DOCKETED	
Docket Number:	22-BSTD-01
Project Title:	2025 Energy Code Pre-Rulemaking
TN #:	251405
Document Title:	Presentation - July 27, 2023 - 2025 Pre-Rulemaking Staff Workshop on Heat Pump Baselines and Photovoltaic System Requirements
Description:	Slides from July 27, 2023, staff pre-rulemaking workshop on proposed 2025 Energy Code heat pump baselines and photovoltaic system requirements.
Filer:	Javier Perez
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	7/31/2023 2:49:25 PM
Docketed Date:	7/31/2023

Good morning and thank you for joining us.

The workshop will begin shortly.

Housekeeping Rules

Public Comment Period

Zoom App/Online

- Click “raise hand”

Telephone

- Press *9 to raise hand
- Press *6 to Mute/Unmute

When called upon

- CEC will open your line
- Unmute on your end
- Spell name and state affiliation, if any
- 2 minutes or less per speaker, 1 speaker per entity

Today’s Agenda

	Topic(s)	Presenter
1	Introduction: a. Authority, Metrics, and Timeline	Javier Perez
2	Heat Pump Baselines: a. Single-Family i. Newly Constructed Buildings [Part 6] ii. Alterations [Part 11] b. Multifamily i. Newly Constructed Buildings [Part 6] c. Nonresidential i. Newly Constructed Buildings [Part 6] ii. Alterations [Part 6 & Part 11]	Bach Tsan Danny Tam Bach Tsan
3	Solar Photovoltaics (PV) & Battery Storage a. JA12, 10-109(k), 10-115 b. Single-Family c. Multifamily/Nonresidential	Muhammad Saeed
4	Questions & Answers	
5	Adjourn	

2025 Energy Code – Pre-Rulemaking

Energy Code Authority, Drivers and Themes, Metrics, and Timeline

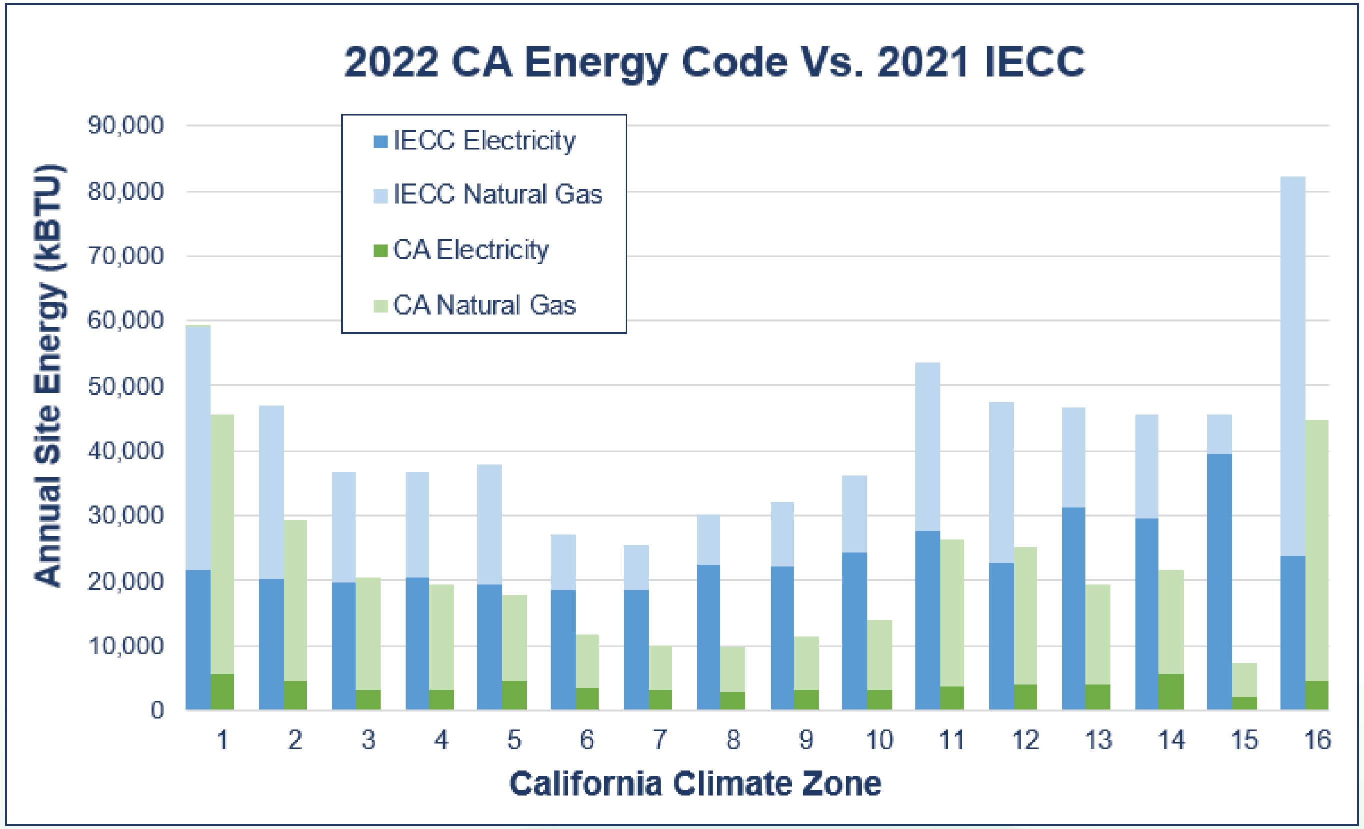
Javier Perez, Energy Commission Specialist III, Building Standards Branch

July 27, 2023

California Energy Commission's Authority and Process

California's Warren Alquist Act Signed into law in 1974

- Reduction of wasteful, uneconomic, inefficient, or unnecessary consumption of energy as it relates to buildings
- Residential Chart Details:
  - Blue bars: Site energy of a single-family building built to 2021 International Energy Conservation Code (IECC)
  - Green bars: Site energy of a single-family building built to 2022 California Energy Code
- For more on how the 2022 Energy Code compares to federal standards, see our 2022 Impact Analysis at: https://www.energy.ca.gov/publications/2023/impact-analysis-2022-update-california-energy-code



2025 Energy Code Drivers and Themes

State Goals

- Increase building energy efficiency cost-effectively
- Contribute to the state's GHG reduction goals

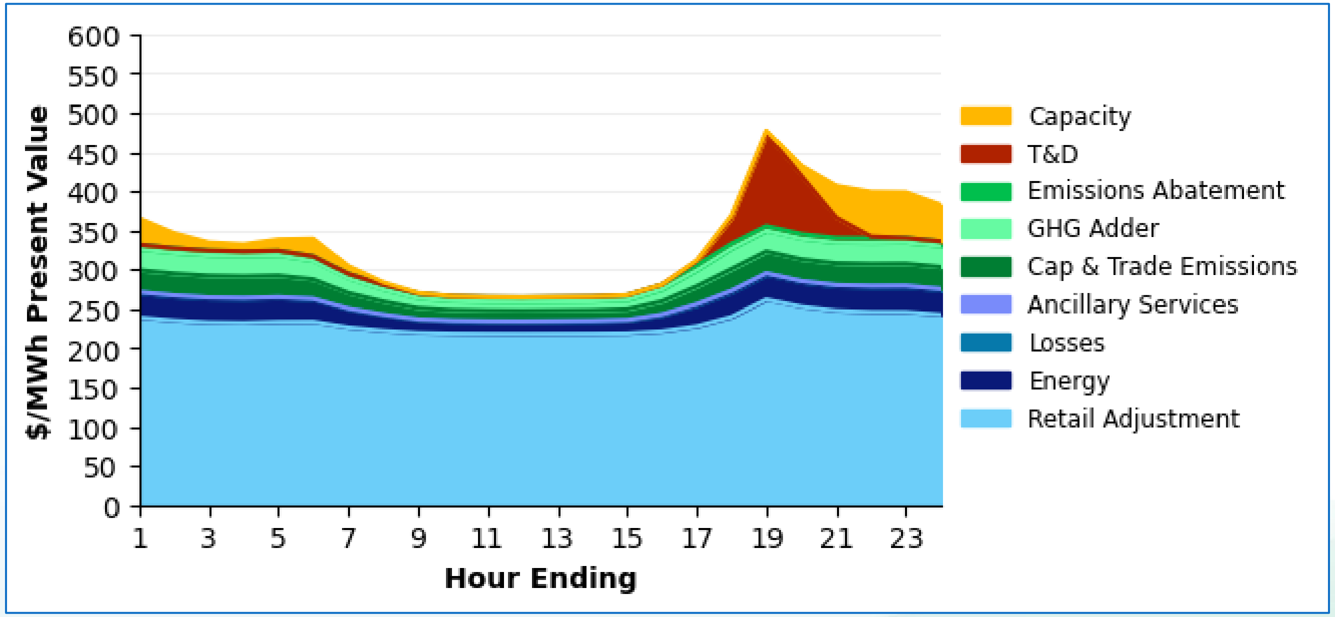
2025 Energy Code Strategies

- Heat pump baselines
- Promote demand flexibility, Solar PV generation and energy storage
- Covered process loads
- Equity & affordable new housing program integration
- Additions, alterations, and smaller homes (e.g., ADUs)
- Electric vehicle readiness support
- Interagency coordination

Long-Term System Cost

Long-term System Cost (LSC) Hourly factors are used to convert predicted site energy use to long-term dollar costs to CA's energy system.

Since the *time* that energy is used is as important as the *amount* of energy used, these factors are generated on an hourly basis for a representative year and created for each of CA's diverse climate zones.



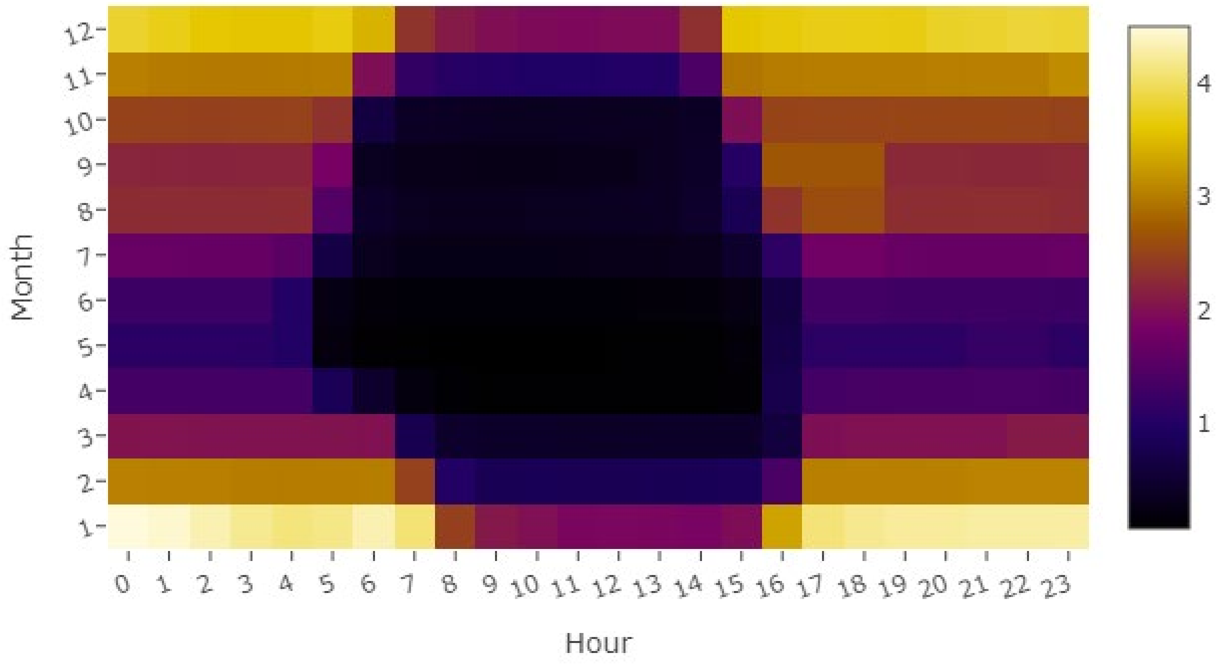
Sample LSC shape by component, average day, levelized 30-year residential, climate zone 12

Source Energy Metric

Long run marginal source energy is defined as the source energy of fossil fuels following the long-term effects of any associated changes in resource procurement.

Source Energy focuses specifically on the amount of fossil fuels that are combusted in association with demand-side energy consumption and assists in aligning our standards with the CA’s environmental goals.

