

1. Limited opportunity for regulated loads to lower EDR in the future
2. Need PV + demand flexibility to achieve low EDR scores or ZNE

Standards and PV Sizing

- For Part 6, PV is sized to net out the buildings annual kWh; larger PV array may be installed but will not receive additional compliance credit
- For Part 11 compliance, CBECC allows PV array coupled with a 6 kWh battery storage system to be oversized by a factor of 1.6; this PV size:
  - Provides additional flexibility for the grid; the battery enables the increased PV capacity to be used by the utility to meet high demand during critical peak periods
  - Promotes self-utilization on peak since PV is coupled with battery storage
  - The 1.6 cap ensures a greater than 1.0 benefit to cost ratio for the building owner even if hourly exports are compensated only at avoided cost
- CBECC provides a size limit bypass checkbox that once checked allows exceeding the 1.6 times size limit, with a warning that this option may violate NEM sizing rules

Estimated Costs by Climate Zones

Average of Two Prototypes						
Climate Zone	High Performance Walls	High Performance Attics	QII	PV Size, kW DC	PV (Average of two prototypes- mixed fuel home)	Total
1	$ 887.90	$ -	$ 396.00	3.2	$ 9,858.00	$ 11,145.08
2	$ 887.90	$ -	$ 396.00	2.7	$ 8,308.00	$ 9,594.58
3	$ 887.90	$ -	$ 396.00	2.6	$ 7,998.00	$ 9,284.48
4	$ 887.90	$ 288.20	$ 396.00	2.6	$ 7,998.00	$ 9,572.68
5	$ 887.90	$ -	$ 396.00	2.4	$ 7,548.50	$ 8,834.84
6	$ -	$ -	$ 396.00	2.6	$ 8,137.50	$ 8,536.13
7	$ -	$ -	$ 396.00	2.5	$ 7,688.00	$ 8,086.48
8	$ 887.90	$ 288.20	$ 396.00	2.7	$ 8,308.00	$ 9,882.78
9	$ 887.90	$ 288.20	$ 396.00	2.8	$ 8,757.50	$ 10,332.43
10	$ 887.90	$ 288.20	$ 396.00	2.9	$ 8,897.00	$ 10,471.97
11	$ 887.90	$ 288.20	$ 396.00	3.4	$ 10,586.50	$ 12,162.02
12	$ 887.90	$ 288.20	$ 396.00	2.8	$ 8,757.50	$ 10,332.43
13	$ 887.90	$ 288.20	$ 396.00	3.6	$ 11,206.50	$ 12,782.22
14	$ 887.90	$ 288.20	$ 396.00	3.1	$ 9,517.00	$ 11,092.17
15	$ 887.90	$ 288.20	$ 396.00	5.3	$ 16,306.00	$ 17,883.36
16	$ 887.90	$ 288.20	$ 396.00	2.7	$ 8,447.50	$ 10,022.33

2 – Life Cycle Costing

Life Cycle Costing for Prescriptive PV Requirement

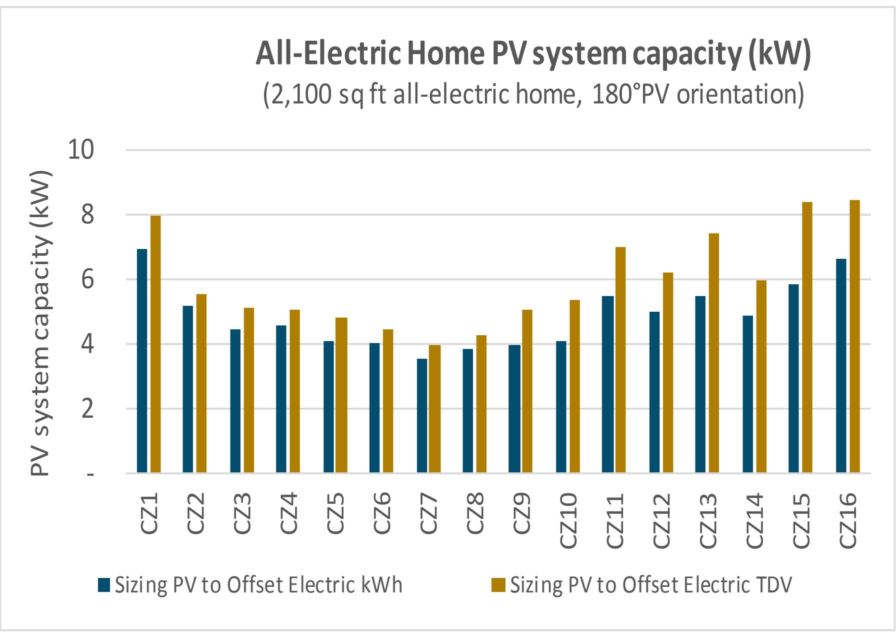
E3 Life Cycle Costing Analysis Finds:

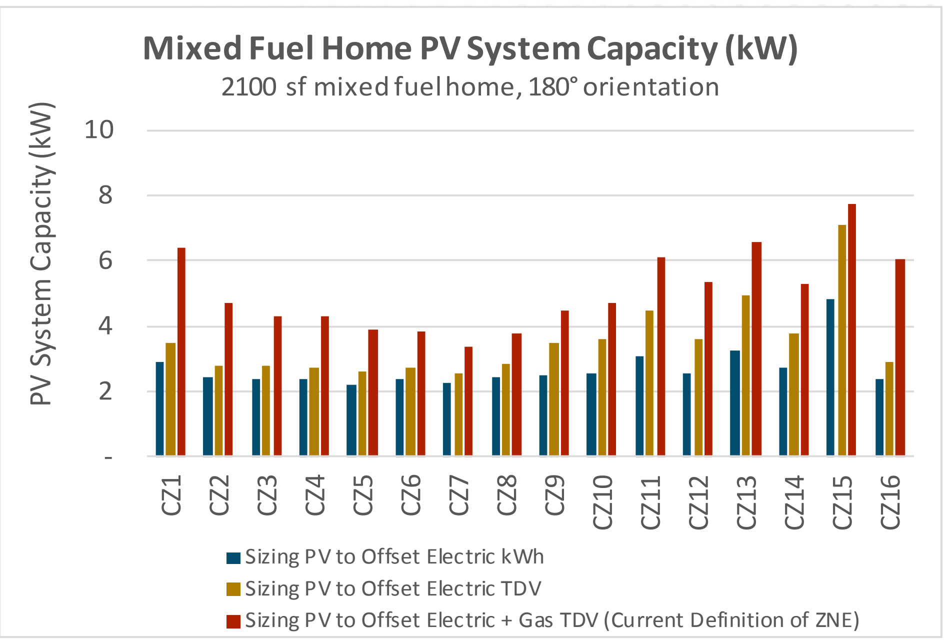
1. **PV systems sized to displace annual kWhs are cost effective in all climate zones**
2. **Even if NEM2 rules are changed to compensate exported kWhs at avoided cost**
3. **With no federal ITC**

The following are a partial representation of E3 analysis and findings (E3's greatest hits) – The full report will be available online

