Building Energy Efficiency Standards

2019 Building Energy Efficiency Standards ZNE Strategy

Building Standards Office:

Mazi Shirakh, PE
ZNE Technical Lead

Christopher Meyer
Manager, Building Standards Office

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

BayREN forum on
Household Electrification as a Pathway to On-Site ZNE

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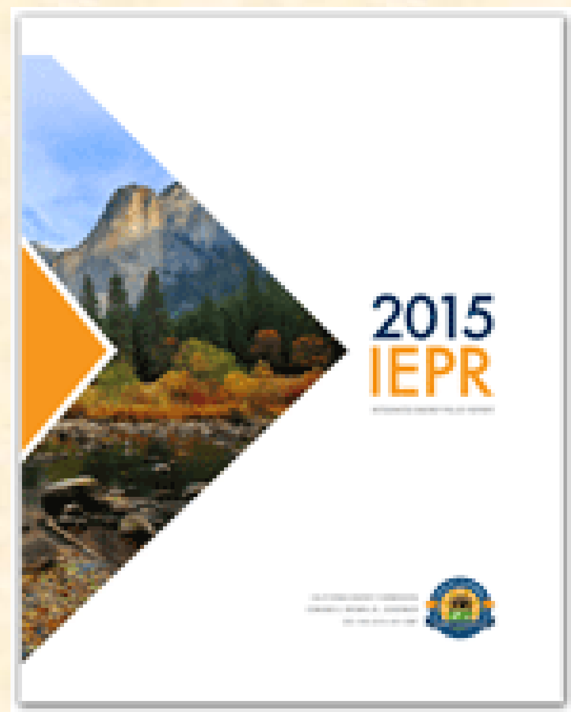
ZNE Standards: the 2015 IPER Vision

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 deployment of **building-based PVs** which **lowers the value of additional electricity around midday**, coincident with utility solar production
- Net energy metering (**NEM)** and Time-Of-Use (**TOU**) on **compensation for residential customer-owned generation and cost effectiveness of PVs**

Also, we have learned that as the **electric grid becomes greener** in the future, rooftop **PVs will have diminished carbon reduction benefits**

ZNE Goals – Lessons Learned - Continued

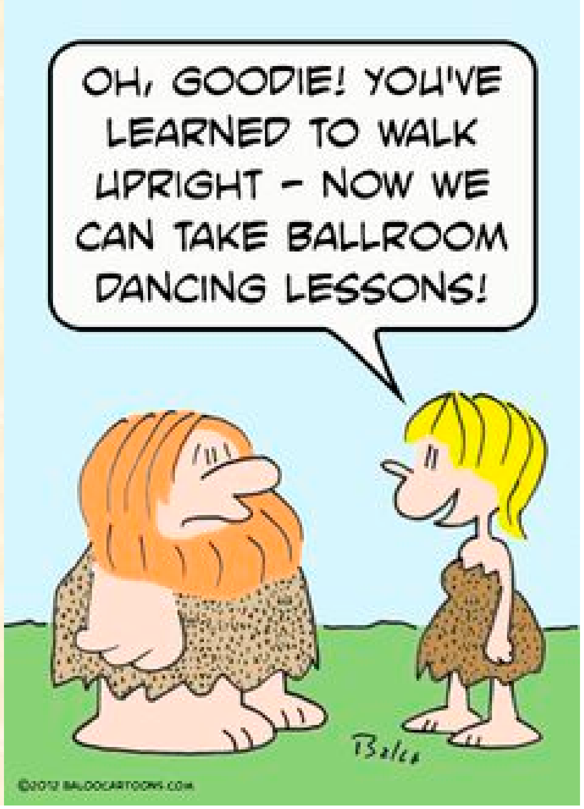
- The current NEM rules treat the grid as "**virtual storage**" (or a bank), where the overgenerated kWhs can be "stored" and retrieved later in the day, or even as if summer kWhs could be stored until winter
- In reality, the **grid as it is now has very little capability** to store and effectively use overgenerated kWhs from PVs
- **Electrification of homes,** which results in a larger PV array**,** must be coupled with **grid harmonization strategies** to avoid aggravating the duck curve issues and to realize the expected environmental benefits
- Currently, customer-owned storage at about $450/kWh is still too expensive to be cost effective using the LCC for the 2019 Standards, but this is a fast evolving technology which can become cost effective under a future cycle of the Standards

ZNE Goals – Lessons Learned - Continued

The most important lesson is that within a few years, perhaps by 2025 **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 minimizes uneconomic exports to the grid, examples of GHS include but not limited to battery storage, demand response, thermal storage, and EV integration.

the 2019 Standards approach must consider these issues



ZNE Goals – 2019 Standards Goals

The 2019 Standards should be structured to **send the right signal to the market** to pave the way for achieving full ZNE in a later cycle of Standards by encouraging:

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

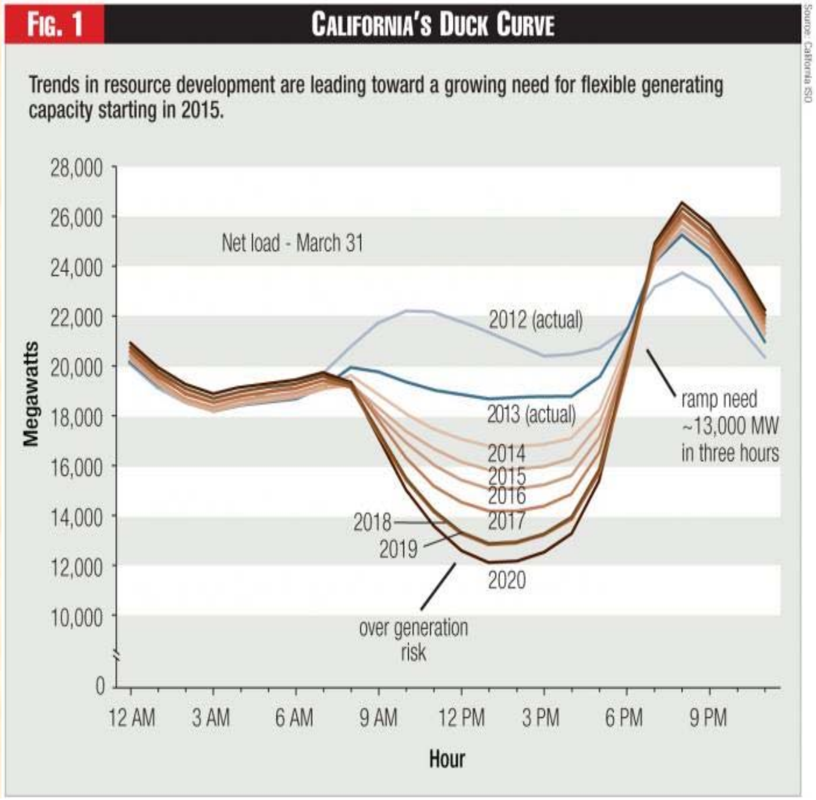
Further, the standards must be framed in a way to **encourage competition, innovation, and flexibility** to foster new solutions as the grid and technologies evolve.