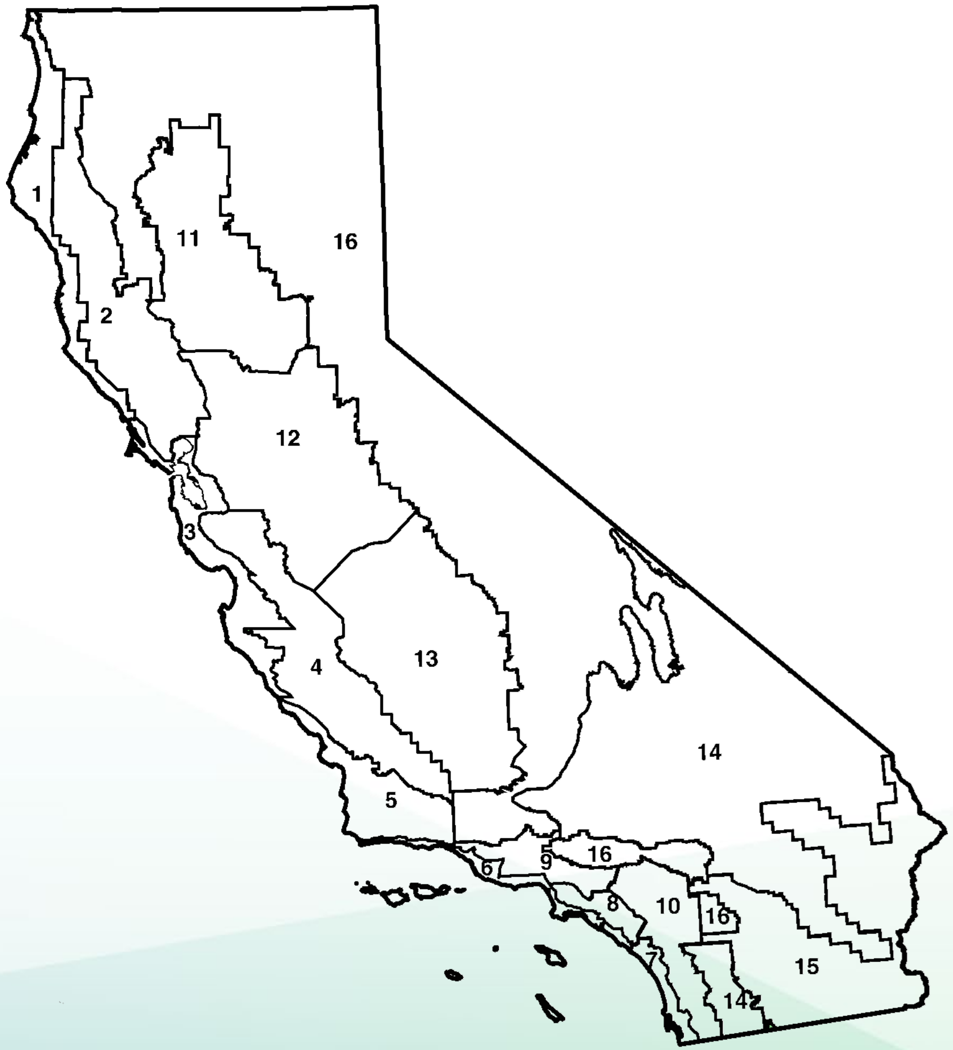
5-Month Average of electricity long run marginal source energy for 2025 Energy Code



California Climate Zones

California has 16 climate zones

- Climate Zones allow software to more accurately simulate variances weather, and as a result, energy consumption of buildings
- A measure's cost effectiveness can vary as a result of weather differences
- Energy Code requirements vary by climate zone as a result



2025 Energy Code Work To Date

Milestones	Timelines
Codes & Standards Enhancement (CASE) Team Requested & Received 2025 Measure Proposal Ideas	June 2021 – May 2022
CEC Updated Weather Data, LSC, and Source Energy Metrics	March - November 2022
CASE Team Held Welcome Webinars on 2025 Measures & Work To Come	October 2022
CASE Team Held Stakeholder Workshops on 2025 Proposals	January – May 2023
Energy Commission Worked Feverishly on 2025 Heat Pump and PV System Measures	November 2022 - Now
CASE Team Published Draft Measure Proposal Reports* + Comment Period	May – July 2023

*To view CASE team draft measure proposal reports, and upcoming final reports, visit https://title24stakeholders.com/2025-cycle-case-reports/

2025 Energy Code Work To Come

Milestones	Timelines
CASE Team Publishes Final Measure Proposal Reports	July – August 2023
CEC 2025 Prerulemaking Workshops*	July – August 2023
CEC Publishes 2025 Energy Code Draft Updates (Draft Express Terms)	October 2023
CEC Rulemaking for 2025 Energy Code	January 2023 – June 2024
2025 Energy Code Business Meeting Adoption	June 2024
Building Standards Commission Approval of 2025 Energy Code	December 2024
2025 Energy Code Effective Date	January 2026

*For details on the 2022 Intervening Code Cycle efforts of the Building Standards Commission, and their workshops scheduled for August 1st – 3rd, visit https://www.dgs.ca.gov/BSC/Rulemaking/2022-Intervening-Cycle/Commission-Mtgs-List-v2/2023-08-01-CommMtg

2025 Energy Code Senior Staff Contacts

- **Javier Perez** – Project Manager
- **Payam Bozorgchami** – Technical Lead, Envelope, Additions and Alterations, ADUs
- **Haile Bucaneg** – Covered Process, Demand Response, Nonresidential and Residential ACM
- **Muhammad Saeed** – Solar Photovoltaic and Energy Storage Systems
- **Bach Tsan** – HVAC Systems, Refrigeration
- **Email Convention at the Energy Commission:** firstname.lastname@energy.ca.gov

2025 Energy Code – Pre-Rulemaking

Heat Pump Baselines for Newly Constructed Single-Family Homes

Bach Tsan P.E., Senior Mechanical Engineer, Building Standards Branch

July 27, 2023

Agenda

- Baselines Overview
- Heat Pump Market
- 2022 Prescriptive Baseline
- 2025 Proposal
- Energy Savings Methodology
- Energy Savings
- Cost Analysis
- Performance Approach Options

Heat Pump Baselines

Heat pump space heaters (HPSH) and heat pump water heaters (HPWH) are used for setting Energy Code performance approach minimums (a.k.a. baselines)

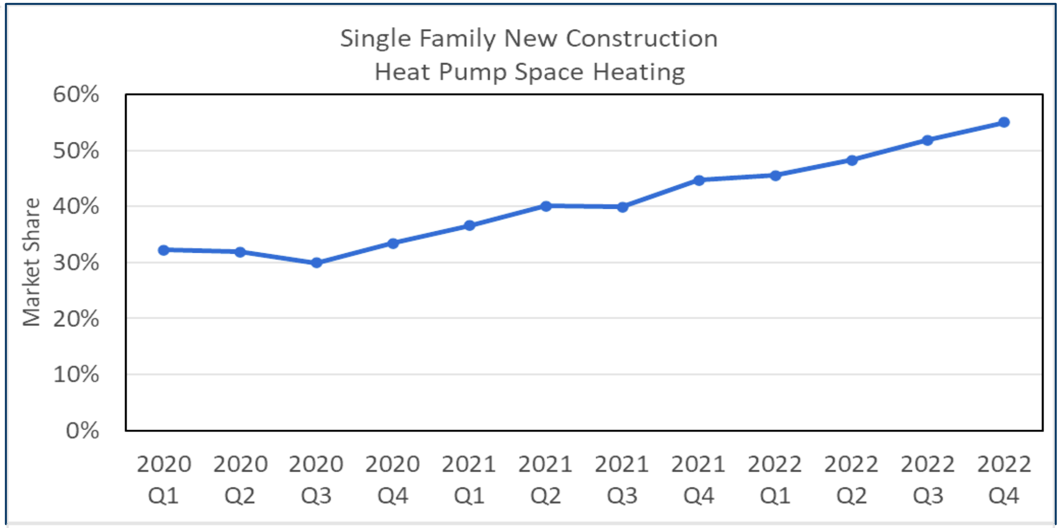
- Similar vapor compression system in cooling with a reversing valve to reverse process to provide heating and cooling in a single package
- Key technology to achieve energy efficiency, building decarbonization, and leverage increasingly clean electricity
- Heat pumps are efficient devices with COPs in excess of 3, thus decrease both energy consumption and GHGs
- Feasible and cost effective

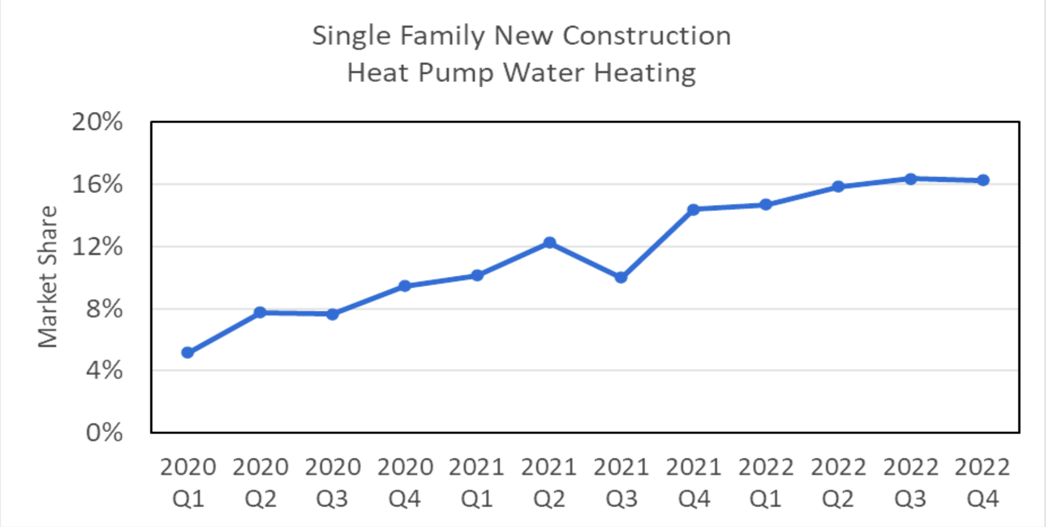
Single-Family Heat Pump Market

2023 Heat Pump Forums (CBIA/Consol/SCE) presented strong public support for heat pumps

CHEERS & CalCERTS registries show increasing market trends

Manufacturers improving supply chain and anticipating growth





Source: Consol presentation at 2023 HP Forums

2022 Prescriptive HVAC & DHW

Climate Zone	HVAC System	Domestic Hot Water System
1	Gas furnace, split AC	HPWH
2	Gas furnace, split AC	HPWH
3	HPSH	Gas tankless
4	HPSH	Gas tankless
5	Gas furnace, split AC	HPWH
6	Gas furnace, split AC	HPWH
7	Gas furnace, split AC	HPWH
8	Gas furnace, split AC	HPWH
9	Gas furnace, split AC	HPWH
10	Gas furnace, split AC	HPWH
11	Gas furnace, split AC	HPWH
12	Gas furnace, split AC	HPWH
13	HPSH	Gas tankless
14	HPSH	Gas tankless
15	Gas furnace, split AC	HPWH
16	Gas furnace, split AC	HPWH

Establishing Heat Pump Baselines

Considerations taken to establish baseline:

- Show Long-term System Cost (LSC) savings when compared to the 2022 Energy Code
- Show source energy savings when compared to the 2022 Energy Code
- Demonstrate measure is cost effective, specific to each building type and CA climate zone
- Ensure technically feasible options exist (mixed fuel and all-electric) to allow for compliance flexibility

Proposed 2025 Prescriptive HVAC & DHW

- Red indicates change from 2022 prescriptive requirements
- HPSH and HPWH in all climate zones except for climate zone 15
- Current analysis shows HPSH cost-effectiveness challenges in climate zone 15

Climate Zone	HVAC System	Domestic Hot Water System
1	HPSH	HPWH
2	HPSH	HPWH
3	HPSH	HPWH
4	HPSH	HPWH
5	HPSH	HPWH
6	HPSH	HPWH
7	HPSH	HPWH
8	HPSH	HPWH
9	HPSH	HPWH
10	HPSH	HPWH
11	HPSH	HPWH
12	HPSH	HPWH
13	HPSH	HPWH
14	HPSH	HPWH
15	**TBD**	HPWH
16	HPSH	HPWH

Assumptions for Estimating Savings

Building energy model prototypes use 2022 Energy Code prescriptive requirements as baseline