TDV ZNE requires a larger PV system than Site ZNE

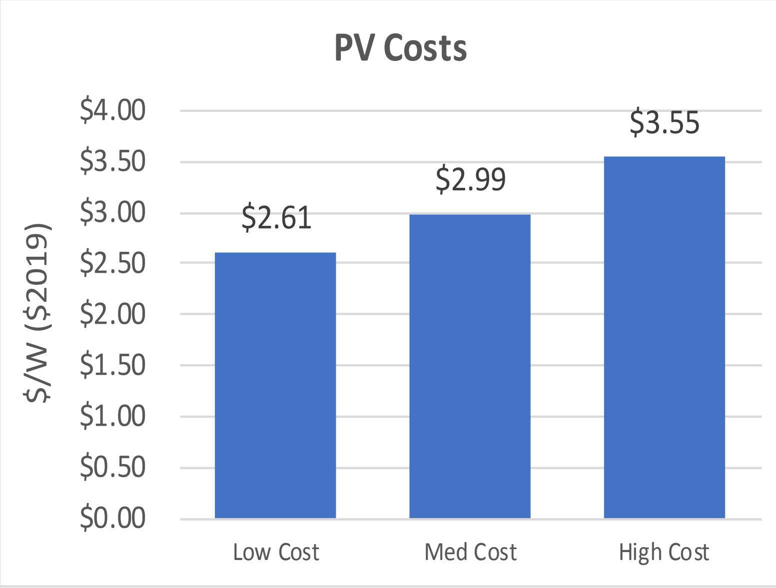
+ **Solar production occurs during low TDV hours, and households demand energy during high TDV hours**
  - PV must be sized larger to reach TDV ZNE vs. Site ZNE (which doesn't account for the changing value of kWh)
+ **For a 2,100 ft^2 home with 180° PV orientation, TDV ZNE requires 7% - 44% larger PV capacity than Site ZNE (average: 21%)**
+ **Because PV interconnection rules limit sizing to electric kWh, this presentation focuses on that size**



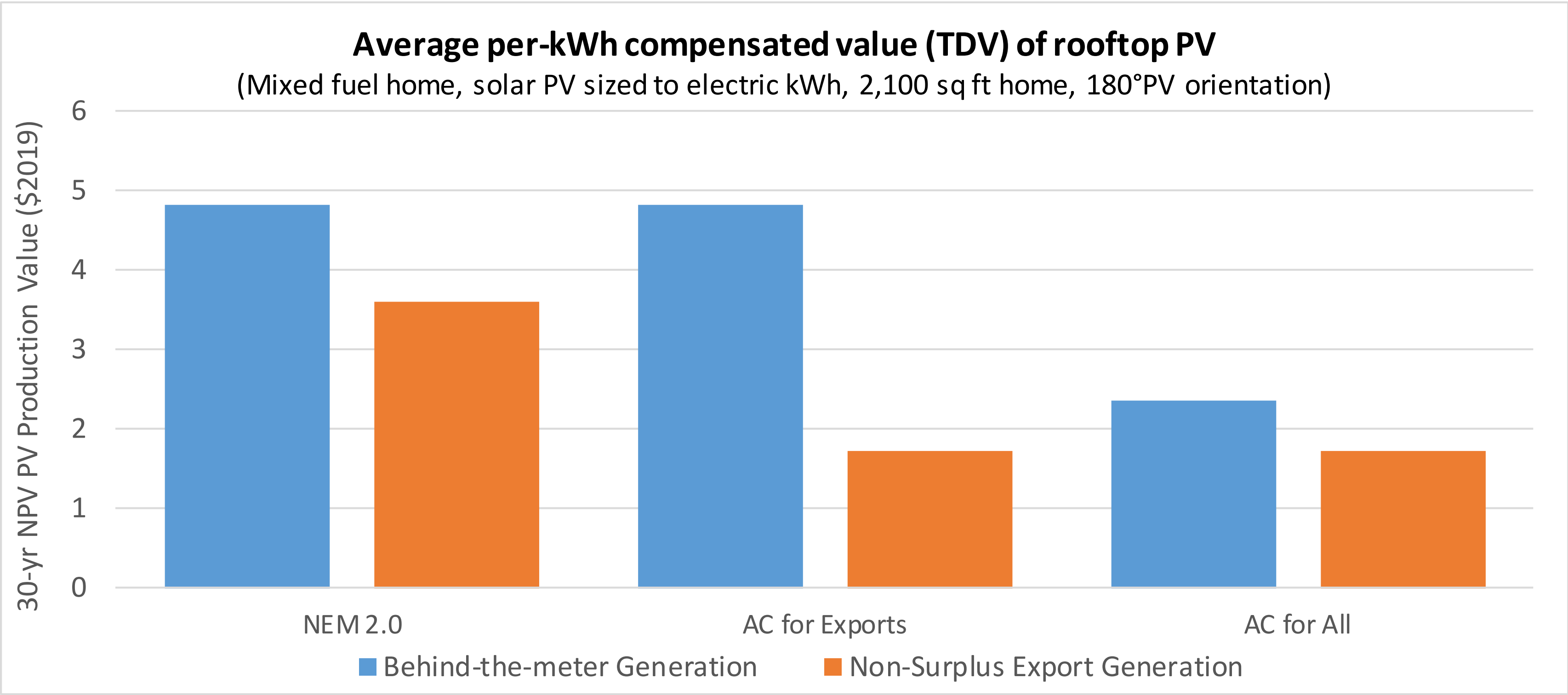


PV Costs

- **No ITC Assumed - The ITC is scheduled to step down throughout the 2020-2022 building standard cycle (26%, 22%, 20%) and then to 0% for residential systems beginning in 2023**
- **All costs assume a 30-yr panel life and inverter replacements after 10 and 20 years (comprises ~$0.40/W in the costs)**
- **Price based on NREL 2016 Installer Price**
  - Low cost case:
    - 30% cost reduction 2016 – 2020 (GreenTech Media)
  - Medium cost case:
    - 18% cost reduction 2016 – 2020 (Bloomberg)
  - High cost case:
    - No cost reduction 2016 - 2020