A possible structure is proposed later in the presentation.

The ZNE Challenge: Grid Harmonization

The value of midday PV generated kWhs decrease as we approach the 50% Renewable Portfolio Standard (RPS) by 2030 and increasing customer-owned renewables; this necessitates developing GHS strategies that prevent the so called "Duck Curve" Issues

However, Hawaii and Australia that have already encountered these problems, are adopting grid integration/harmonization strategies to maximize self-utilizations and minimize exports to the grid



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 50% RPS by 2030, the LCC finds:

Appropriately sized PVs that displace the site kWh are found to be cost effective in all climate zones, even if the NEM2 rules are changed to compensate exported kWhs at wholesale - even assuming no Federal ITC

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
2. An EDR Contribution for PV array that is sized to displace the annual site kWhs
3. Combine the energy efficiency EDR with the PV EDR for one 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
2. 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)**
3. Calculate EDR of PV array as follows:
   i. Calculate the PV size required to displace the site kWh in each CZ
   ii. Calculate the EDR contribution of the PV array
4. Combine the EDR contribution of EE to the EDR contribution of PV and **establish a Target EDR in each CZ that the building must meet to comply**

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**; the concept is a modern version of California's **performance standards** consistent with the Warren-Alquist Act expectation to provide builders with compliance flexibility
2. As shown by the **2016 HPA and HPW approach, builders appreciated having many options** to comply, leading to a flurry of **innovation in attics and walls**, which continues to date
3. Similarly, the target **EDR if structured correctly**, can send the **right signals to the market about EE, PV sizing, demand response and flexibility**, and other options that can achieve ZNE in the future
4. Target EDR allows the builder **to use more efficiency and less PV to get to the target**; the builder can also **use high performance glazing or appliances that are higher than minimum efficiency** levels that we are prevented to require because of preemption
5. Target EDR can provide **credit for demand response and flexibility, storage, EV integration, and other grid harmonization strategies** that can achieve full ZNE in the future
6. Target EDR is fully **compatible with the reach codes**, local jurisdiction simply identify a lower target EDR (or zero) that can be met with a combination of additional EE, PV, demand response/flexibility, EV integration, or storage
7. 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:

2016CZ12_2700ft2 - CZ12 STD2700 EGLASS20 2016PKG

Energy Use Details | Summary | Energy Design Rating

EDR of Proposed Design: 43.0   EDR of Proposed PV+Battery: 20.8   Final Proposed EDR: **22.2**

EDR of Standard Design: 47.3

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	568	472.4	43.85	176	204.7	18.41	25.44
Space Cooling	1,687		58.92	355		20.18	38.74
IAQ Ventilation	141		1.45	141		1.45	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		176.3	13.03		121.9	9.01	4.02
Photovoltaics				-4,870		-46.97	46.97
Battery						0.00	0.00
Inside Lighting	2,615		30.28	616		6.95	23.33
Appl. & Cooking	989	73.4	15.65	1,041	45.1	14.45	1.20
Plug Loads	3,267		35.03	2,371		25.01	10.02
Exterior	328		3.52	152		1.61	1.91
TOTAL	9,595	722.1	201.73	-19	371.8	50.10	151.63

Done

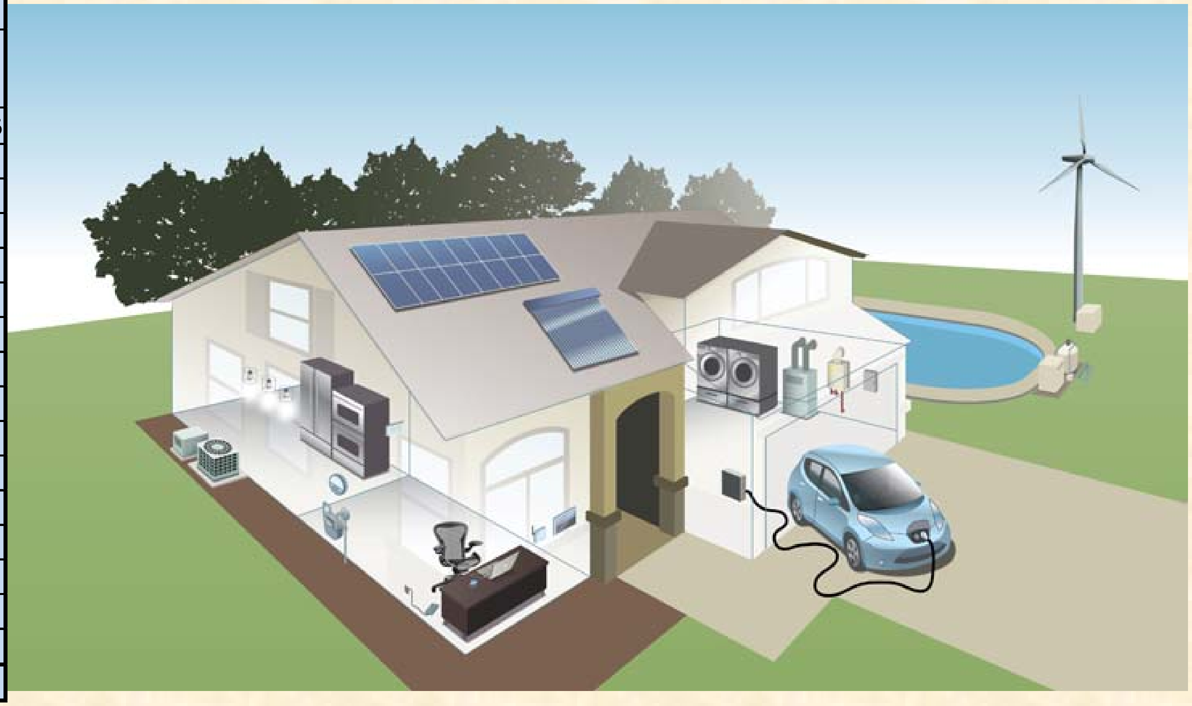
All-Electric Home Option

What should be the EE EDR and Target EDR for All-Electric Homes (AEH)? Staff proposes the same EDRs used for mixed fuel homes be used for the AEH:

1. Requiring a much larger PV system on AEH to displace the larger annual kWh will disincentivize the AEH approach
2. The larger PV needed to displace the AEH kWh, without grid harmonization strategies, will aggravate duck curve issues

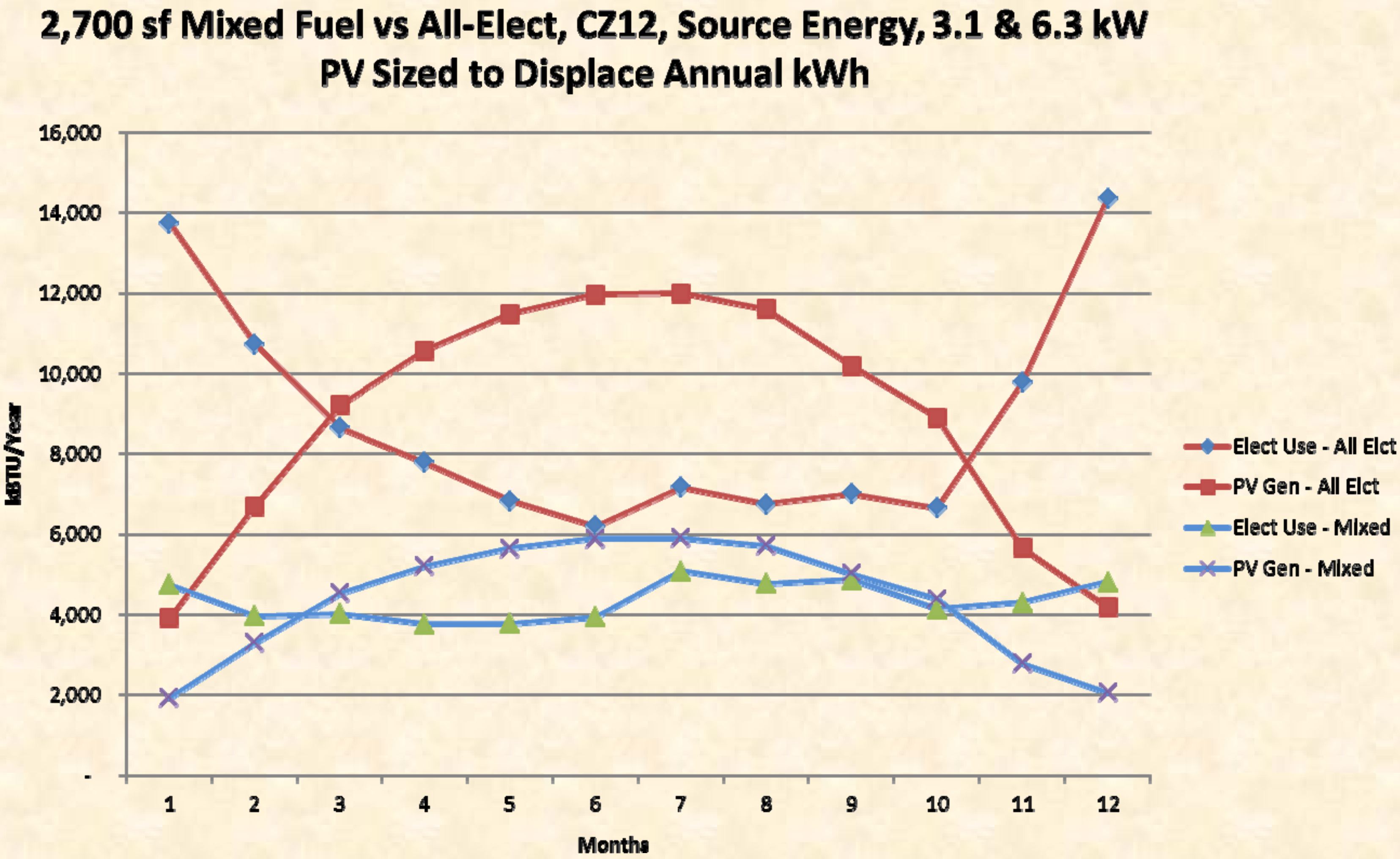
Large number of AEHs, due to higher winter kWh usage than summer, can cause a winter peak that may be as large or larger than the summer peak with limited solar resources in the winter to help.

	All-Electric Challenge	
CZ	Summer Cooling kWh	Winter Heating kWh
1	0	4,686
2	30	2,367
3	3	932
4	52	2,128
5	-	2,339
6	37	909
7	9	139
8	302	307
9	632	845
10	839	1,020
11	1,577	2,179
12	543	2,208
13	1,757	1,868
14	1,578	2,266
15	5,282	119
16	105	5,596
Total	12,746	29,908



All-Electric - Summer Duck vs Christmas Turkey

All-Electric homes use more kWhs in the winter than summer that may result in higher peak and demand in winter – Grid harmonization becomes more important



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

1	2	3	4	5	6	7	8
CZ	Efficiency EDR without PV, based on 2019 Efficiency Measures	Target Design Rating Score for Displacing kWh Elect with PV from Col 4	kW PV Size for Displacing kWh Electric Only – Totally Cool with NEM	Standalone PV Sized to Zero EDR (Dumb PV) **– Violates NEM, Not Good for GH**	PV Size for Zero EDR with Battery with Basic Controls **– May Violate NEM, Not Good for GH**	PV Size for Zero EDR with Battery with Optimum Controls – Cool with NEM	Similar to Col 7 But With 95 Furn, 0.95 WH – Real Cool with NEM
1	55.7	31.5	3.4	8.9	8.1	5.6	4.9
2	41.2	18.0	2.9	6.1	5.5	3.1	2.8
3	46.9	22.7	2.8	5.8	5.3	3.2	2.9
6	48.0	20.9	2.9	5.3	4.5	2.9	2.8
7	48.0	14.9	2.7	4.6	3.9	2.4	2.3
8	43.0	14.6	2.9	5.3	4.3	2.7	2.6
11	43.2	20.7	3.8	8.3	6.4	4.2	3.9
12	43.2	22.2	3.1	6.5	5.3	3.4	3.1
13	44.8	22.1	4.0	9.0	6.2	4.9	4.6
14	44.6	21.3	3.4	7.4	5.4	4.4	4.1
15	48.0	17.9	5.7	10.5	8.1	6.9	6.8
16	48.9	29.6	2.8	7.9	6.6	4.9	4.3