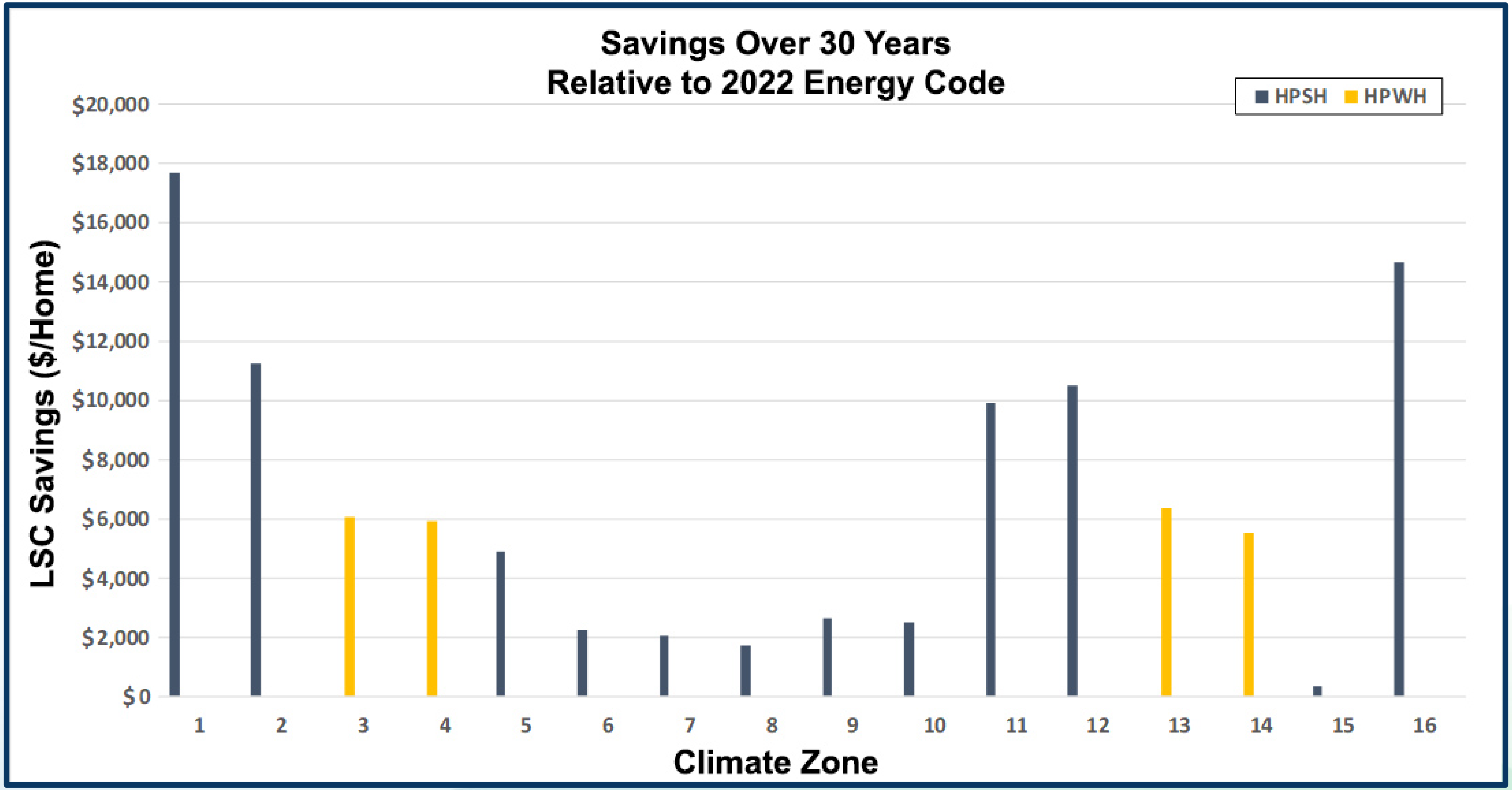
Minimum Efficiencies for Appliances

- Heat Pump Space Heater (SEER2 14.3)
- Heat Pump Water Heater (UEF 2.0)
- AC/Furnace Combination (SEER2 14.3/11.7 EER)
- Instantaneous Gas Water Heater (UEF 0.81)

Energy Savings

Climate Zone	First Year Electricity Savings (kWh)	First Year Natural Gas Savings (therms)	Source Energy Savings (kBtu/yr)	LSC Savings ($ Over 30 Years)
1	(3,207)	342	21,754	$17,537
2	(2,058)	222	13,560	$11,253
3	(1,368)	128	9,230	$8,085
4	(1,316)	123	8,781	$7,899
5	(933)	99	5,753	$4,769
6	(267)	36	2,143	$2,253
7	(218)	29	1,783	$2,085
8	(277)	33	1,773	$1,725
9	(439)	51	2,739	$2,667
10	(460)	52	2,781	$2,520
11	(1,696)	189	11,139	$10,056
12	(1,738)	195	11,767	$10,505
13	(1,040)	111	8,098	$7,968
14	(1,232)	115	7,923	$7,608
15	(129)	13	514	$377
16	(3,228)	323	19,694	$14,722

Long-term System Cost Savings



HPSH Costs – Cooling Dominated Climates

- Cooling dominated climate zones cost compared between mixed fuel system and heat pump space heating systems
- Equipment sizing based on cooling load
- Costs are all present value

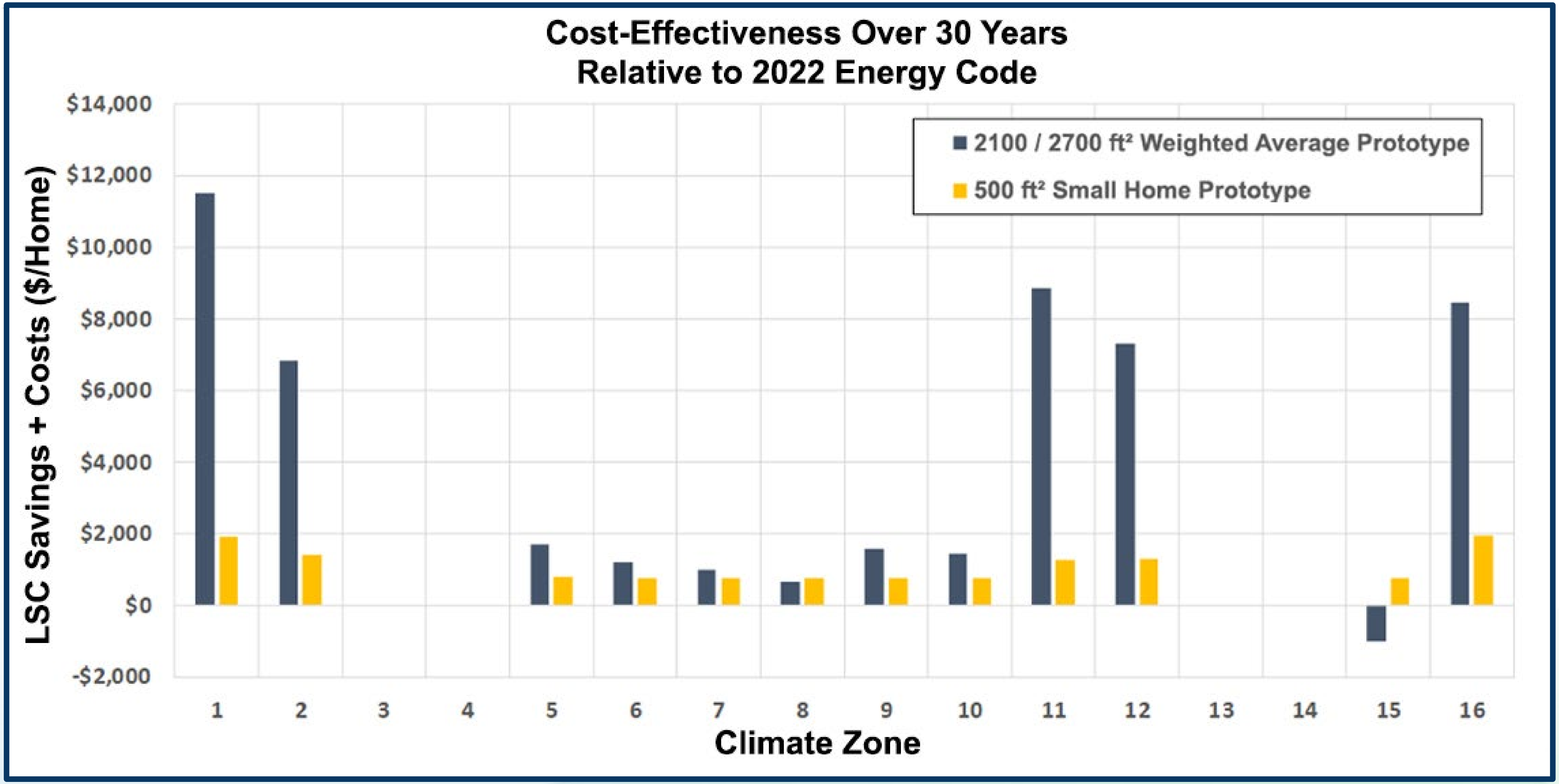
Cooling Dominated Climate: Examples		All CZ 500 ft²			CZ 8/9/10	CZ 6/7/11	CZ15
Gas/AC System	Capacity (Tons)	1.5	2	2.5	3	3.5	4.5
	First Cost	$9,383	$10,182	$11,049	$11,692	$12,990	$15,207
	Replacement Cost(Future Value)	$8,803	$9,602	$10,469	$11,112	$12,410	$14,627
	Replacement Cost(Present Value)	$4,212	$4,594	$5,009	$5,316	$5,938	$6,998
HP (No Strip Heat)	Capacity (Tons)	1.5	2	2.5	3	3.5	4.5
	First Cost	$7,263	$8,437	$9,604	$10,648	$11,915	$14,196
	Replacement Cost(Future Value)	$7,263	$8,437	$9,604	$10,648	$11,915	$14,196
	Replacement Cost(Present Value)	$4,662	$5,416	$6,165	$6,835	$7,648	$9,112
Incremental Costs	First Cost	-$2,120	-$1,744	-$1,445	-$1,044	-$1,075	-$1,011
	Replacement Cost(Present Value)	$450	$822	$1,156	$1,518	$1,710	$2,114
	Lifetime Cost (Present Value)	**-$1,670**	**-$923**	**-$289**	**$474**	**$635**	**$1,102**

HPSH Costs – Heating Dominated Climates

- Heating dominated climate capacity increases sized by CBECC-Res.
- Equipment sizing based on heating load
- Assumes same nominal system cost at time of replacement, less gas and electrical infrastructure.
- Except $600 increase for ultra low NOx furnace.
- Costs are all present value

Heating Dominated Climate:		CZ1	CZ16	CZ12	CZ5	CZ2
Gas/AC System	Capacity (Tons)	1.5	2.5	3	3.5	3.5
	First Cost	$9,383	$11,049	$11,692	$12,990	$12,990
	Replacement Cost(Future Value)	$8,803	$10,469	$11,112	$12,410	$12,410
	Replacement Cost(Present Value)	$4,212	$5,009	$5,316	$5,938	$5,938
HP (+Strip Heat)	Capacity (Tons)	4	4.5	3.5	4	4.5
	First Cost	$12,914	$14,808	$12,513	$12,914	$14,808
	Replacement Cost(Future Value)	$12,309	$14,196	$11,915	$12,309	$14,196
	Replacement Cost(Present Value)	$7,901	$9,112	$7,648	$7,901	$9,112
Incremental Costs	First Cost	$3,531	$3,759	$821	-$76	$1,818
	Replacement Cost(Present Value)	$3,689	$4,103	$2,332	$1,963	$3,174
	Lifetime Cost (Future Value)	**$7,219**	**$7,862**	**$3,152**	**$1,887**	**$4,992**

Heat Pump Space Heater Cost Effectiveness



HPWH Vs. Gas Tankless Costs

- Costs from reach code report 2022 Cost-Effectiveness Study: Single Family New Construction.[1]
- First cost adjusted based on recent contractor feedback
- HPWH replaced at year 15, gas tankless at year 20.
- For 2,100 / 2,700 ft² weighted prototype HPWH located in garage
- For 500 ft² small home prototype HPWH located inside conditioned space w/ supply air ducted to outside
- Costs are all present value

[1]https://localenergycodes.com/download/1240/file_path/fieldList/2022%20Single%20Family%20NewCon%20Cost-eff%20Study.pdf