Three solar compensation policies

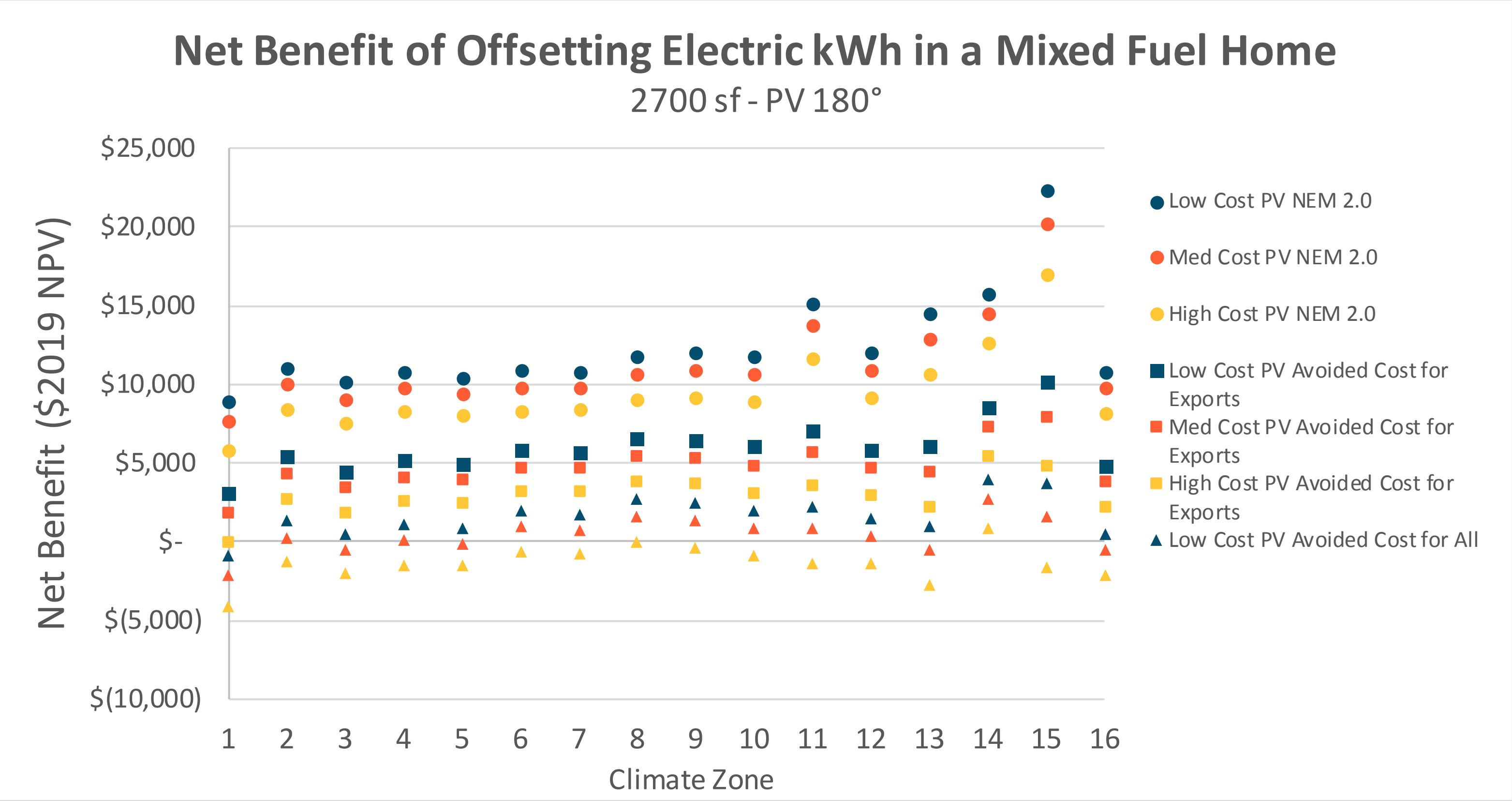


AC = Avoided Costs

Non-surplus Export Generation are the hourly exports

Cost-Effectiveness of Offsetting Elec kWh in a Mixed Fuel Home

- Offsetting electric kWh with solar PV is cost-effective except under the most aggressive NEM reform scenarios



CZ	PV kW
1	2.89
2	2.46
3	2.38
4	2.36
5	2.22
6	2.38
7	2.26
8	2.46
9	2.51
10	2.58
11	3.10
12	2.58
13	3.28
14	2.73
15	4.83
16	2.37

Energy+Environmental Economics

3 - Strategies for Reach Codes

NEM Rules and Oversizing PV – DRAFT

March 2, 2017

Snuller Price, Zachary Ming, Brian Conlon

PV Sizing Methods

+ Electric kWh

- PV scaled such that annual generation = annual electric load

+ Maximize Net Benefits

- PV scaled to maximize net TDV benefit to customer
  - Practically, this is the same capacity as sizing to kWh, i.e., further generation will only receive Net Surplus Compensation (NSC)

+ Electric TDV

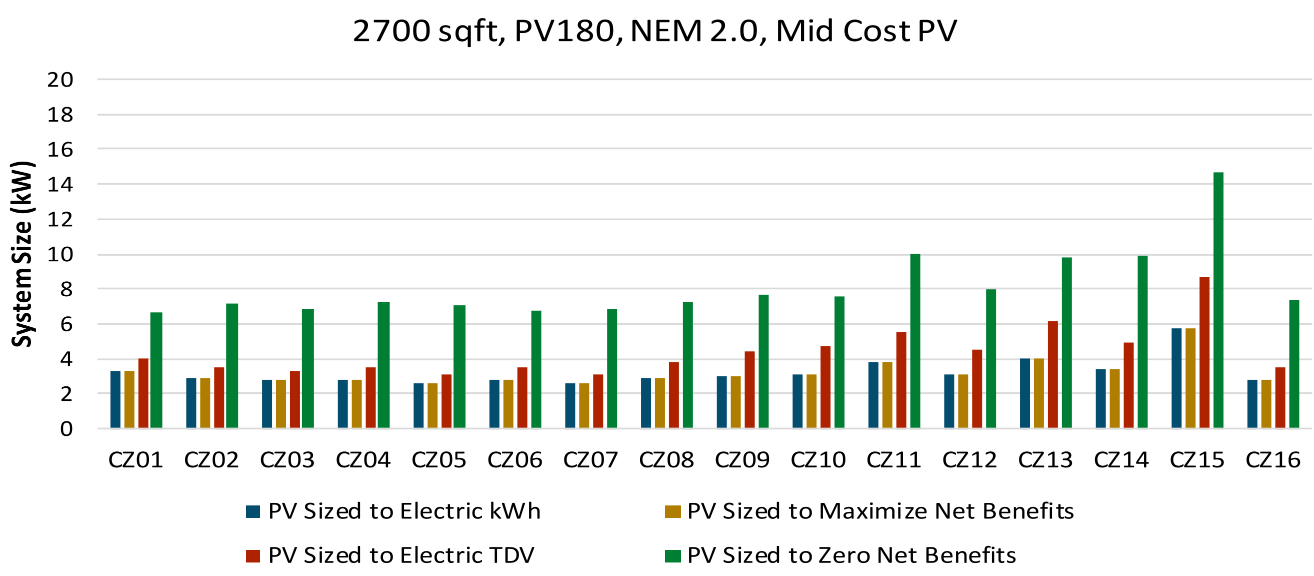
- PV scaled such that annual TDVs generated = annual TDV of electric load

+ Zero Net Benefits (Breakeven Point)

- PV scaled to point at which a larger system will not be cost-effective
- Cost of PV system = Revenue from PV generation

Sizing Comparison
NEM 2.0, Mid Cost PV

- **PV sized to max net benefits is smaller than sized to electric TDV**
  - Sizing to TDV does not reflect lower compensation for exports from NEM 2.0
- **At sizes beyond max net benefits, incremental kW only receive NSC**
  - Large net benefit and small marginal net cost (PV cost – NSC) at the point of maximum net benefits require much larger systems to zero out net benefits
  - Retail for self-use and exports, NSC for net surplus – NEM2



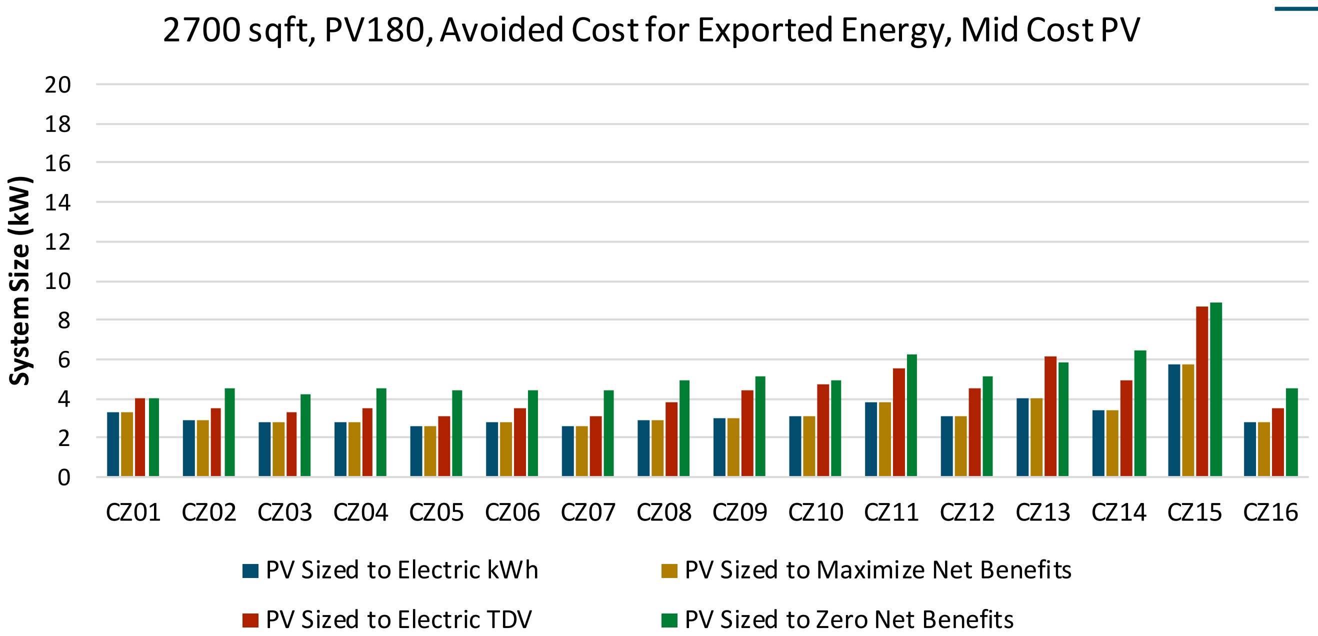
Ratio of PV Sized to Zero Net Benefits / PV Sized to Electric kWh