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:

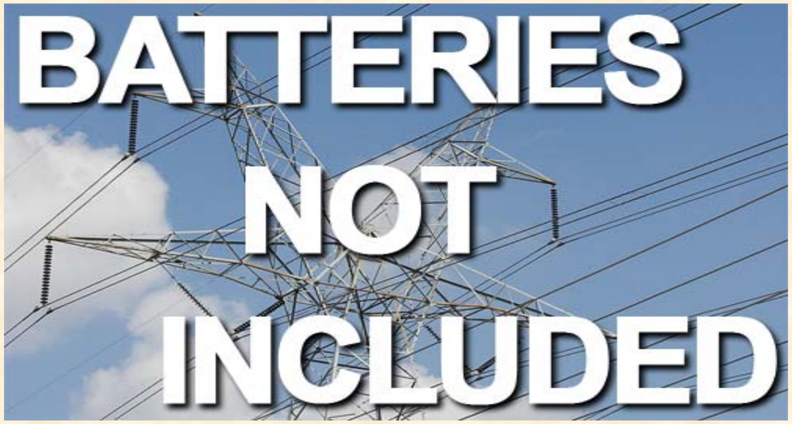
Note: At this time these numbers are examples only and may change as our tools evolve

NEM = Net Energy Metering; GH = Grid Harmonization

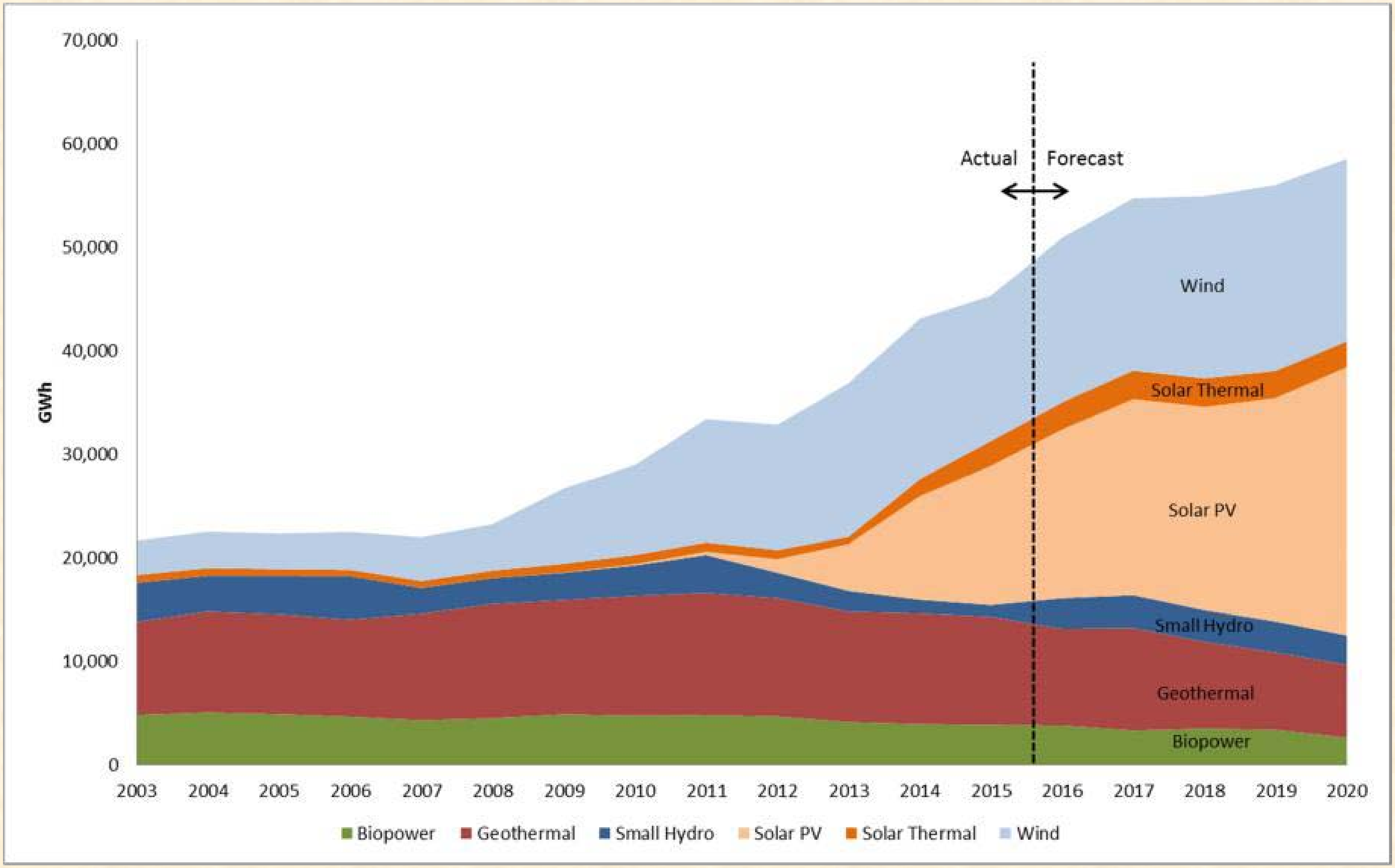
1	2	3	4	5	6	7	8
CZ	Target Design Rating Score for Displacing kWh Elect with PV Size from Col 3	kW PV Size for Displacing kWh Electric Only in Mixed Fuel Homes– Totally Cool with NEM	Standalone PV Size Needed to Displace Annual kWh – Cool with NEM – **not Cool for GH**	Standalone PV Sized for Zero EDR (Dumb PV) **– Violates NEM – Not Cool for GH**	PV Sized for Zero EDR with Battery with Basic Controls **– May Violate NEM**	PV Sized for Zero EDR with Battery with Optimum 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
1	39.7	3.4	7.7	9.8	8.8	5.9	5.6
2	29.6	2.9	5.9	7.2	6.5	3.9	3.7
3	32.1	2.8	5.4	7.0	6.0	3.8	3.6
6	26.6	2.9	4.6	5.9	4.9	3.2	3.0
7	26.0	2.7	4.1	5.3	4.4	2.7	2.6
8	26.0	2.9	4.6	6.1	4.8	3.1	2.9
11	31.4	3.8	6.6	9.9	7.6	5.9	5.3
12	30.0	3.1	5.9	8.4	6.7	4.8	4.4
13	30.8	4.0	6.7	10.3	8.0	6.5	5.8
14	33.3	3.4	5.9	8.6	6.7	5.8	5.3
15	26.2	5.7	7.0	11.5	9.2	8.0	7.0
16	48.3	2.8	7.7	10.8	9.7	7.6	7.5