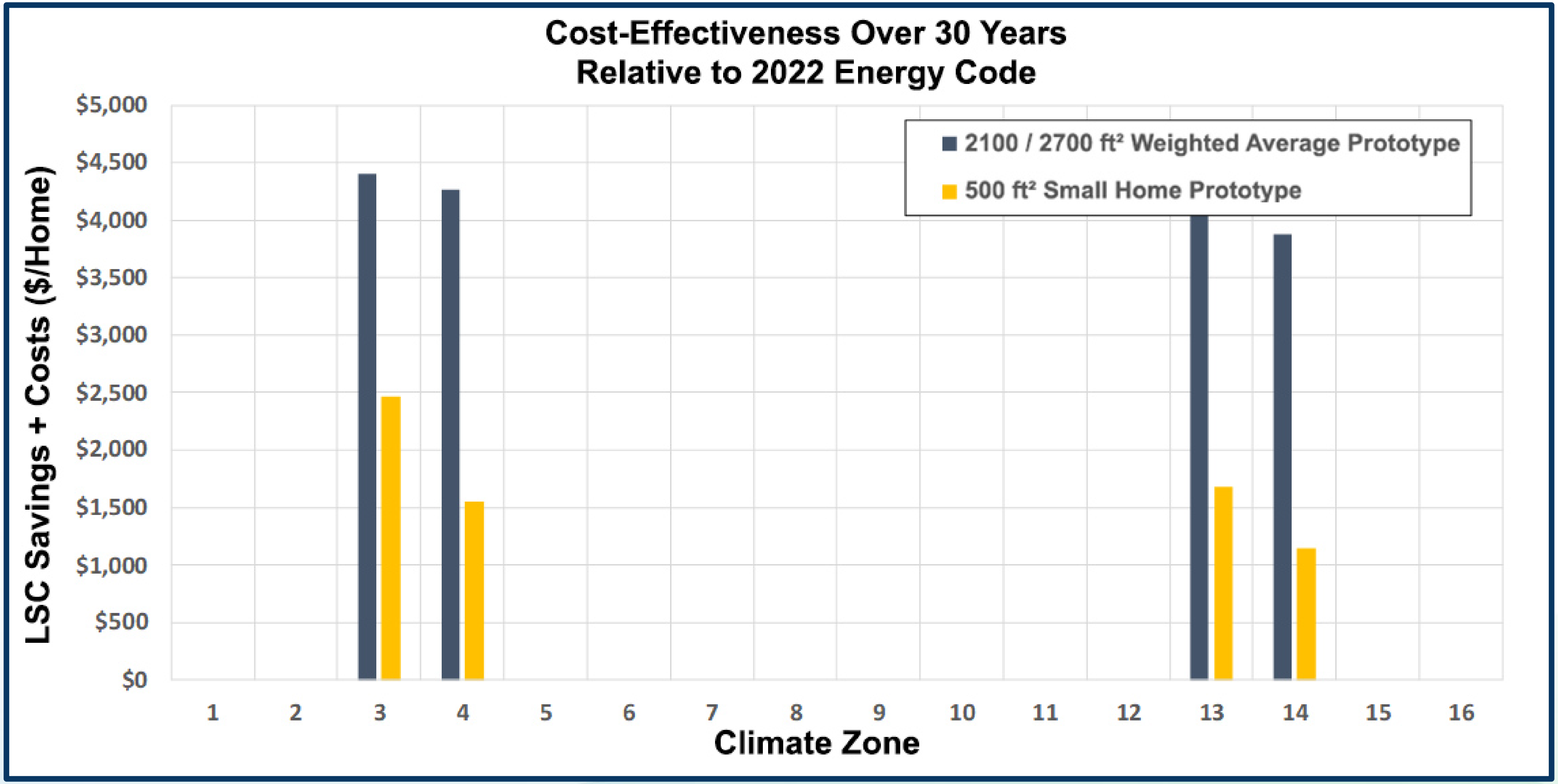
2,100/2.700 ft² Prototype

	First Cost	Replacement Cost	Incremental Lifetime Cost
Equipment & Installation	$800	$1,396	$2,196
Electric Service Upgrade	$43	$0	$43
In-House Gas Piping	($580)	$0	($580)
Totals	$263	$1,396	**$1,659**

500 ft² Prototype

	First Cost	Replacement Cost	Incremental Lifetime Cost
Equipment & Installation	$1,452	$1,396	$2,848
Electric Service Upgrade	$43	$0	$43
In-House Gas Piping	($580)	$0	($580)
Totals	$915	$1,396	**$2,311**

Heat Pump Water Heater Cost Effectiveness



Performance Approach Options

CZ	Mixed Fuel (0 Heat Pumps)	Mixed Fuel (1 Heat Pump)	Dual Fuel Heat Pump
1	Solar Fraction DHW[1] + Triple Pane[2] + 2.5ACH50 + VLLDCS[3] + CDHW[4] + R60 Attic + HRV[5]	High Eff.[6]+Triple Pane+ 5kWh Battery	Solar Fraction DHW
2	Solar Fraction DHW+Triple Pane+VLLDCS+HRV	High Eff. +Triple Pane	Solar Fraction DHW
3	Solar Fraction DHW+Triple Pane+VLLDCS+HRV	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW
4	Solar Fraction DHW+Triple Pane+VLLDCS	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW+Triple Pane
5	Solar Fraction DHW+VLLDSC	High Efficiency	Solar Fraction DHW
6	Solar Fraction DHW+Triple Pane	High Efficiency	Solar Fraction DHW
7	Solar Fraction DHW+Triple Pane+VLLDCS	High Efficiency	Solar Fraction DHW
8	Solar Fraction DHW+Triple Pane	High Efficiency	Solar Fraction DHW
9	Solar Fraction DHW+Triple Pane+VLLDCS	High Eff. +Triple Pane	Solar Fraction DHW
10	Solar Fraction DHW+Triple Pane+VLLDCS	High Efficiency	Solar Fraction DHW
11	Solar Fraction DHW+Triple Pane+VLLDCS	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW+Triple Pane
12	Solar Fraction DHW+Triple Pane+VLLDCS+HRV	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW
13	Solar Fraction DHW+Triple Pane+2.5ACH50+VLLDCS	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW+Triple Pane
14	Solar Fraction DHW+Triple Pane+VLLDCS	High Efficiency + 5kWh Battery	Solar Fraction DHW+Triple Pane
15	Solar Fraction DHW+VLLDCS	High Efficiency	Solar Fraction DHW+Triple Pane+VLLDCS
16	Solar Fraction DHW + Triple Pane + 2.5ACH50 + VLLDCS + CDHW + R60 Attic + HRV	High Eff. +Triple Pane+ 5kWh Battery	Solar Fraction DHW+Triple Pane+VLDCS+R60 Attic+HRV

Notes

[1] 0.7 Solar Fraction Domestic Hot Water (DHW) Heater
[2] 0.2 U-Factor Windows
[3] VLLDCS = Verified Low Leakage Ducts in Cond. Space
[4] CDHW – Compact Domestic Hot Water Distribution
[5] 67/67 SRE ASRE except CZ 1 73/80

[6] High Efficiency = 95 AFUE, 16 SEER2, 8 HSPF2, 0.95 UEF (0.96 UEF in CZ3), and Self Utilization Credit

Comments

Comments on today's workshop due

August 9, 2023, by 5:00 PM

Submit comments to CEC Docket 22-BSTD-01

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

Contact: Bach.Tsan@energy.ca.gov

Thank You!

2025 Energy Code – Pre-Rulemaking

Heat Pump Baselines for Single-Family Alterations – Part 11

Bach Tsan P.E., Senior Mechanical Engineer, Building Standards Branch

July 27, 2023

CALGreen

California Green Building Standards Code (Title 24, Part 11), known as CALGreen

- AB 32 2007 greenhouse gas reduction goals
- Buildings – 2nd largest greenhouse gas emitters
- First in the nation green building code
- Mandatory code with voluntary provisions
- Reviewed and updated every 3 years

Nonresidential

Residential

Hospitals & Institutions

Schools

Energy

Mandatory Vs. Voluntary

Energy Code (Title 24, Part 6)

- Energy efficiency requirements

CALGreen (Title 24, Part 11)

- Voluntary energy efficiency standards
- Choose from a menu of prerequisite options, and
- Meet performance target for climate zone (CZ)

2025 Proposed Voluntary Standards

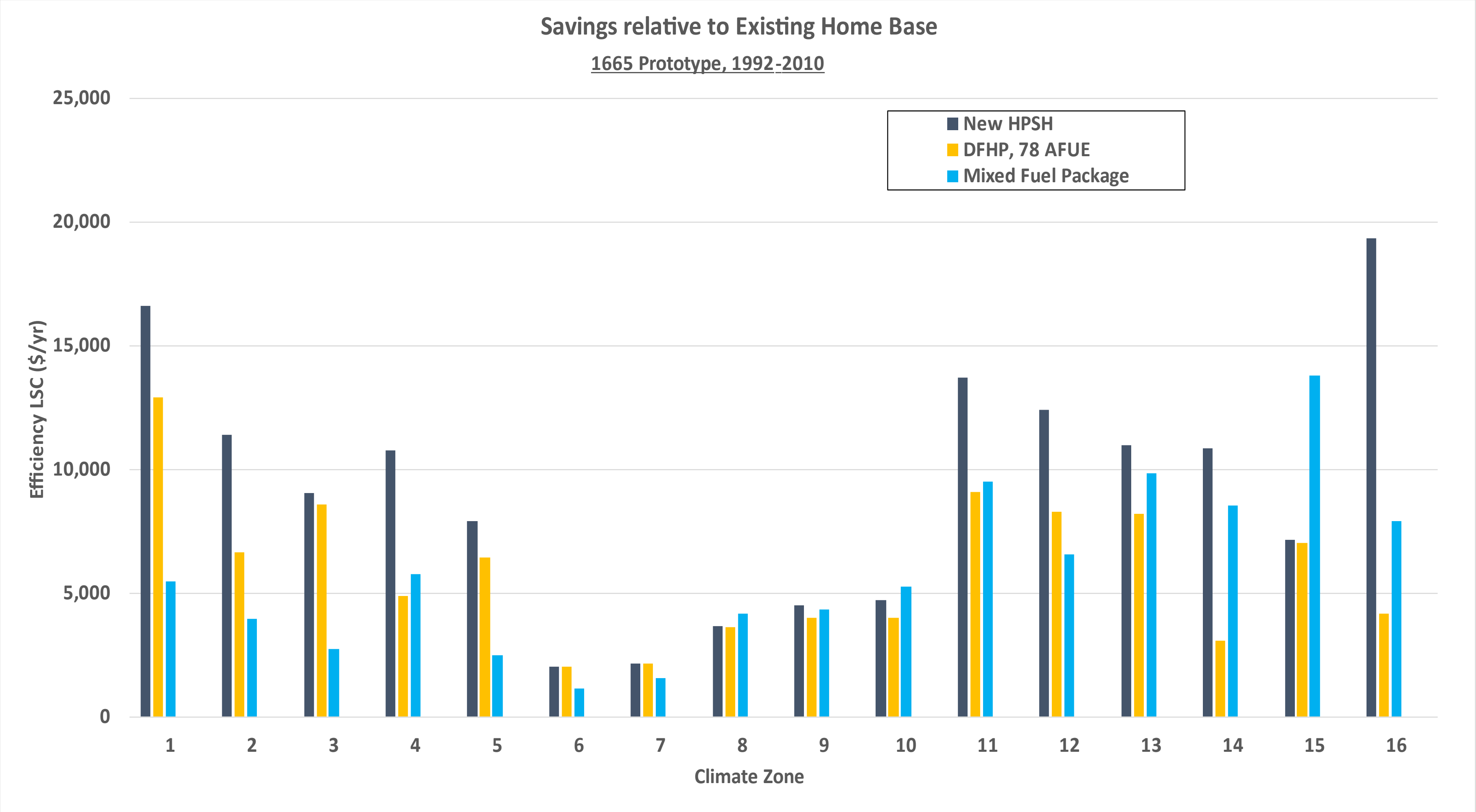
When an air conditioner is altered by replacement, the altered system shall meet one of the following:

1. A heat pump
2. A heat pump with gas backup – existing gas furnace may remain in place to provide backup heat
3. An air conditioner that meets specific requirements described in the mixed fuel package (next slide)

Voluntary Performance Approach Options

New AC/furnace/AC package measures for mixed fuel

- New R-8 ducts, 5% leakage
- 400 cfm/ton airflow
- 0.35 W/cfm fan efficacy
- Refrigerant charge
- R-49 attic insulation
- Air sealing of the ceiling



Voluntary Energy Savings

Climate Zone	First Year Electricity Savings (kWh)	First Year Natural Gas Savings (therms)	Source Energy Savings (kBtu/yr)	LSC Savings ($ over 30 Years)
1	(2,848)	305	11.7	$15,651
2	(2,138)	222	8.1	$10,606
3	(1,405)	163	6.1	$8,625
4	(1,951)	201	7.1	$9,407
5	(1,443)	151	5.5	$7,459
6	(215)	29	1.0	$1,765
7	(167)	23	0.9	$1,665
8	(315)	37	1.2	$2,031
9	(488)	56	1.9	$2,930
10	(490)	54	1.8	$2,664
11	(1,813)	200	7.1	$10,373
12	(1,877)	204	7.4	$10,556
13	(1,266)	140	5.0	$7,110
14	(2,103)	200	6.4	$7,992
15	(102)	13	0.3	$466
16	(3,994)	396	14.6	$17,549