CZ1	1.98
CZ2	2.51
CZ3	2.49
CZ4	2.62
CZ5	2.76
CZ6	2.42
CZ7	2.61
CZ8	2.49
CZ9	2.55
CZ10	2.43
CZ11	2.65
CZ12	2.59
CZ13	2.43
CZ14	2.96
CZ15	2.55
CZ16	2.61

Sizing Comparison

AC for Exports, Mid Cost PV

- **Valuing export PV generation at avoided cost reduces cost-effectiveness of PV sized to offset kWh**
  - Smaller net benefits for systems sized to offset kWh means less kW at marginal net cost are needed to zero out net benefits
  - Retail for self-use, AC for exports, NSC for net surplus, NEM"3"

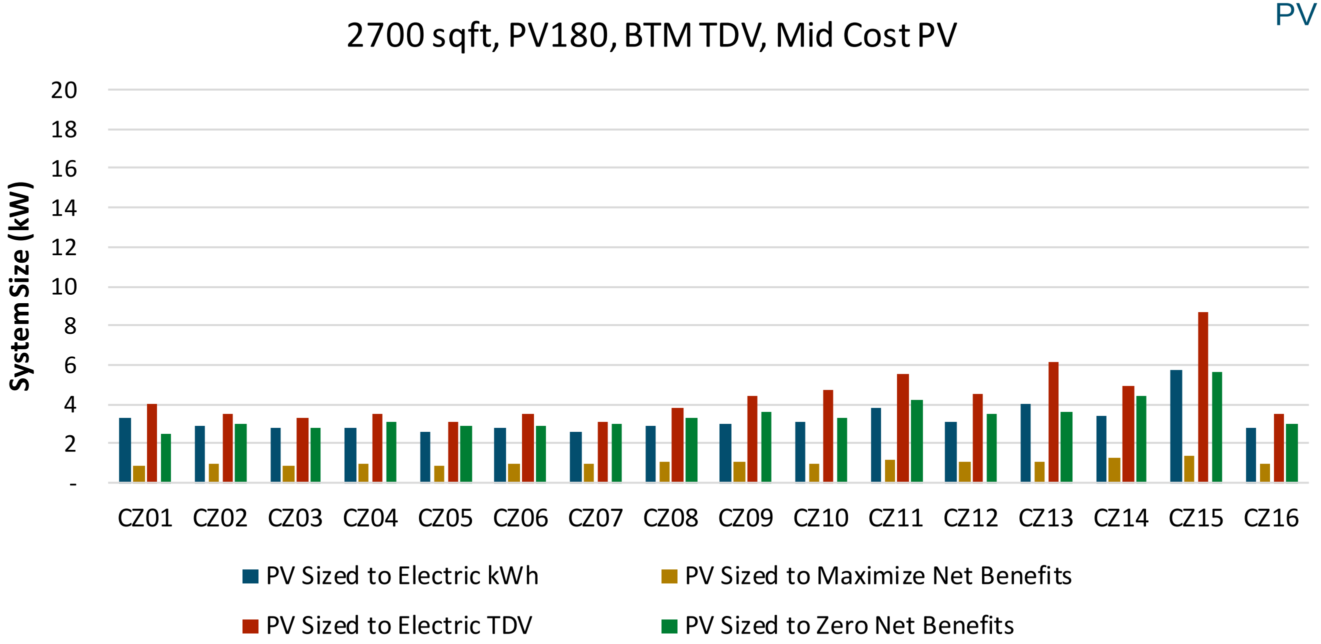


Ratio of PV Sized to Zero Net Benefits / PV Sized to Electric kWh

CZ01	1.21
CZ02	1.57
CZ03	1.52
CZ04	1.64
CZ05	1.71
CZ06	1.58
CZ07	1.67
CZ08	1.67
CZ09	1.69
CZ10	1.57
CZ11	1.65
CZ12	1.64
CZ13	1.45
CZ14	1.91
CZ15	1.55
CZ16	1.60

Sizing Comparison
BTM TDV, Mid Cost PV

+ **BTM TDV means**
    - All PV production consumed behind-the-meter (BTM) receives full TDV value
    - All PV production exported to the grid as well as all net surplus above a system sized to annual kWh receives net surplus compensation (NSC)
+ **PV sized to electric kWh and electric TDV are unchanged from previous rate structures**
+ **PV sized to maximize net benefits and PV sized to zero net benefits are substantially reduced**
+ Retail for self-use, NSC for exports and annual surplus



Ratio of PV Sized to Zero Net Benefits / PV Sized to Electric kWh

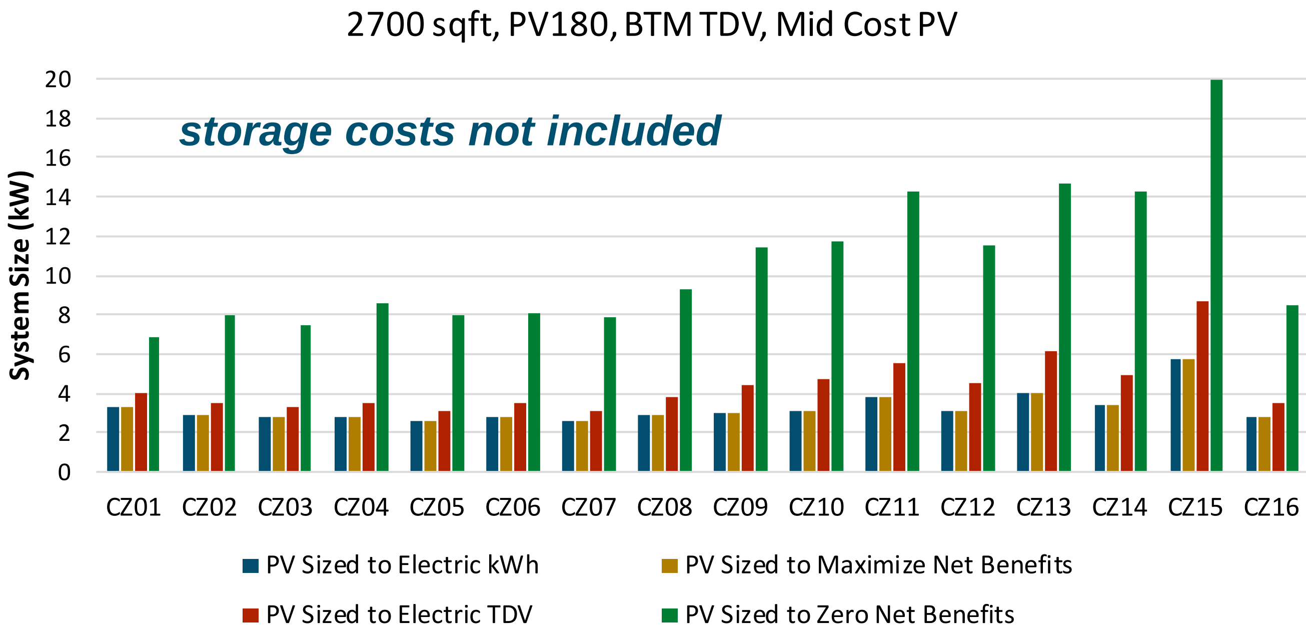
CZ1	0.74
CZ2	1.05
CZ3	1.01
CZ4	1.11
CZ5	1.14
CZ6	1.04
CZ7	1.12
CZ8	1.11
CZ9	1.18
CZ10	1.05
CZ11	1.11
CZ12	1.14
CZ13	0.89
CZ14	1.30
CZ15	0.98
CZ16	1.07