All-Electric Building Code Challenges

- Coincidence of hourly load and generation
- Coincidence of seasonal load and generation
- All-electric building load higher in winter than summer
- Lack of installed utility-scale storage (voltage support and load following)
- Lack of utility-scale seasonal energy storage
- Current expansion capacity of many distribution circuits
- Current cost-effectiveness of behind-the-meter storage



Renewable resource mix, actual and forecasted (nameplate capacity)



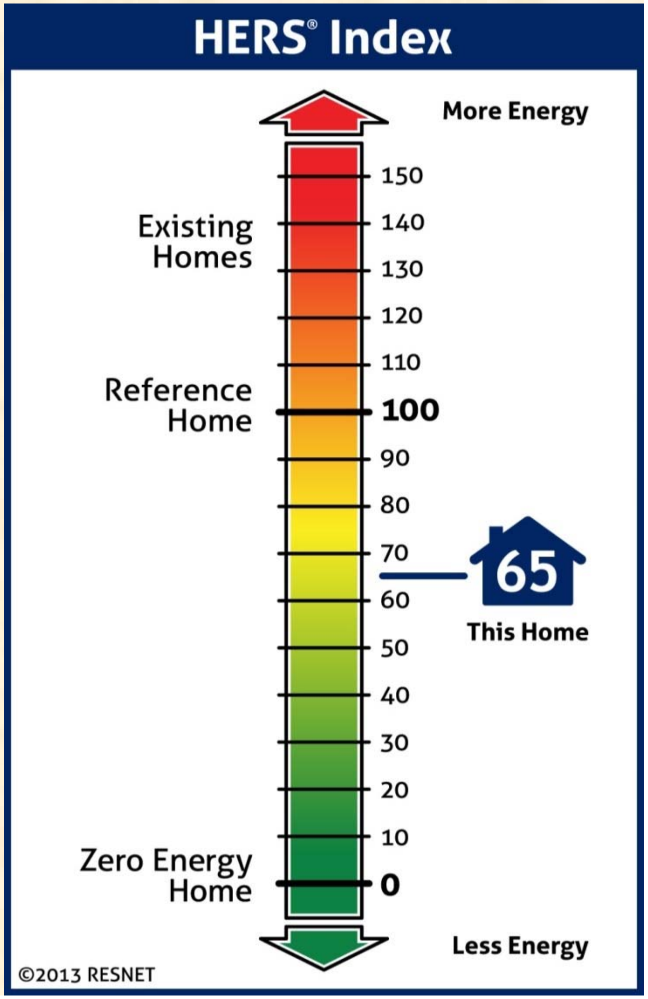
Builds on Commission's Energy Design Rating Tool

- **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**

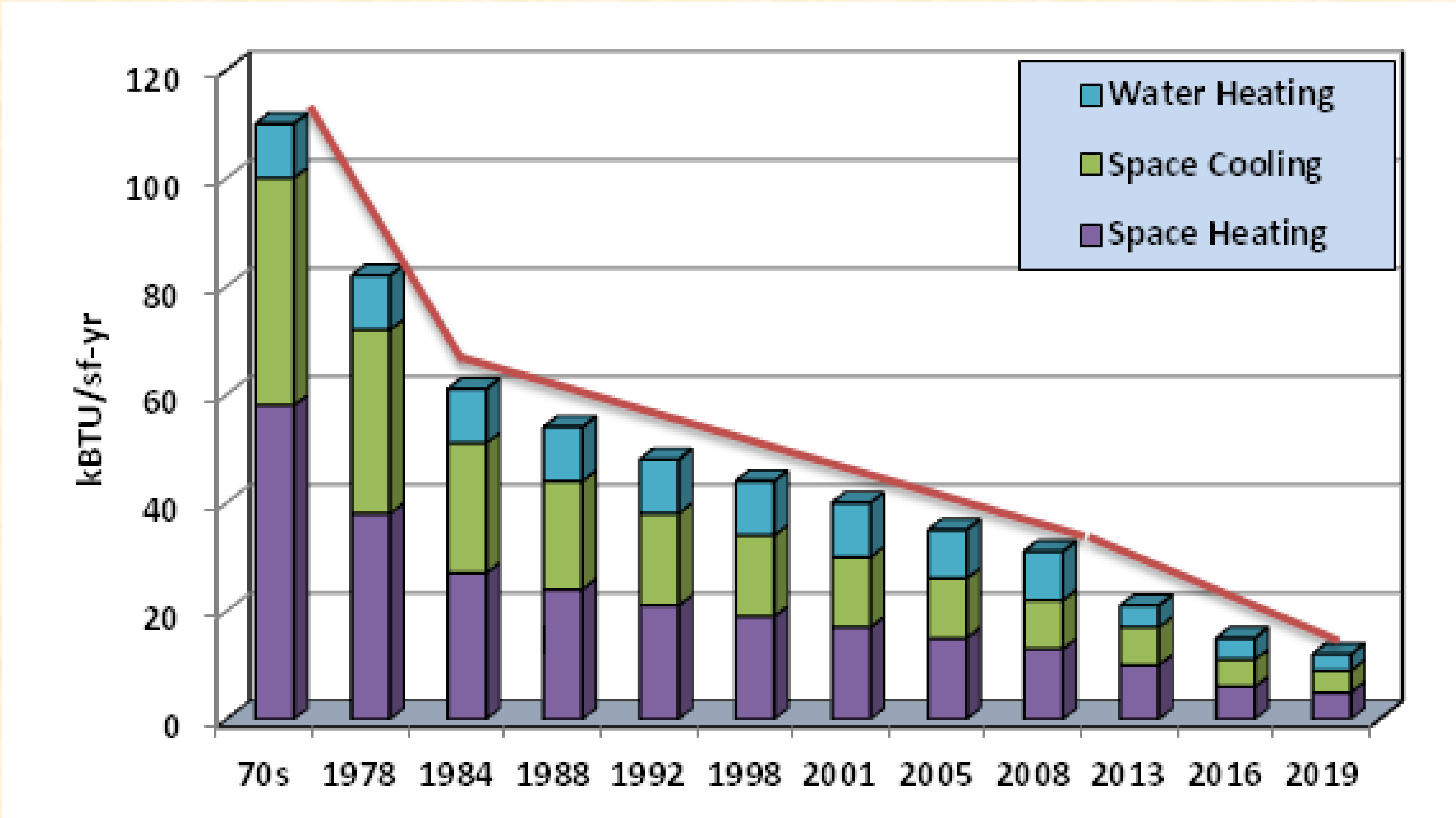
Download CBECC-Res here for free:

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



BEES Impact on EUI

Impacts of Building Standards on Home Energy Use



2019 BEES Schedule

2019 STANDARDS UPDATE SCHEDULE	
DATE	**MILESTONES**
August 2016 to April 2017	Stakeholder-hosted workshops & proposal development
January2017-March2017	Second round of Stakeholder-hosted workshops & proposal development
April 2017	**DRAFT Code proposals (CASE Reports) submitted to the CEC**
June 2017	Pre-rulemaking Draft Express Terms prepared, made available for public comment
June 2017	**FINAL Code proposals (CASE Reports) submitted to the CEC**
July 2017	Incorporate public comments into Draft Express Terms; prepare Notice of Proposed Action (NOPA) and Initial Statement of Reasons (ISOR)
September2017	File Draft Express Terms, ISOR, NOPA with CBSC
November 2017	Draft Express Terms, ISOR, NOPA published; 45-day Public Review Period begins
November-December 2017	Host 45-day Language Hearings
January 2018	End of 45-day review/comment period; begin review of submitted comments and preparation of 15-day language
February 2018	Publish 15-day language; begin 15-day Public Review Period
May 2018	Adopt Final Express Terms of the 2019 Standards at Business Meeting
June 2018	Begin updating Software, Compliance Manuals, Electronic Documents
July/August 2018	CBSC Code Advisory Committee Meeting-CalGREEN
September/October 2018	Adoption CalGREEN (energy provisions) at Business Meeting
November 2018	Deliver Final Rulemaking Package to CBSC; Approve updates to Compliance Manuals
December 2018	CBSC Approval Hearing
January 2019	Make Software, Compliance Manuals, Electronic Documents Available to Industry
January 1, 2020	Effective Date of 2019 Building Energy Efficiency Standards (Title 24, Part 6)

Informational Resources

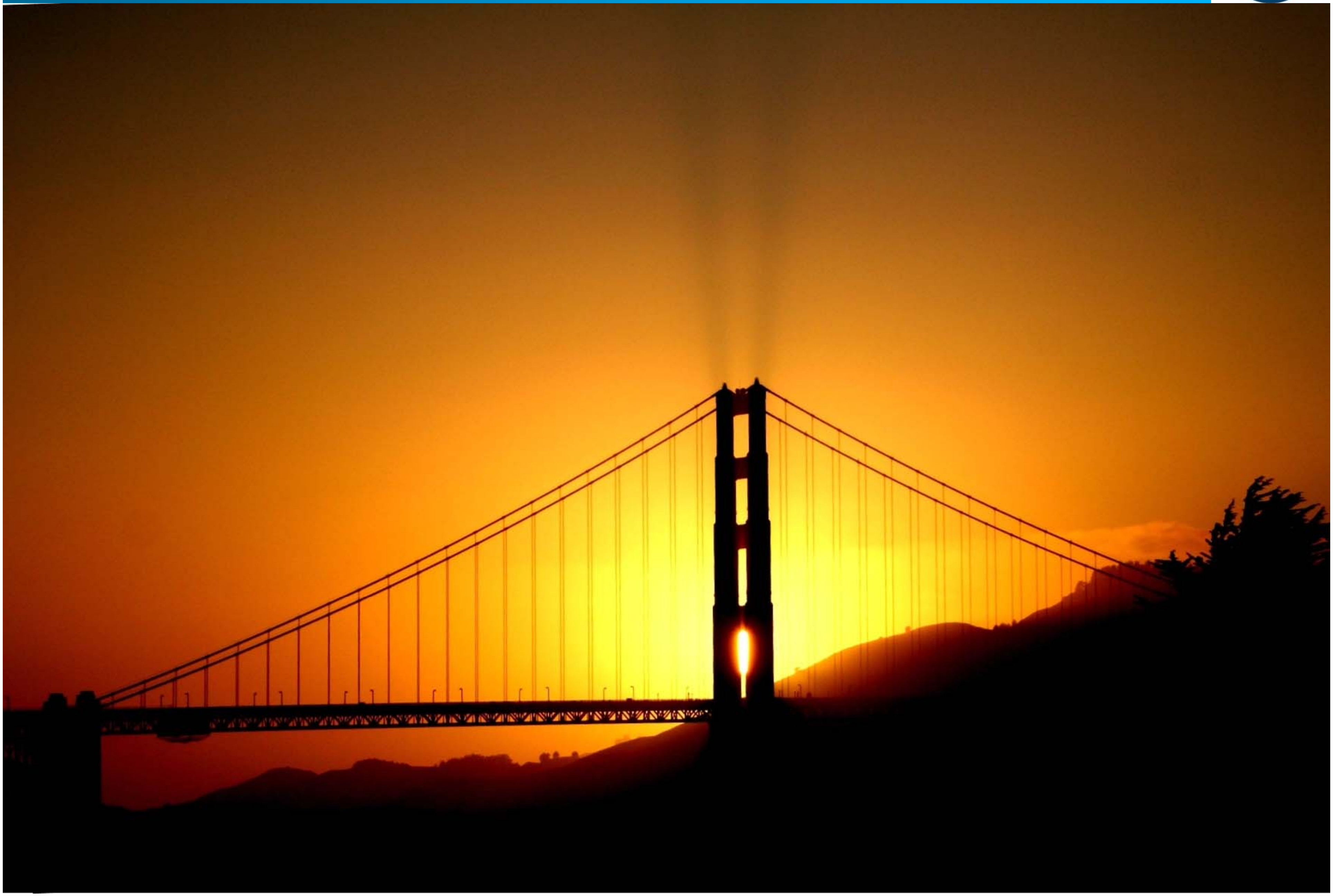
- Energy Efficiency Standards approved computer compliance programs, CBECC-Res and CBECC-Com can be downloaded for free at: http://www.energy.ca.gov/title24/2016standards/2016_computer_prog_list.html

- Information on the current 2016 Building Energy Efficiency Standards, including Compliance Manuals, worksheets and additional resources can be found at: http://www.energy.ca.gov/title24/2016standards/index.html

- To receive documents and notification of upcoming events, please sign up on the List Serve for the 2019 Building Energy Efficiency Standards (Docket #2016-BSTD-06) at: http://www.energy.ca.gov/title24/2019standards/prerulemaking/index.html

- Title 24 Support Hotline: Title24@energy.ca.gov

Questions?