Voluntary HPSH Vs. Gas/AC Costs

- Costs from 2021 reach code report 2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades[1]
- System lifetimes based on DEER
- HPSH replaced at year 15, furnace / AC at year 17.5
- [1] https://localenergycodes.com/download/875/file_path/fieldList/2019%20V2-Residential%20Retrofit%20Cost-eff%20Report-2021-08-27.pdf

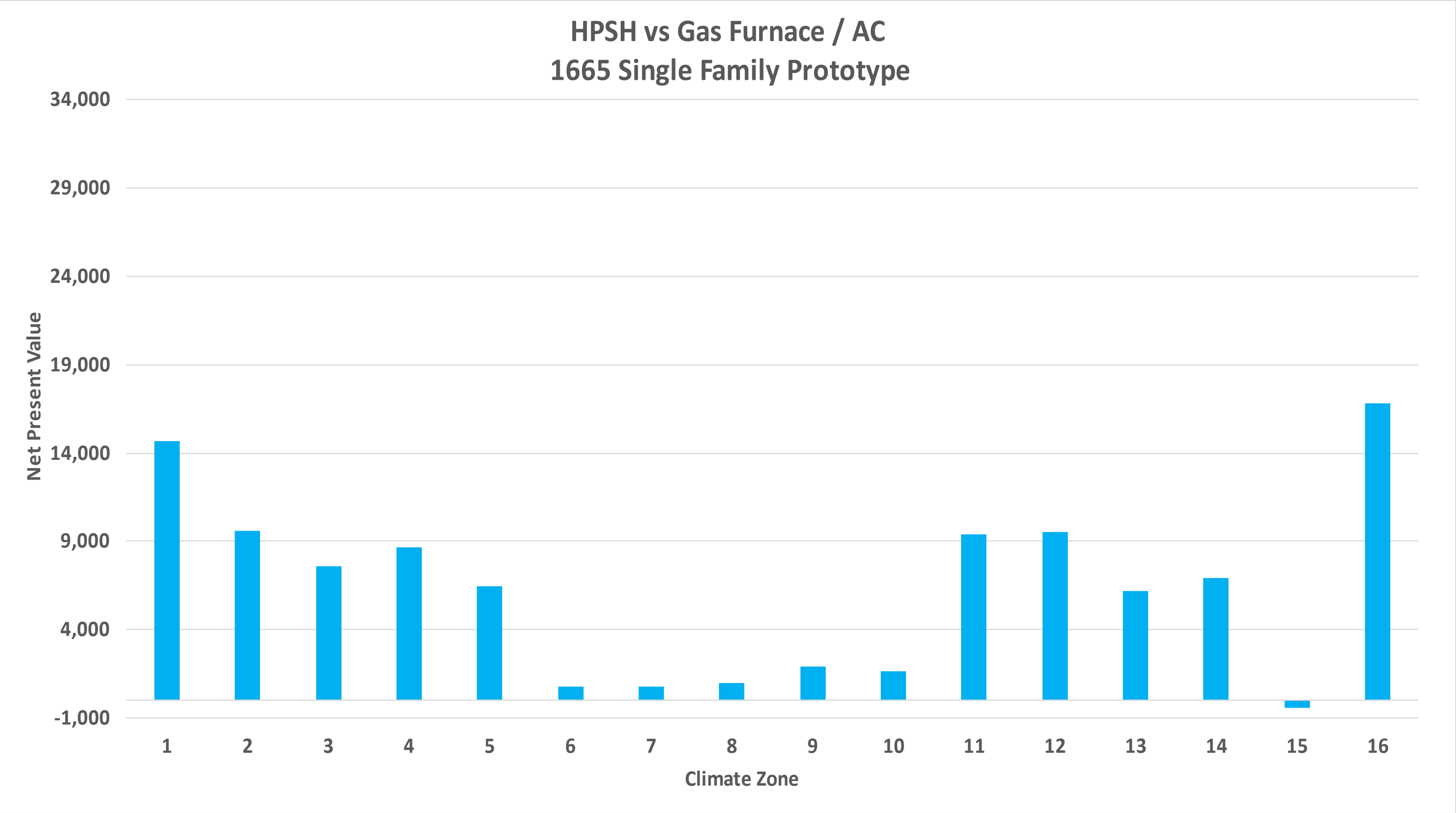
1,665 ft^2 Existing Home Prototype

	First Cost	Replacement Cost	Lifetime Cost
Gas/AC System	$9,243	$13,373	$22,908
HPSH	$9,101	$14,630	$23,731
Incremental Cost	($142)	$1,257	**$1,115**

Heat Pump Space Heater Cost Effectiveness

- Cost effective in climate zones 1-14 and 16
- Climate zone 15 has a negative benefit to cost ratio due to lower heating needs

Climate Zone	Benefit to Cost Ratio
CZ01	15.4
CZ02	10.4
CZ03	8.5
CZ04	9.5
CZ05	7.3
CZ06	1.8
CZ07	1.8
CZ08	2.0
CZ09	2.9
CZ10	2.6
CZ11	10.3
CZ12	10.4
CZ13	7.1
CZ14	7.8
CZ15	-0.6
CZ16	17.5



Comments

Comments on today's workshop due

August 9, 2023, by 5:00 PM

Submit comments to CEC Docket 22-BSTD-01

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

Contact: Bach.Tsan@energy.ca.gov

Thank You!

2025 Energy Code – Pre-Rulemaking

Heat Pump Water Heater Baseline For Multifamily Buildings

Danny Tam, Mechanical Engineer, Building Standards Branch

July 27, 2023

Existing 2022 Code Requirements

- **Section: 170.2(d)– Water-heating systems**

- **Different requirements for system serving individual dwelling unit and central system**
- **Different requirements for gas and electric systems.**
  - For system serving single dwelling, if electric, the system shall be a heat pump water heater (HPWH)
  - If gas, the system shall be an instantaneous water heater
- **Performance baseline follows the prescriptive requirements in Section 170.2(d)**

2025 Proposed Requirements

- **Criteria to address in establishing heat pump baselines**
  - Show LSC savings when compared to buildings built to 2022 Standards
  - Show source energy savings when compared to buildings built to 2022 Standards
  - Prove measures to be cost effective
  - Ensuring options exist to allow for buildings flexibility with mixed fuel systems

2025 Proposed Requirements

Section: 170.2(d)1– Water-heating systems

- **Applicable to systems serving individual units only**
  - No changes to central systems
- **HPWH prescriptive baseline**
  - Remove gas instantaneous prescriptive option
  - Other system types can comply using performance

2025 Proposed Requirements

- **Update the single dwelling system water heating baseline for performance compliance**
  - Set the LSC target for water heating as HPWH
  - Maintain the source energy target the same as 2022 Standard Design (HP space heating only)

Key Assumptions

- The HPWH is a federal minimum efficiency generic heat pump water heater (UEF 2.0)
- The instantaneous gas water heater is a federal minimum efficiency instantaneous gas (UEF 0.81)
- The HPWH is located in an interior closet, ducted to corridor louvers

Software Used & Prototypes

- **All analysis performed using the research version of 2025 CBECC**
  - Contains the 2025 Long-Term Systemwide Cost (LSC), hourly source energy factors, and 2025 weather data

- **Prototype Used**

Prototype ID	Number of Stories	Floor Area (square feet)	Description
LowRiseGarden	2	7,680	2-story, 8-unit apartment building. Average dwelling unit size: 960 ft^2.
LoadedCorridor	3	40,000	3-story, 36-unit apartment building. Average dwelling unit size: 960 ft^2.
MidRiseMixedUse	5	113,100	4-story (4-story residential, 1-story commercial), 88-unit building.
HighRiseMixedUse	10	125,400	10-story (9-story residential, 1-story commercial), 117-unit building. Avg dwelling unit size: 850 ft^2.

Energy Impact – Low-Rise Garden Prototype

Climate Zone	First Year Electricity Savings (kWh/Dwelling Unit)	First Year Natural Gas Savings (therms/Dwelling Unit)	Source Energy Savings (kBtu/Dwelling Unit)	LSC Energy Savings (2026 PV$/Dwelling Unit)
1	(1335.89)	103.04	7,465.44	3453.37
2	(1097.50)	95.50	7,049.40	4063.73
3	(1040.82)	94.24	7,068.35	4267.06
4	(1004.93)	91.11	6,771.68	4407.38
5	(1067.32)	94.75	7,071.66	4324.62
6	(779.61)	85.91	6,728.27	5332.44
7	(741.83)	84.85	6,653.09	5668.76
8	(665.50)	82.75	6,488.90	5648.98
9	(694.05)	83.48	6,523.46	5579.04
10	(664.89)	82.20	6,421.46	5545.47
11	(799.65)	84.78	6,389.53	4951.56
12	(897.43)	89.51	6,748.72	4963.84
13	(734.07)	82.73	6,327.79	5167.82
14	(850.55)	85.59	6,296.46	4708.99
15	(381.68)	67.11	5,498.38	5675.35
16	(854.29)	73.07	5,428.66	3051.04

Energy Impact – Low-Rise Loaded Corridor Prototype

Climate Zone	First Year Electricity Savings (kWh/Dwelling Unit)	First Year Natural Gas Savings (therms/Dwelling Unit)	Source Energy Savings (kBtu/Dwelling Unit)	LSC Energy Savings (2026 PV$/Dwelling Unit)
1	(1549.91)	103.38	6,975.71	1980.91
2	(1359.36)	95.79	6,532.64	2290.39
3	(1346.55)	94.53	6,484.00	2253.08
4	(1238.18)	91.38	6,290.09	2756.85
5	(1335.28)	95.04	6,556.62	2455.58
6	(1101.56)	86.15	6,070.68	3042.64
7	(1086.29)	85.09	5,955.41	3133.18
8	(988.46)	82.98	5,889.79	3368.45
9	(1046.76)	83.71	5,866.74	3088.45
10	(1027.82)	82.43	5,763.54	3031.87
11	(1147.59)	85.01	5,781.79	2512.35
12	(1174.68)	89.77	6,196.68	2927.22
13	(1089.37)	82.95	5,698.29	2675.61
14	(1188.44)	85.83	5,736.58	2418.34
15	(814.55)	67.26	4,693.79	2634.59
16	(1203.17)	82.66	5,541.47	1775.84

Energy Impact – Mid-Rise Mixed Use Prototype

Climate Zone	First Year Electricity Savings (kWh/Dwelling Unit)	First Year Natural Gas Savings (therms/Dwelling Unit)	Source Energy Savings (kBtu/Dwelling Unit)	LSC Energy Savings (2026 PV$/Dwelling Unit)
1	(1369.34)	100.94	6,820.06	2613.84
2	(1206.14)	94.17	6,299.54	2670.34
3	(1223.32)	92.93	6,213.82	2470.80
4	(1120.86)	89.84	5,951.89	2940.49
5	(1219.58)	93.43	6,253.92	2542.86
6	(974.95)	84.73	5,856.05	3489.23
7	(944.78)	83.69	5,775.40	3655.35
8	(904.66)	81.62	5,584.60	3565.61
9	(912.99)	82.33	5,637.74	3617.16
10	(893.98)	81.08	5,555.27	3600.86
11	(1005.94)	83.60	5,591.51	3105.18
12	(1048.08)	88.26	5,944.18	3230.44
13	(967.97)	81.58	5,488.18	3156.73
14	(1032.32)	84.39	5,528.02	3094.90
15	(673.66)	66.20	4,623.05	3322.17
16	(1142.61)	97.92	6,718.53	3781.94

Energy Impact – High-Rise Mixed Use Prototype

Climate Zone	First Year Electricity Savings (kWh/Dwelling Unit)	First Year Natural Gas Savings (therms/Dwelling Unit)	Source Energy Savings (kBtu/Dwelling Unit)	LSC Energy Savings (2026 PV$/Dwelling Unit)
1	(1421.59)	97.39	6,426.20	1867.58
2	(1334.74)	90.81	5,843.49	1527.48
3	(1300.10)	89.62	5,823.73	1608.38
4	(1236.97)	86.67	5,603.05	1855.32
5	(1325.12)	90.11	5,815.17	1439.18
6	(1095.58)	81.77	5,423.71	2203.58
7	(1077.91)	80.77	5,354.64	2399.53
8	(1034.76)	78.79	5,265.65	2397.51
9	(1063.28)	79.47	5,243.39	2276.56
10	(1029.48)	78.28	5,193.91	2357.20
11	(1144.74)	80.70	5,255.55	1865.74
12	(1233.23)	85.16	5,478.08	1696.86
13	(1095.18)	78.76	5,171.10	1994.47
14	(1183.84)	81.46	5,135.56	1746.14
15	(826.53)	64.03	4,249.14	2071.83
16	(1230.15)	94.71	6,336.96	2839.13