Storage Overview

- **E3 analyzed the additional value of a battery storage system to an existing PV system of a 2700 sf, mixed fuel home**
- **BTM TDV rate scenario**
  - BTM generation receives full TDV value (~$0.20/kWh); exported generation receives net surplus compensation value (~$0.03/kWh)
- **Battery assumptions**
  - 14 kWh
  - 5 kW
  - 90% round trip efficiency
  - $500/kWh fully installed

Sizing Comparison
BTM TDV With Storage, Mid Cost PV

- **Installing storage (without accounting for the storage costs) increases the benefits to the homeowner, allowing them to install more solar**
- The Generous Santa option: Demonstrates how PV value increases if coupled with storage at no cost
- Retail for self-use, and NSC for exports and annual surplus



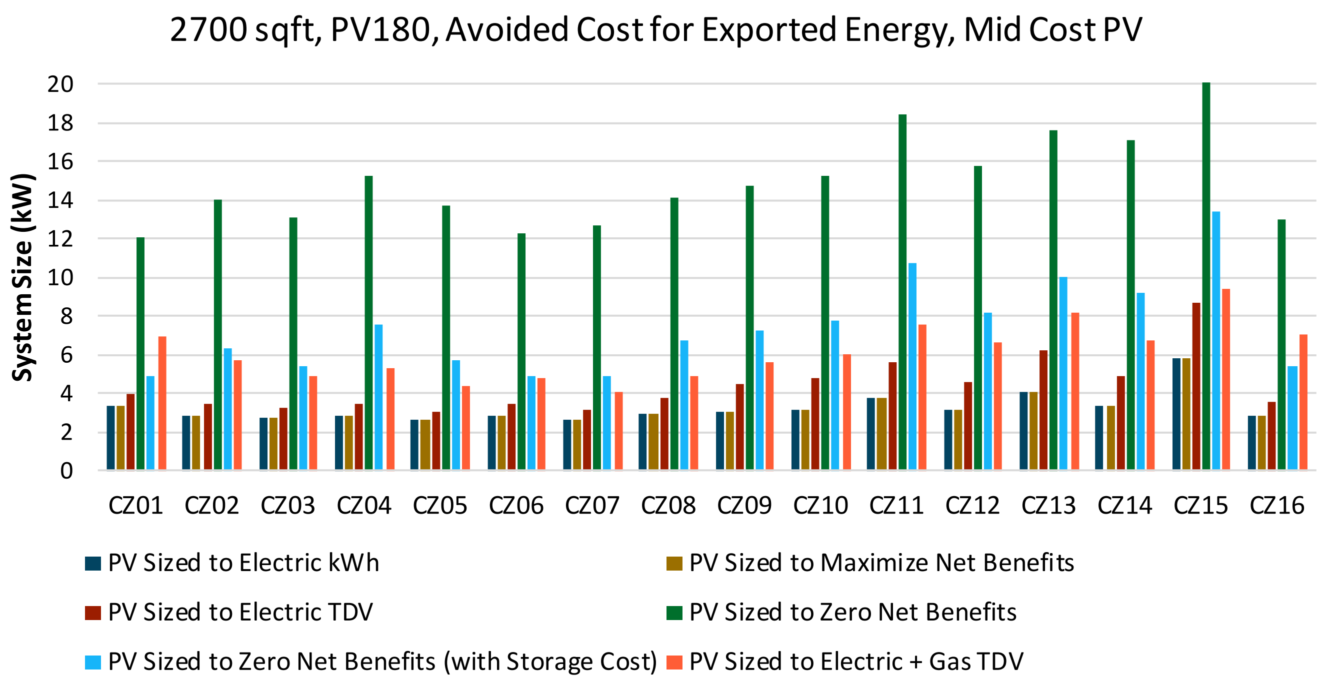
Ratio of PV Sized to Zero Net Benefits / PV Sized to Electric kWh

CZ1	2.05
CZ2	2.78
CZ3	2.70
CZ4	3.09
CZ5	3.09
CZ6	2.89
CZ7	2.97
CZ8	3.17
CZ9	3.77
CZ10	3.75
CZ11	3.76
CZ12	3.71
CZ13	3.66
CZ14	4.26
CZ15	3.47
CZ16	3.02

Sizing Comparison
Avoided Cost for Exported Energy With Storage, Mid Cost PV

NEW

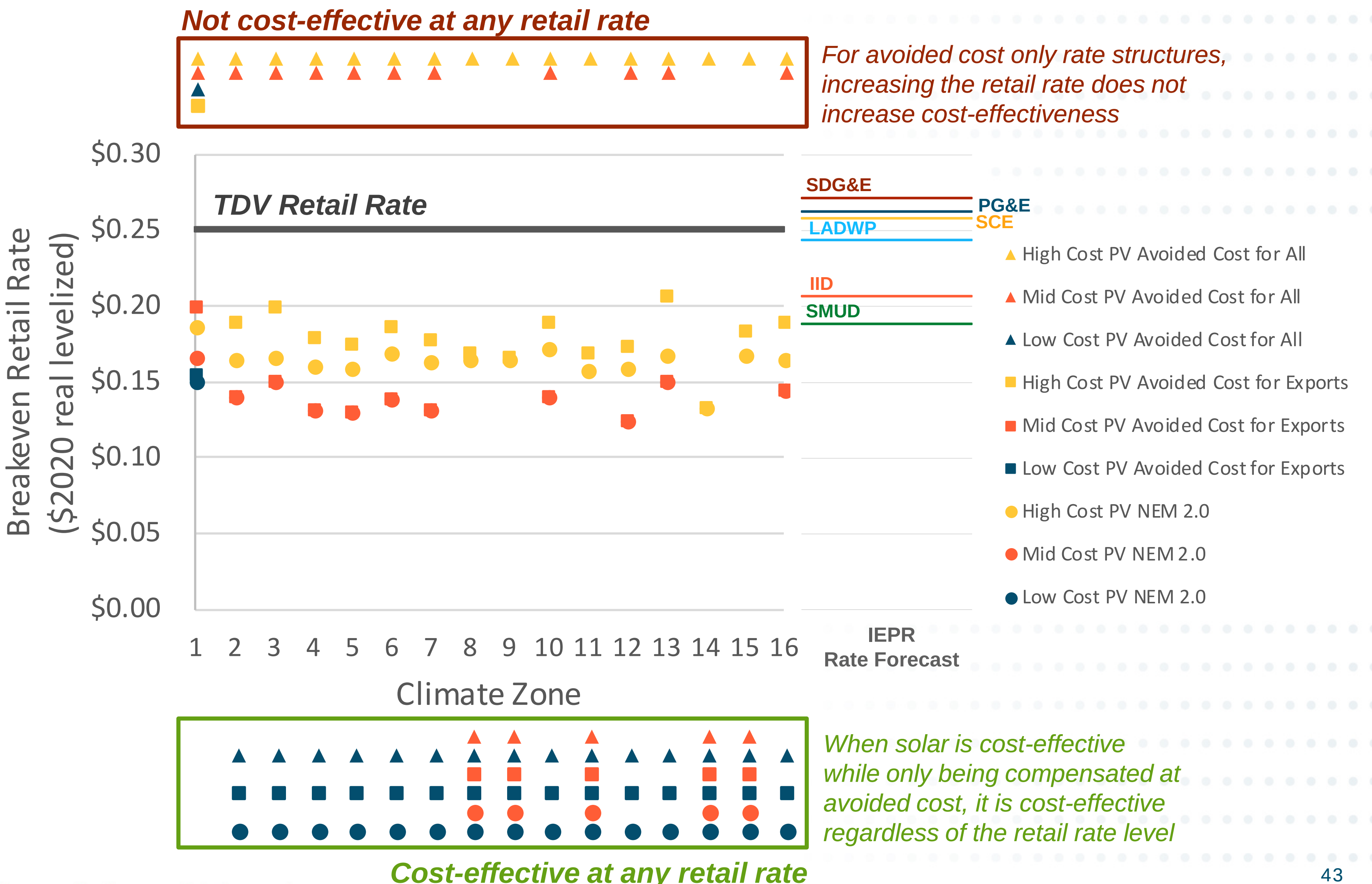
- Changing the rate structure to avoided cost for exported energy increases the net benefits of solar + storage and therefore increases the amount of solar that can be installed before net benefits are reduced to zero; annual surplus at NSC
- The Stingy Santa option – Demonstrates the impact on the PV if Santa charges you for the storage
- Retail for self-use, AC for exports, and NSC for annual surplus – NEM"3"