Additional Information

E3 Life Cycle Costing Analysis Finds:

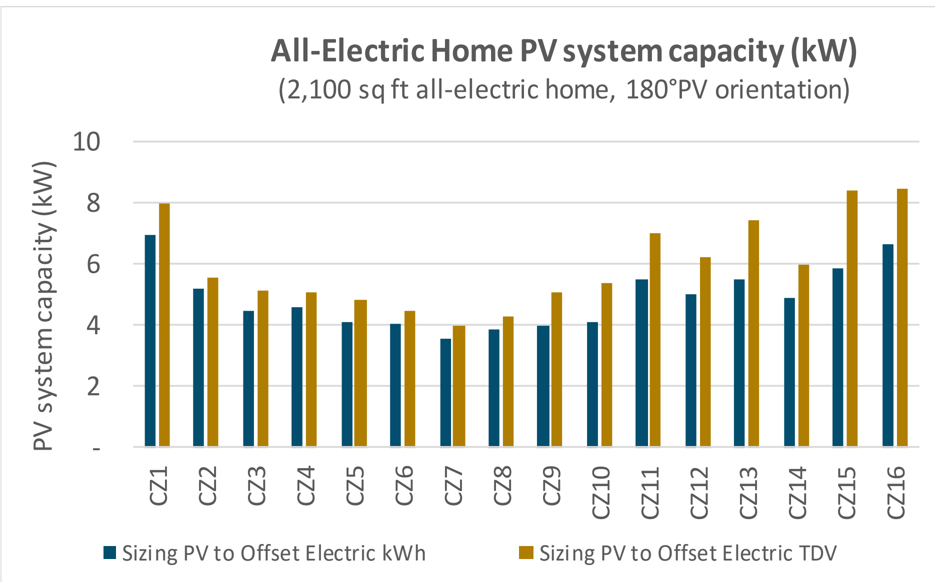
PV systems sized to displace site annual kWh cost effective in all climate zones

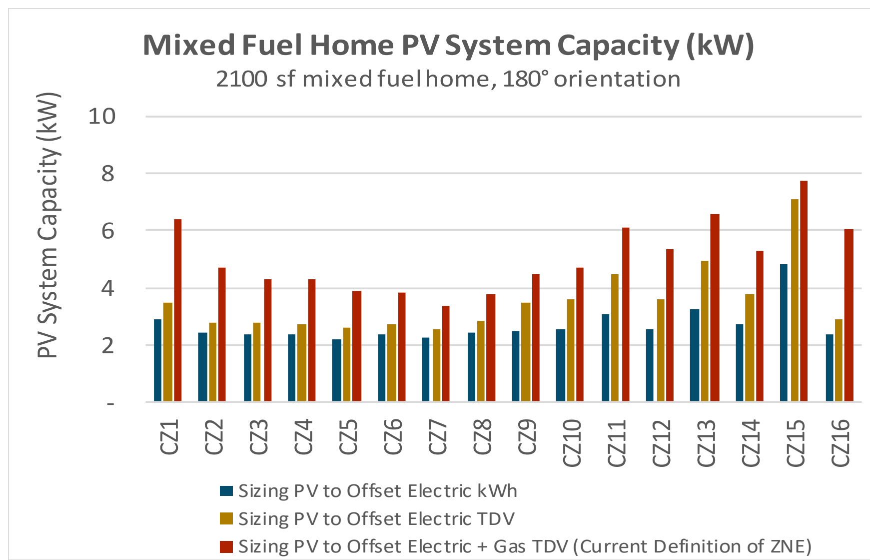
Even if NEM2 rules are changed to compensate exported kWhs at avoided cost

With no federal ITC

TDV ZNE requires a larger PV system than Site ZNE

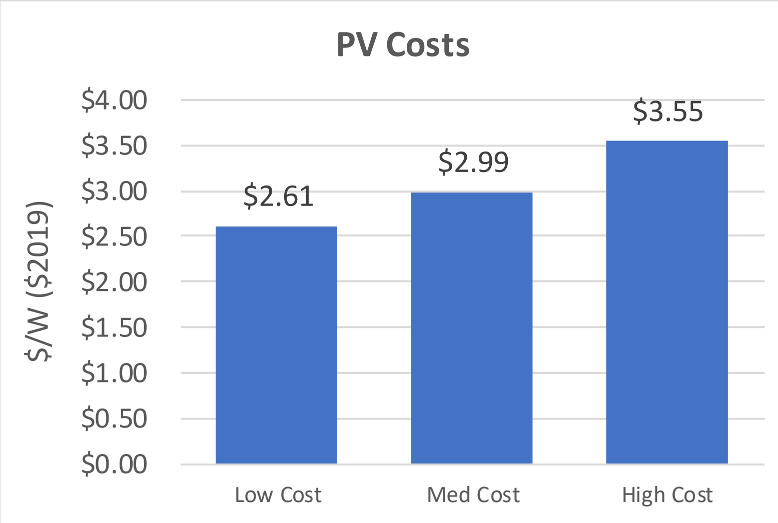
- **Solar production occurs during low TDV hours, and households demand energy during high TDV hours**
  - PV must be sized larger to reach TDV ZNE vs. Site ZNE (which doesn't account for the changing value of kWh)
- **For a 2,100 ft² home with 180° PV orientation, TDV ZNE requires 7% - 44% larger PV capacity than Site ZNE (average: 21%)**
- **Because PV interconnection rules limit sizing to electric kWh, this presentation focuses on that size**