Flexible Compliance Paths – Low-Rise Garden Prototype

Climate Zone	HPSH + Instantaneous Gas DHW	Gas Furnace + Instantaneous Gas DHW
1	ECMs and Battery; or SWH	ECMs and Battery; or SWH
2	ECMs and Battery; or SWH	ECMs and Battery; or SWH
3	ECMs and Battery; or SWH	ECMs and Battery; or SWH
4	ECMs and Battery; or SWH	ECMs, Battery and PV, or SWH
5	ECMs and Battery; or SWH	ECMs and Battery, or SWH
6	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
7	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
8	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
9	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
10	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
11	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
12	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
13	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
14	ECMs and Battery; or SWH	ECMs and Battery; or SWH
15	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
16	ECMs and Battery, or SWH	ECMs and Battery, or SWH

*ECMs: Glazing U-0.25, Drain Water Heat Recovery, DHW Compact Distribution Credit
**Battery: not required in baseline
***PV: In addition to the prescriptive requirement, not exceeding roof area
****SWH: Solar water heating

Flexible compliance paths – Low-Rise Loaded Corridor Prototype

Climate Zone	HPSH + Gas DHW	Gas Furnace + Gas DHW
1	ECMs or SWH	ECMs, Battery and PV, or SWH
2	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
3	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
4	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
5	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
6	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
7	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
8	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
9	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
10	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
11	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
12	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
13	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
14	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
15	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
16	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH

*ECMs: Glazing U-0.25, Drain Water Heat Recovery, DHW Compact Distribution Credit

**Battery: not required in baseline

***PV: In addition to the prescriptive requirement, not exceeding roof area

****SWH: Solar water heating

Flexible Compliance Paths – Mid-Rise Mixed Use Prototype

Climate Zone	HPSH + Gas DHW	Gas Furnace + Gas DHW
1	ECMs or SWH	ECMs and Battery, or SWH
2	ECMs and Battery, or SWH	ECMs and Battery, or SWH
3	ECMs and Battery, or SWH	ECMs and Battery, or SWH
4	ECMs and Battery, or SWH	ECMs, Battery and PV, or SWH
5	ECMs and Battery, or SWH	ECMs and Battery, or SWH
6	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
7	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
8	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
9	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
10	ECMs, Battery and PV, or SWH	ECMs, Battery and PV, or SWH
11	ECMs and Battery, or SWH	ECMs and Battery, or SWH
12	ECMs and Battery, or SWH	ECMs, Battery and PV, or SWH
13	ECMs and Battery, or SWH	ECMs and Battery, or SWH
14	ECMs and Battery, or SWH	ECMs and Battery, or SWH
15	ECMs and Battery, or SWH	ECMs and Battery, or SWH
16	ECMs	ECMs or SWH

*ECMs: Glazing U-0.25, Drain Water Heat Recovery, DHW Compact Distribution Credit
**Battery: not required in baseline
***PV: In addition to the prescriptive requirement, not exceeding roof area
****SWH: Solar water heating

Flexible Compliance Paths – High-Rise Mixed Use Prototype

Climate Zone	HPSH + Gas DHW	Gas Furnace + Gas DHW
1	ECMs or SWH	ECMs and Battery, or SWH
2	ECMs and Battery, or SWH	SWH
3	SWH	SWH
4	SWH	SWH
5	SWH	SWH
6	SWH	SWH
7	SWH	SWH
8	SWH	SWH
9	SWH	SWH
10	SWH	SWH
11	SWH	SWH
12	SWH	SWH
13	SWH	SWH
14	SWH	SWH
15	SWH	SWH
16	SWH	SWH

*ECMs: Glazing U-0.25, Drain Water Heat Recovery, DHW Compact Distribution Credit

**Battery: not required in baseline

***SWH: Solar water heating

Questions

- Is the proposed standard design HPWH location and venting option appropriate?

Comments

Comments on today's workshop due

August 9, 2023, by 5:00 PM

Submit comments to CEC Docket 22-BSTD-01

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

Contact: danny.tam@energy.ca.gov

Thank You!

2025 Energy Code – Pre-Rulemaking

Heat Pump Baselines for Nonresidential Medium and Large Offices and Large Schools

Bach Tsan P.E., Senior Mechanical Engineer, Building Standards Branch

July 27, 2023

Agenda

- Baseline Overview
- 2022 Prescriptive Baselines
- 2025 Proposal
- Energy Savings Methodology
- Energy Impact Results
- Cost Analysis
- Performance Option Approach

2022 Nonres Prescriptive HVAC Requirements

(Single zone systems with direct expansion cooling ≤ 240,000 Btu/hr)

School Building Spaces

- Climate Zones 2-15: Heat Pump
- Climate Zones 1, 16: Dual-fuel Heat Pump

Retail and Grocery Building Spaces

- Climate Zones 2-15: Heat Pump
- Climate Zones 1, 16:
  - Cooling capacity < 65,000 Btu/hr: Furnace A/C
  - Cooling capacity ≥ 65,000 Btu/hr: Dual-fuel Heat Pump

Office, Financial Institution and Library Building Spaces

- Climate Zones 1-15: Heat Pump
- Climate Zone 16:
- Cooling capacity < 65,000 Btu/hr: Furnace A/C
- Cooling capacity ≥ 65,000 Btu/hr: Dual-fuel Heat Pump

Office Spaces in Warehouses

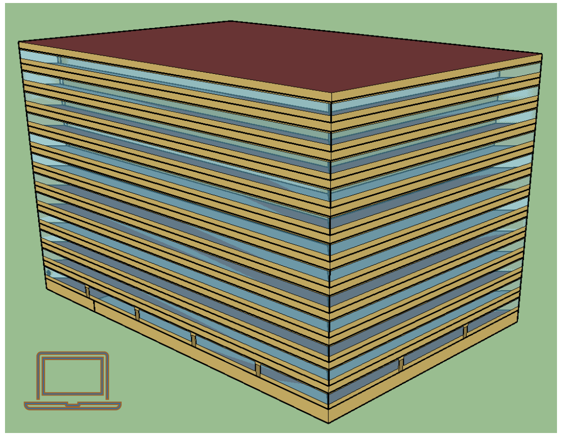
- Climate Zones 1-16: Heat Pump

2022 HVAC Standard Designs

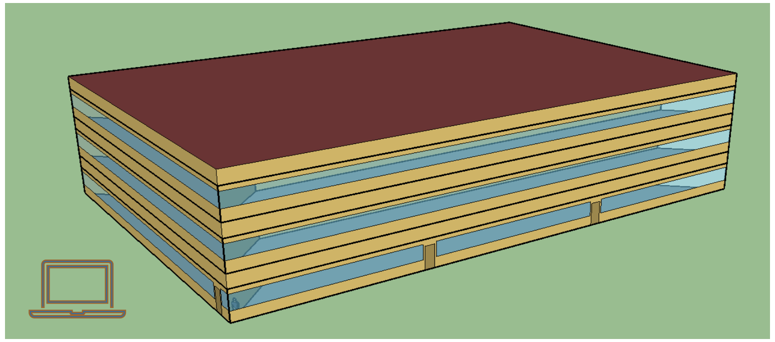
Building Prototype	Description
Medium Office	Packaged VAV Unit; VAV reheat system; packaged variable volume DX unit with gas heating and with hot water reheat terminal units
Large Office	Built-up VAV Unit; Variable volume system with chilled water and hot water coils, water-cooled chiller, tower, and central boiler
Large School	Built-up VAV Unit; Variable volume system with chilled water and hot water coils, water-cooled chiller, tower, and central boiler

2022 Prescriptive Building Prototypes

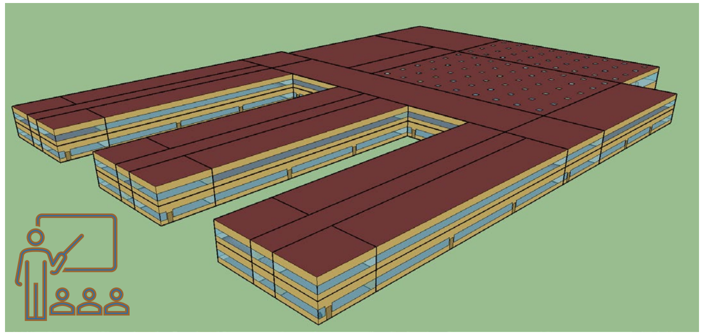
Large Office

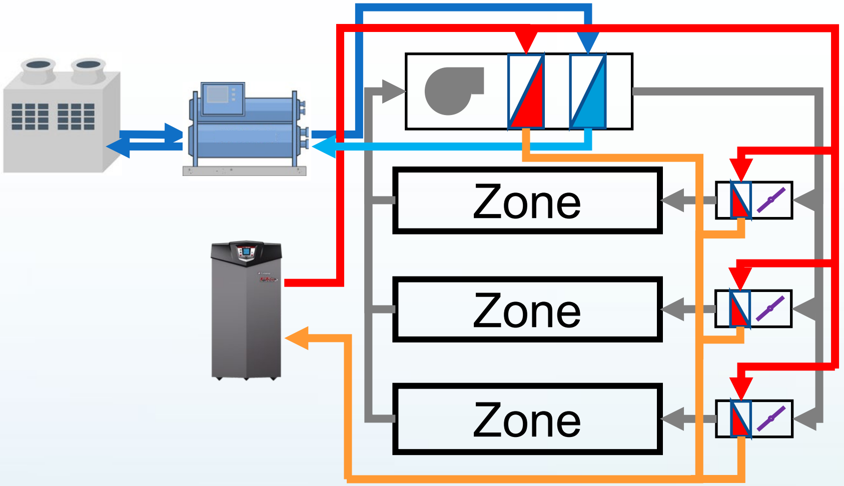


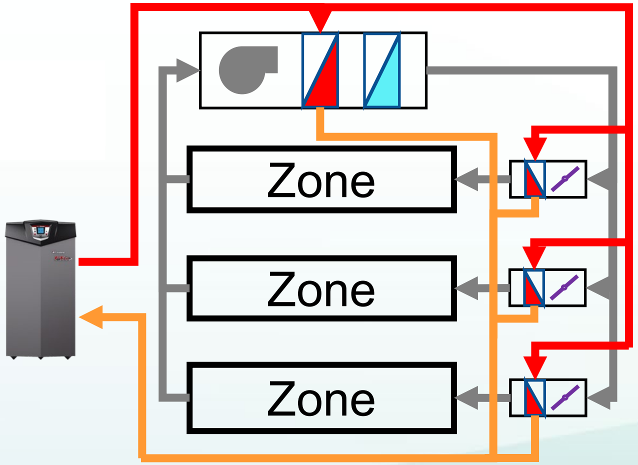
Medium Office

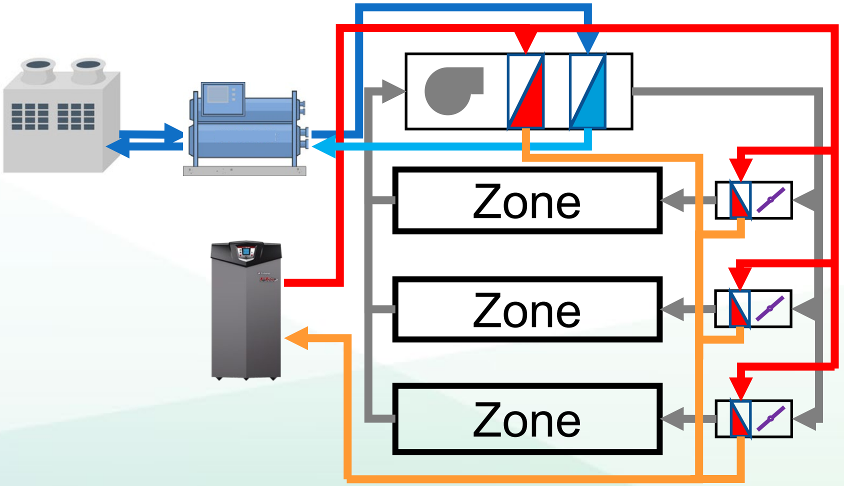


Large School









Establishing Heat Pump Baselines

Considerations taken to establish baseline:

- Show Long-term System Cost (LSC) savings when compared to the 2022 Energy Code
- Show source energy savings when compared to the 2022 Energy Code
- Demonstrate measure is cost effective, specific to each building type and CA climate zone
- Ensure technically feasible options exist (mixed fuel and all-electric) to allow for compliance flexibility

Software

CBECC creates EnergyPlus Input Data File (IDF) file

- AWHP feature introduced to CBECC in the 2022 version allowed for analysis
- 2025 CBECC Research version 0.4IDF is modified