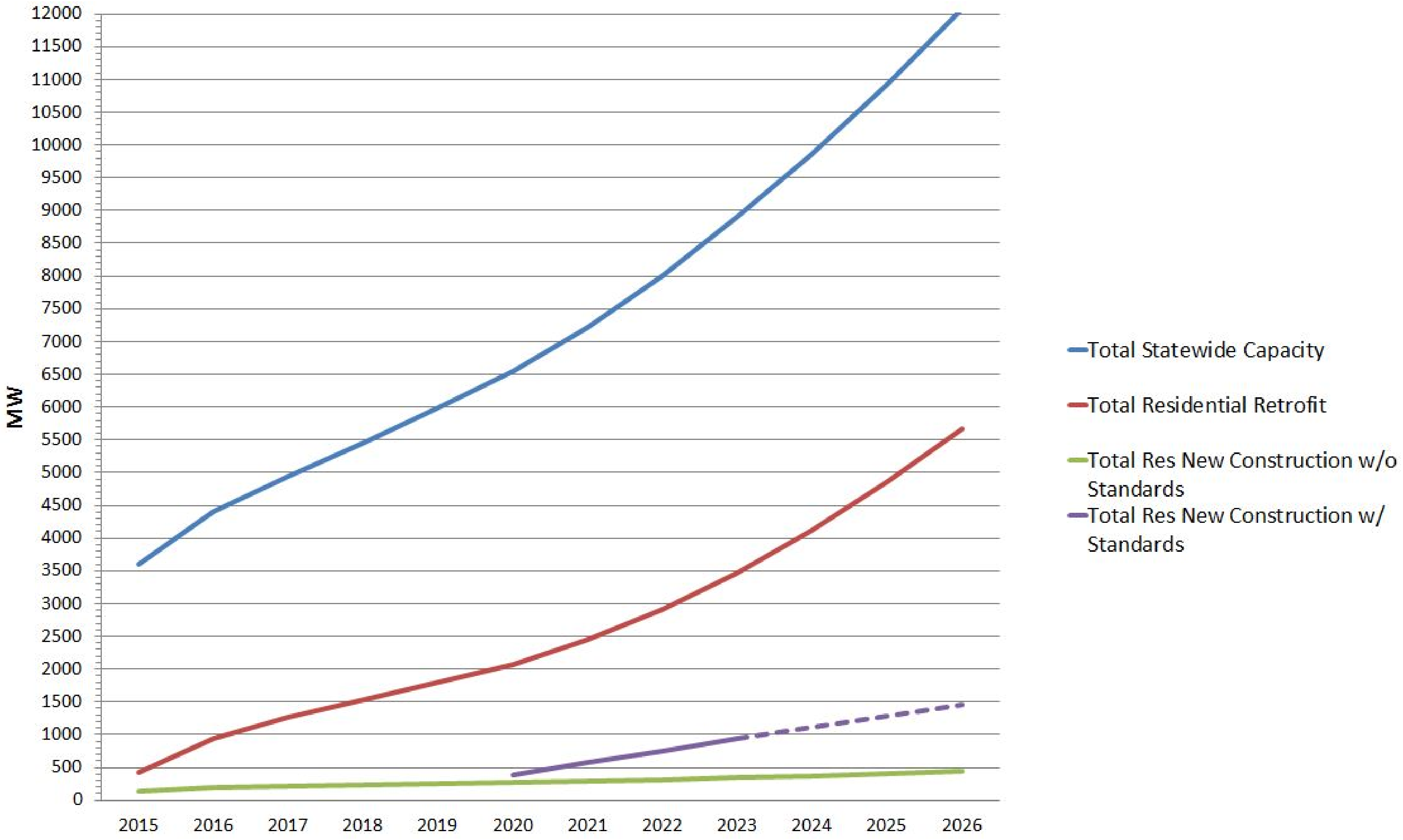
Ratio of PV Sized to Zero Net Benefits (with Storage Costs)

PV Sized to Electric kWh	
CZ1	1.48
CZ2	2.21
CZ3	1.96
CZ4	2.71
CZ5	2.23
CZ6	1.73
CZ7	1.87
CZ8	2.29
CZ9	2.39
CZ10	2.47
CZ11	2.82
CZ12	2.63
CZ13	2.49
CZ14	2.73
CZ15	2.33
CZ16	1.90

POU PV Cost / Benefit Breakeven Analysis



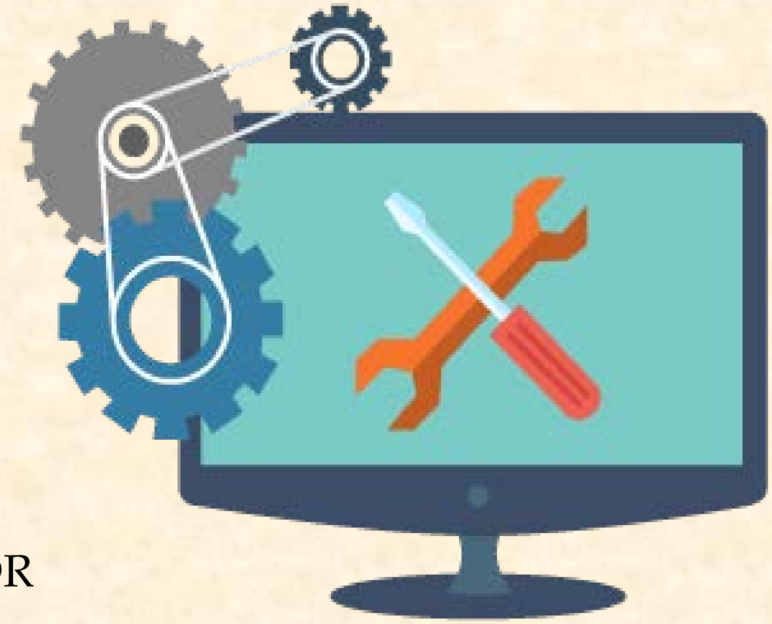
Limited Impact of Standards PV Requirements Compared to Other Forecasted PV Development