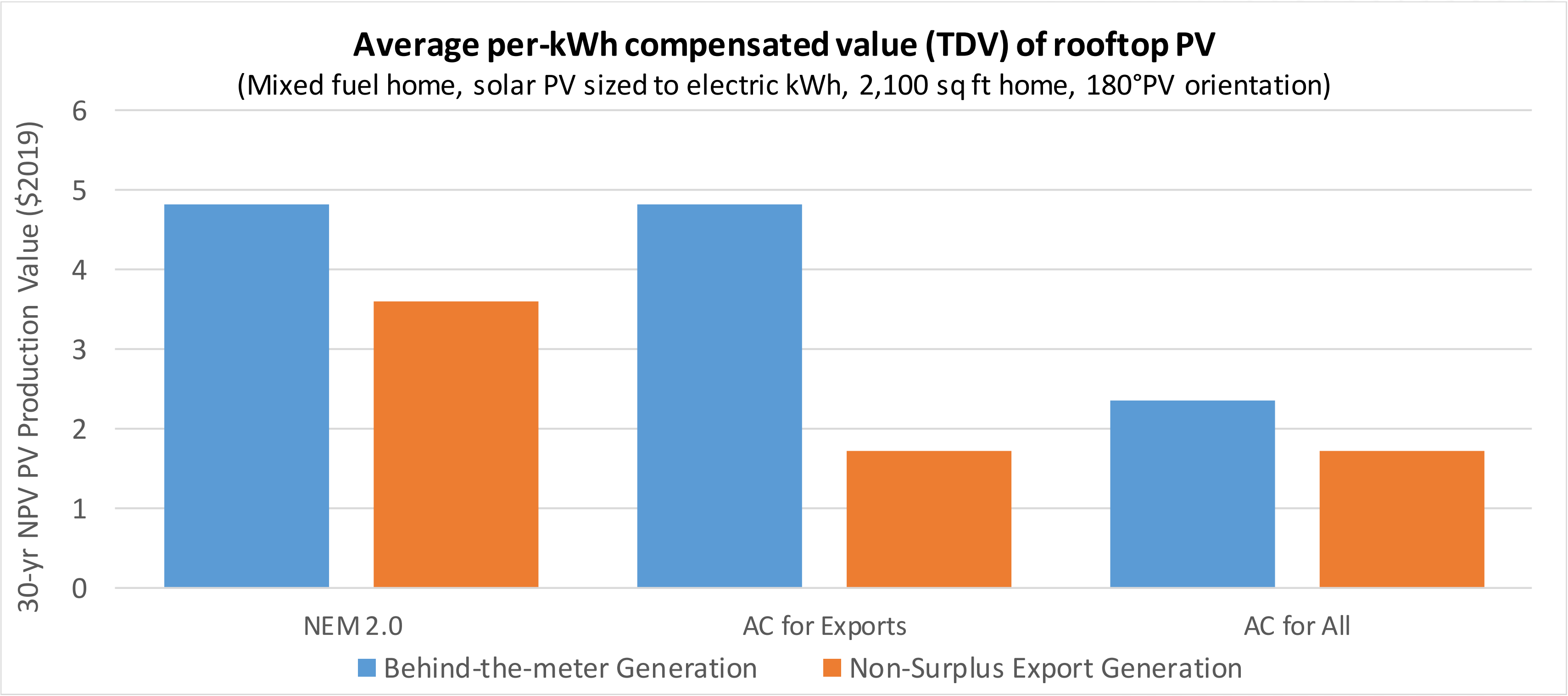


PV Costs

- PV costs have been changed from levelized PPA prices to upfront purchase by customer as a part of the home
- 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
- Because of the step-down and looming 2023 expiration, the base case assumes 0% ITC (provides a longer term view for consistency)
- 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

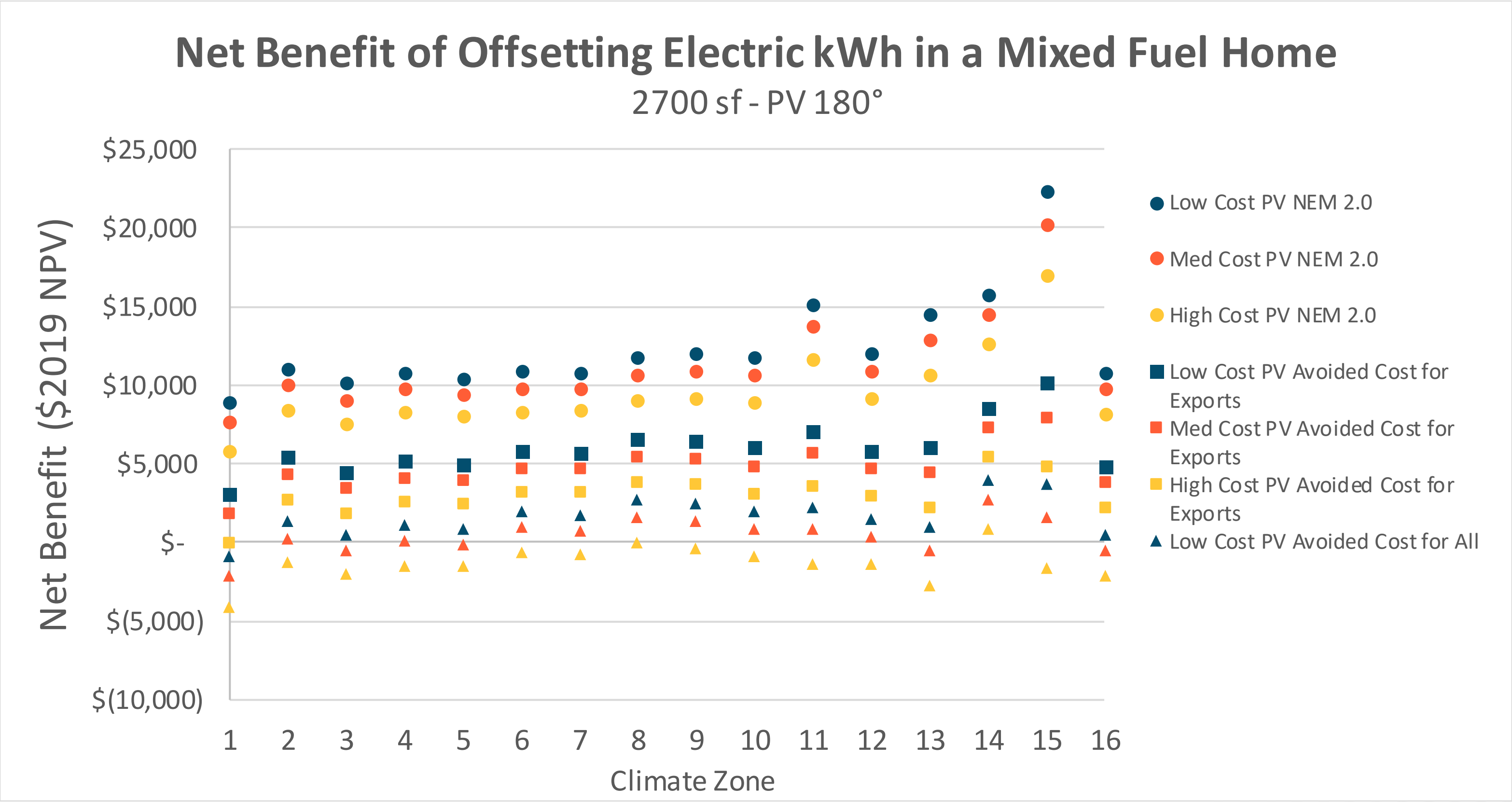


Three solar compensation policies



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