Meet minimum prescriptive requirements

- To add measures onto prescriptive minimum (e.g., AWHP)
- EnergyPlus version 9.4
- Results are consolidated and graphics created in Excel

2025 Proposed Requirements

- Large offices and large schools using central, space-heating systems will prescriptively require
  - Central air-to-water heat pumps (AWHP)
    - Minimum 3.29 COP at rated conditions for design condition’s leaving water temperature
    - Buffer tank minimum 8 gallons/ton
  - Four-pipe fan coil (FPFC)
    - Minimum 3-speeds, plus off
  - Dedicated outdoor air system (DOAS)
    - Sized for ventilation
    - 0.77 W/cfm
    - HRV w/Bypass for cooling
    - 55 F bypass lower limit

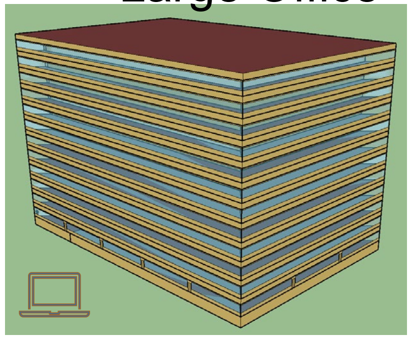
2025 Proposed Nonresidential Baseline System – Large Office and Large Schools

Hydronic Heating Water System Components:

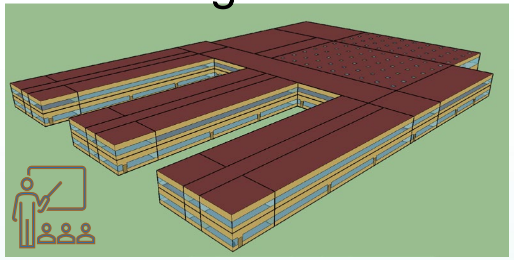
- Air to Water Heat Pump
- Four Pipe Fan Coil
- Dedicated Outside Air System
- Heat Recovery Ventilation with bypass; performs economizer function

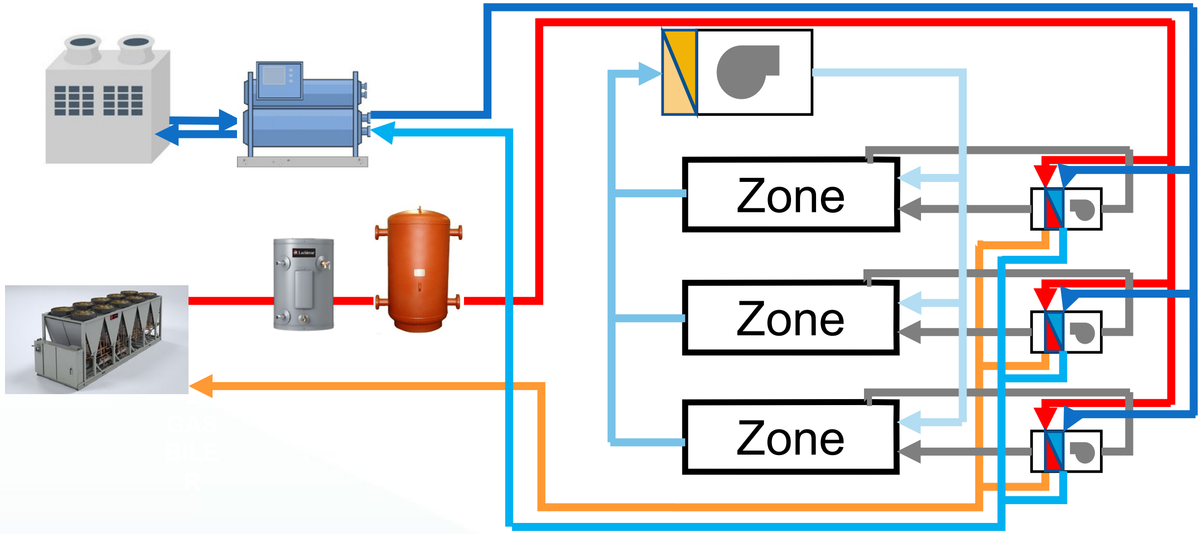
Air-to-water heat pumps are a proven design option for electric central space heating in office, laboratory and municipal buildings.

Large Office



Large School

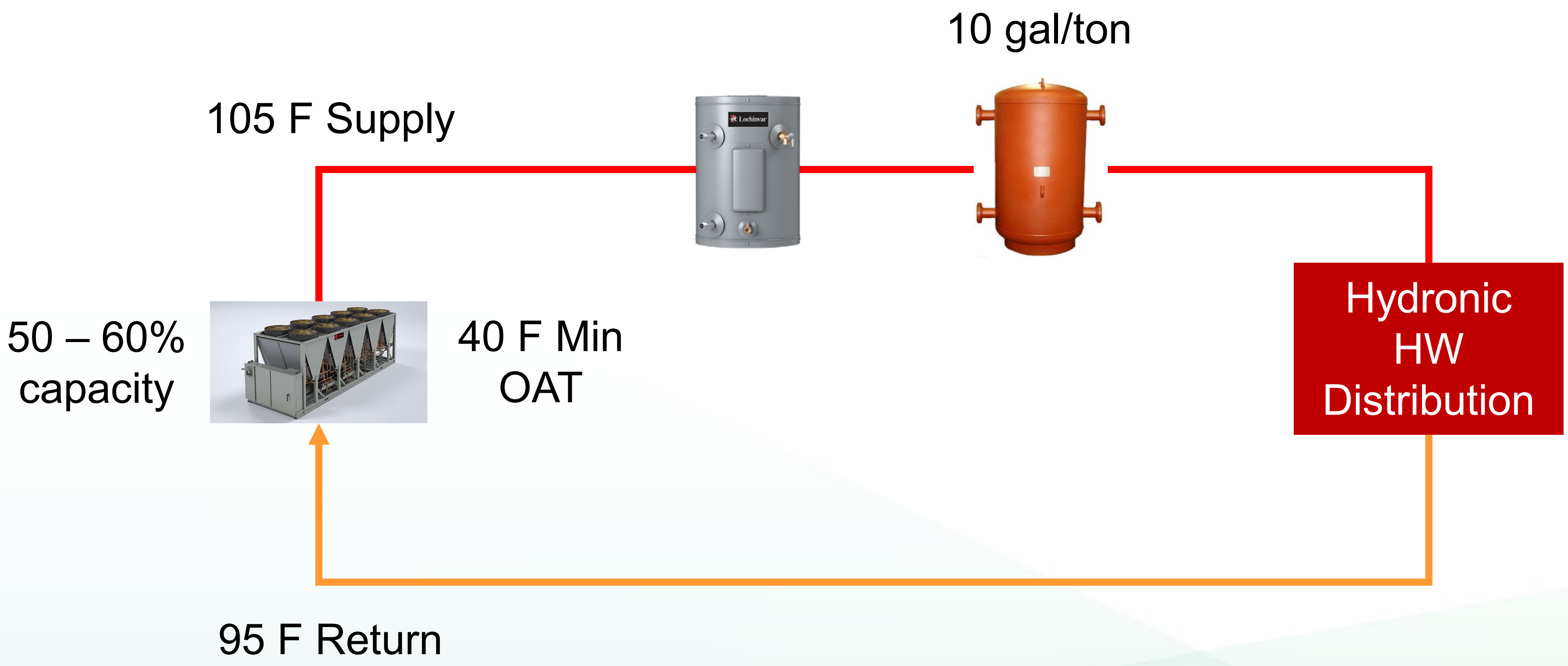




AWHP Sizing and Specification

System Sizing :

- AWHP provides only 50% of design load, remainder from supplemental heat
- System Sized for 50% of design load can meet load for over 90% of operating hours



2025 Proposed Requirements

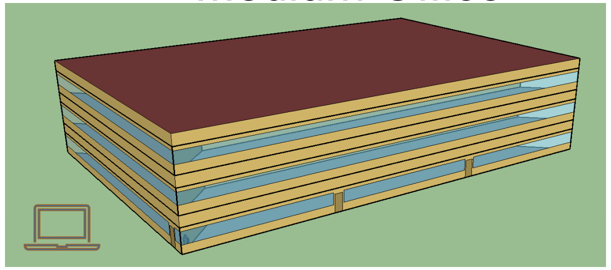
- Medium offices using central, space-heating systems will prescriptively require
  - Variable Refrigerant Flow (VRF)
    - Minimum 3-speeds, plus off
    - Heat Recovery
  - Dedicated outdoor air system (DOAS)
    - Sized for ventilation
    - 0.77 W/cfm
    - HRV w/Bypass for cooling
    - 55 F bypass lower limit

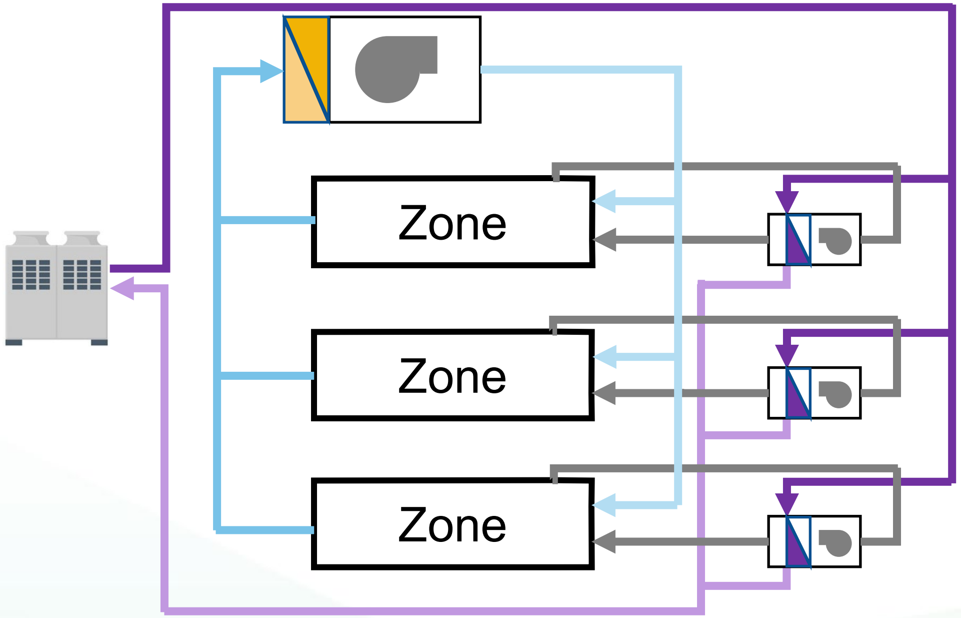
2025 Proposed Nonresidential Baseline System - Medium Office

HVAC System Description:

- Variable Refrigerant Flow with heat recovery
- Dedicated Outside Air System
- Heat Recovery Ventilation

Medium Office





Energy Impact – Large Office

Climate Zone	First Year Electricity Savings (kWh/sf)	First Year Natural Gas Savings (therms/sf)	LSC Energy Savings ($/sf over 30 year period)	Source Energy (kBtu/ft2)
1	-0.38	0.07660	$3.28	6.9
2	0.17	0.08930	$5.37	8.2
3	-0.51	0.06140	$1.38	5.1
4	0.33	0.09900	$7.38	9.2
5	-0.45	0.06180	$1.33	5.1
6	0.10	0.04060	$2.64	3.5
7	0.45	0.07420	$6.82	7.0
8	0.91	0.09710	$9.74	9.5
9	0.86	0.10390	$9.94	10.1
10	0.85	0.09910	$9.73	9.7
11	0.94	0.15840	$13.73	15.3
12	0.47	0.11760	$9.20	11.3
13	1.05	0.13890	$13.47	13.9
14	0.84	0.12380	$11.03	11.9
15	2.06	0.15650	$18.15	15.9
16	-0.09	0.13240	$6.78	11.5