4. Software Tools

The CBECC-Res Compliance Software May Be Used For:

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

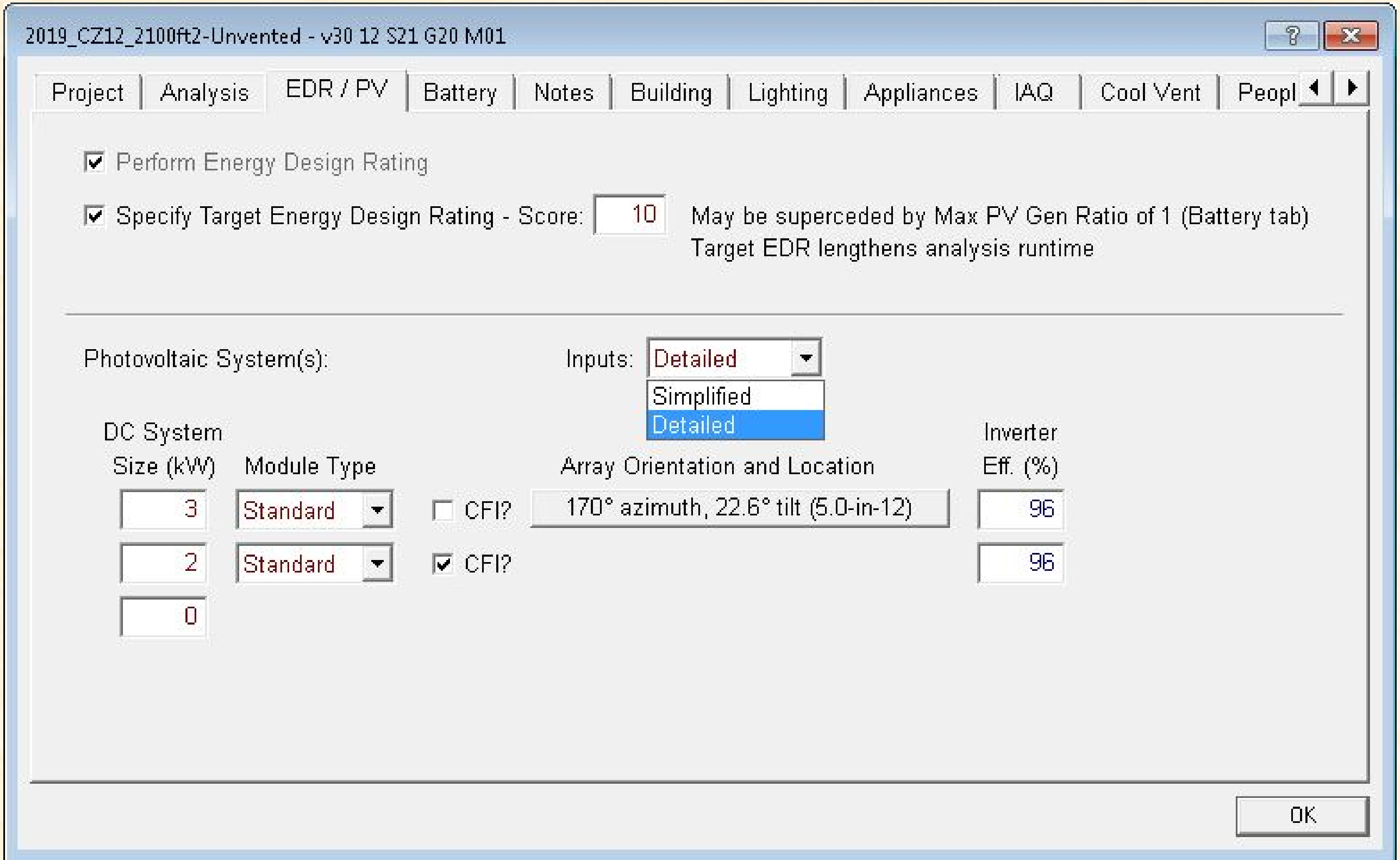


The Software can be used to:

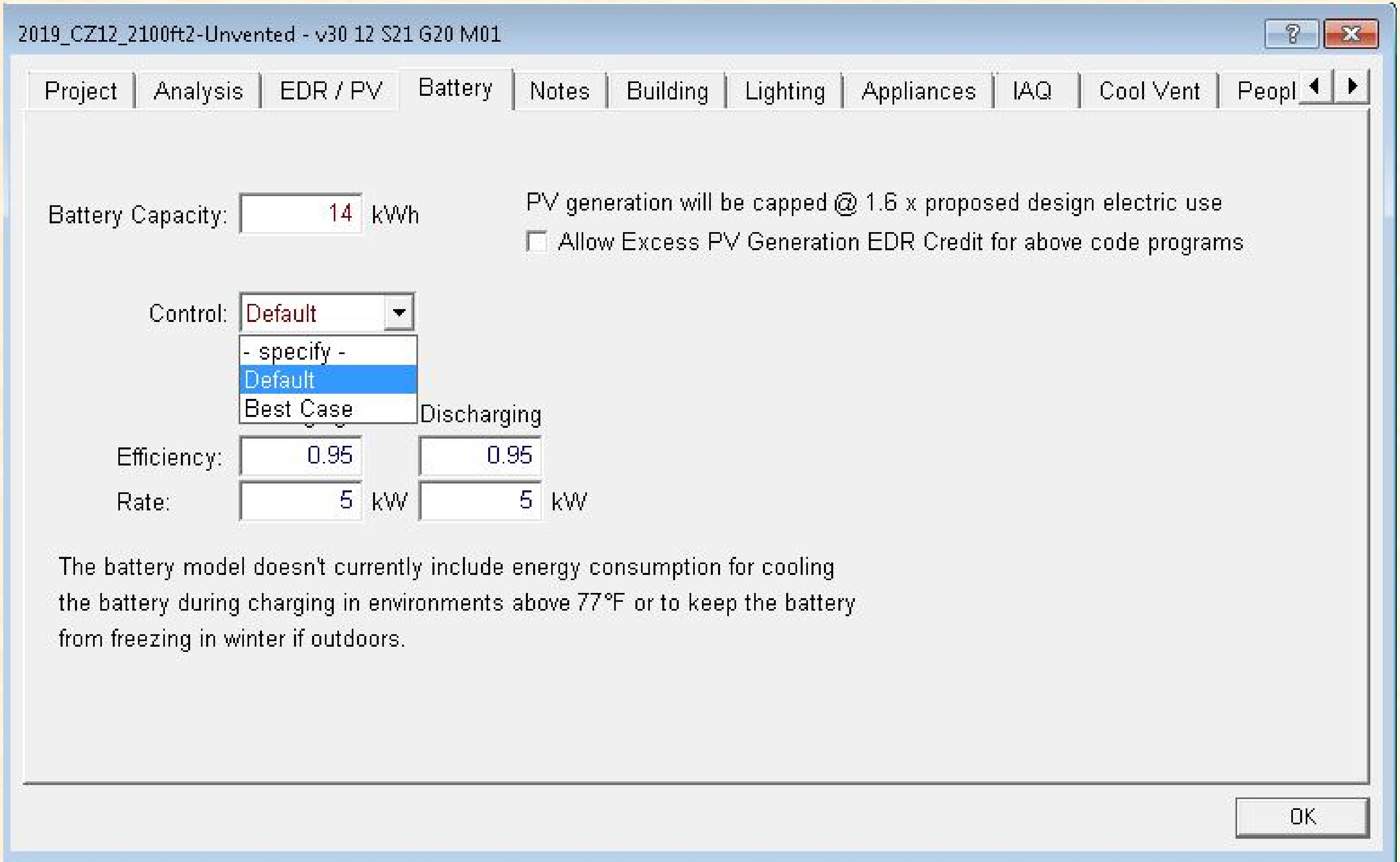
- Size PV for Part 6 compliance or lower target EDRs for Reach Codes
- Assess the impact of battery storage on lowering EDR
- Assess the impact of precooling and other DR strategies on lowering EDR
- Assess the impact of HPWH DR on lowering EDR
- And other options

Software Tools – Input Screens

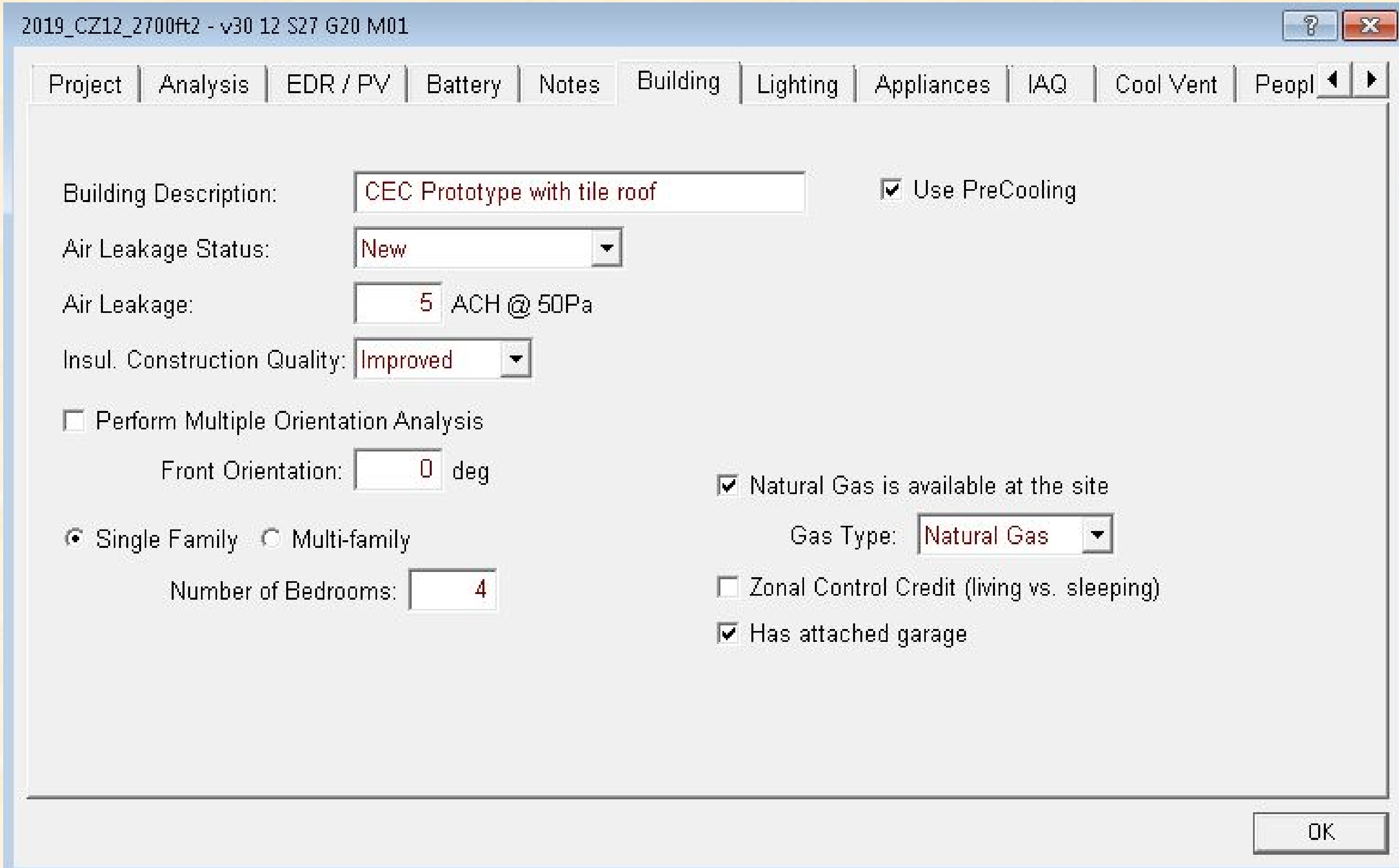
This screen can be used to specify an EDR target that may be required by reach codes to size the PV system



Software Tools – Input Screens



Software Tools – Input Screens



Software Tools – Results Screens

For Compliance for Part 6 and Part 11

2019_CZ12_2700ft2 - v30 12 S27 G20 M01

Compliance Summary | Energy Design Rating | Energy Use Details

EDR of Proposed Efficiency:	41.9	-	EDR of Prop PV + Flexibility:	19.1	=	Final Proposed EDR:	**22.8**
EDR of Standard Efficiency:	43.2	-	EDR of Minimum Required PV:	18.5	=	Final Std Design EDR:	24.7

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	584	486.0	45.09	187	217.2	19.51	25.58
Space Cooling	1,729		59.71	317		17.22	42.49
IAQ Ventilation	194		1.99	194		1.99	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		176.3	13.03		119.9	8.86	4.17
Photovoltaics				-5,022		-43.51	43.51
Battery						0.00	0.00
Inside Lighting	2,615		30.42	616		6.98	23.44
Appl. & Cooking	989	73.4	15.65	1,040	45.1	14.46	1.19
Plug Loads	3,267		35.06	2,371		25.03	10.03
Exterior	328		3.54	152		1.61	1.93
TOTAL	9,705	735.7	204.49	-146	382.3	52.15	152.34

Done

Software Tools – Results Screens

Compliance Pass/Fail

2019_CZ12_2700ft2 - v30 12 S27 G20 M01

Compliance Summary | Energy Design Rating | Energy Use Details

	Energy Design Ratings:		Compliance Margins:	
	Efficiency[1] (EDR)	Final[2] (EDR)	Efficiency[1] (EDR)	Final[2] (EDR)
Standard Design	43.2	24.7		
Proposed Design	41.9	22.8	1.3	1.9

Result[3]: **COMPLIES**

(not current)

[1] Efficiency measures include improvements like a better building envelope and more efficient equipment

[2] Final EDR includes efficiency, photovoltaics and batteries

[3] Building complies when all efficiency and final margins are greater than or equal to zero

Done

Questions?

Mitigating Distribution System Impact

The 2019 BEES will require or encourage the smart, grid harmonized PV systems that will greatly reduce or eliminate the distribution system impacts of the proposed PV systems for new buildings; and may also serve as a model for PV systems installed on existing buildings:

1. Limiting of requirements and compliance credits to right-sized PV systems that on average (considering Standards exceptions) will be substantially smaller than allowed by current interconnection rules,
2. Specification of the smartest inverters (phase III) that the CPUC has approved for use in IOU territories, capable of providing transmission and distribution ancillary services
3. Strong compliance credits for battery storage to encourage self-utilization onpeak and avoidance of offpeak, hourly exports

DNVGL Study Doesn't Match Standards Proposal

Study	Standards Proposal
100% of homes, 2.5 kW – No Exceptions	Many Exceptions
Phase 1 Inverter – voltage control not utilized	CPUC Phase 3 Inverters – nullify study impacts if IOUs use capabilities
No onsite storage	Onsite storage strong compliance option – nullify study impacts in each house with storage
Low PV self-utilization; high grid exports	High PV self-utilization; low grid exports