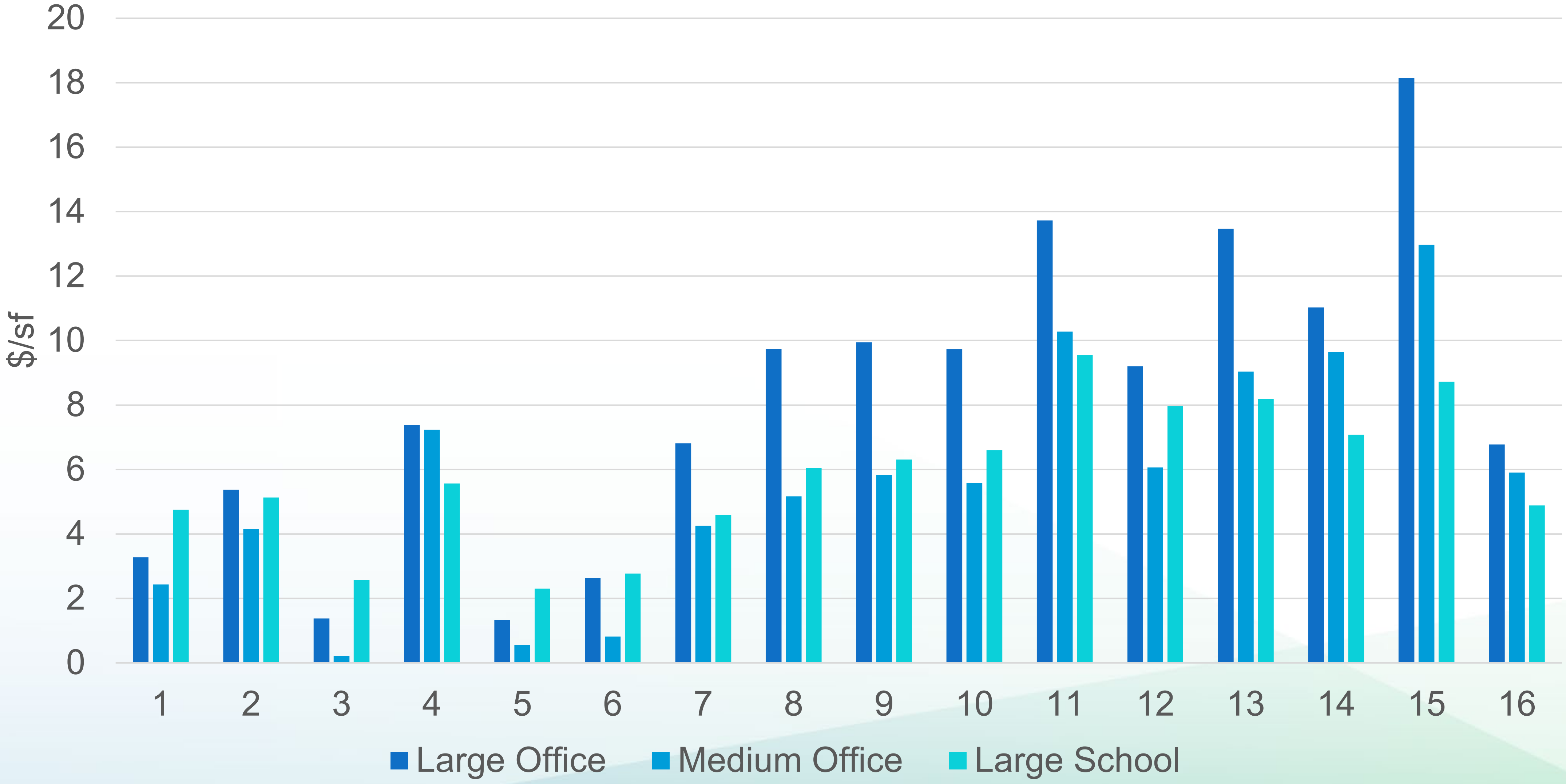
Energy Impact – Large Schools

Climate Zone	Electricity Savings (kWh/sf)	Natural Gas Savings (therms/sf)	LSC Energy Savings ($/sf over 30 year period)	Source Energy (kBtu/ft2)
1	-0.22	0.10300	$4.75	9.3
2	0.12	0.08630	$5.13	7.8
3	-0.35	0.07550	$2.57	6.3
4	0.16	0.08390	$5.57	7.5
5	-0.33	0.07220	$2.30	6.0
6	0.05	0.04720	$2.77	4.1
7	0.08	0.07440	$4.59	6.5
8	0.33	0.08220	$6.05	7.4
9	0.30	0.08790	$6.31	7.9
10	0.44	0.07950	$6.60	7.5
11	0.45	0.12710	$9.55	11.9
12	0.23	0.11760	$7.97	10.9
13	0.42	0.10700	$8.19	10.0
14	0.48	0.08290	$7.08	7.8
15	0.98	0.07930	$8.73	7.9
16	-0.25	0.11460	$4.89	9.6

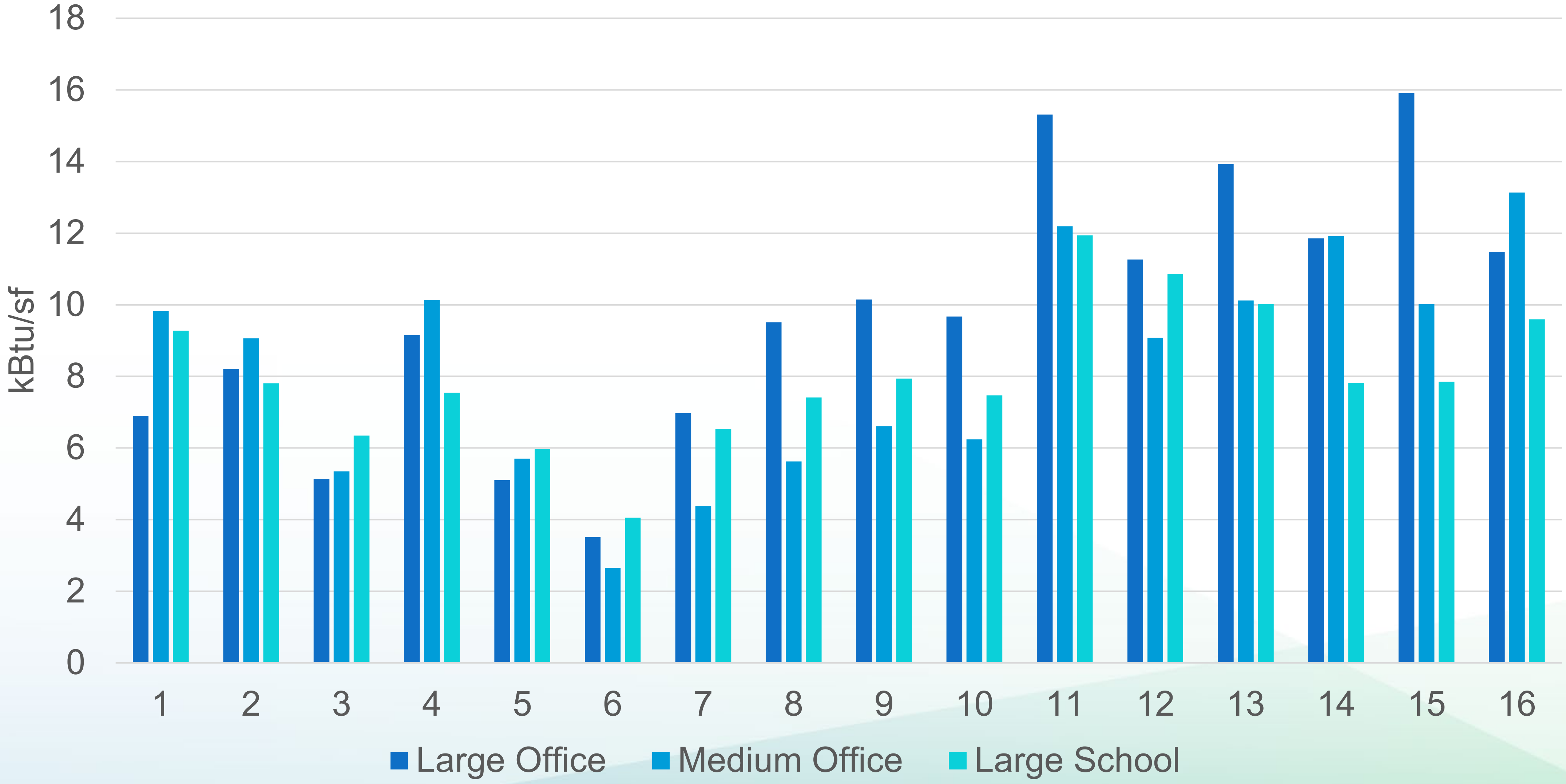
Energy Impact – Medium Office

Climate Zone	Electricity Savings (kWh/sf)	Natural Gas Savings (therms/sf)	LSC Energy Savings ($/sf over 30 year period)	Source Energy (kBtu/ft2)
1	-0.99	0.11930	$2.44	9.8
2	-0.33	0.10490	$4.15	9.1
3	-0.87	0.06790	$0.22	5.3
4	0.02	0.11160	$7.23	10.1
5	-0.76	0.07150	$0.56	5.7
6	-0.26	0.03450	$0.82	2.7
7	0.08	0.04830	$4.25	4.4
8	0.29	0.06020	$5.17	5.6
9	0.28	0.06990	$5.84	6.6
10	0.25	0.06670	$5.59	6.2
11	0.39	0.12880	$10.28	12.2
12	-0.10	0.10040	$6.07	9.1
13	0.35	0.10420	$9.04	10.1
14	0.33	0.12720	$9.64	11.9
15	1.39	0.09580	$12.97	10.0
16	-0.59	0.15640	$5.91	13.1

Long-Term System Cost (LSC) Savings



Source Energy Savings



Incremental Costs: Large Office

Climate Zone	Baseline First Cost	Baseline Replacement Cost	Baseline Maintenance Cost	Baseline Total	AWHP+FPFC First Cost	AWHP+FPFC Replacement Cost	AWHP+FPFC Maintenance Cost	AWHP+FPFC Total	AGIC Avoided Cost $/sf	Incremental Cost $/sf
1	$11.52	$1.39	$0.50	$13.41	$10.14	$2.04	$1.14	$13.32	$0.07	($0.16)
2	$11.57	$1.41	$0.50	$13.48	$10.10	$2.02	$1.14	$13.26	$0.07	($0.29)
3	$11.63	$1.45	$0.50	$13.58	$10.02	$1.98	$1.14	$13.15	$0.07	($0.51)
4	$11.64	$1.45	$0.50	$13.59	$10.14	$2.04	$1.14	$13.32	$0.07	($0.34)
5	$11.56	$1.41	$0.50	$13.47	$10.06	$2.00	$1.14	$13.20	$0.07	($0.34)
6	$11.59	$1.43	$0.50	$13.52	$9.87	$1.90	$1.14	$12.92	$0.04	($0.65)
7	$11.63	$1.44	$0.50	$13.57	$9.83	$1.88	$1.14	$12.86	$0.04	($0.75)
8	$11.63	$1.44	$0.50	$13.58	$9.87	$1.90	$1.14	$12.92	$0.04	($0.70)
9	$11.73	$1.49	$0.50	$13.72	$9.91	$1.92	$1.14	$12.97	$0.04	($0.79)
10	$11.66	$1.46	$0.50	$13.62	$9.95	$1.94	$1.14	$13.03	$0.04	($0.63)
11	$11.81	$1.53	$0.50	$13.84	$10.14	$2.04	$1.14	$13.32	$0.07	($0.59)
12	$11.63	$1.44	$0.50	$13.57	$10.10	$2.02	$1.14	$13.26	$0.04	($0.35)
13	$11.73	$1.49	$0.50	$13.72	$10.02	$1.98	$1.14	$13.15	$0.07	($0.64)
14	$11.87	$1.56	$0.50	$13.93	$10.06	$2.00	$1.14	$13.20	$0.04	($0.77)
15	$11.83	$1.54	$0.50	$13.87	$9.87	$1.90	$1.14	$12.92	$0.07	($1.02)
16	$12.06	$1.65	$0.50	$14.21	$10.14	$2.04	$1.14	$13.32	$0.07	($0.96)

Large Office Cost

- AWHP with FPFC and DOAS
  - Significant savings in air distribution ductwork
  - DOAS System has lower first cost than built-up AHU
  - Some additional cost for fan coil units (first cost and O&M)
  - Net incremental cost shows slight savings over baseline
  - Avoided Gas Infrastructure Cost (AGIC) included

Incremental Costs: Large School

Climate Zone	Baseline First Cost	Baseline Replacement Cost	Baseline Maintenance Cost	Baseline Total	AWHP+FPFC First Cost	AWHP+FPFC Replacement Cost	AWHP+FPFC Maintenance Cost	AWHP+FPFC Total	AGIC Avoided Cost $/sf	Incremental Cost $/sf
1	$13.25	$1.70	$0.39	$15.34	$13.90	$2.89	$0.85	$17.64	$0.00	$2.30
2	$13.39	$1.77	$0.39	$15.55	$13.99	$2.93	$0.85	$17.77	$0.00	$2.22
3	$13.35	$1.76	$0.39	$15.51	$13.72	$2.80	$0.85	$17.37	$0.00	$1.86
4	$13.44	$1.80	$0.39	$15.64	$13.99	$2.93	$0.85	$17.77	$0.00	$2.14
5	$13.32	$1.74	$0.39	$15.44	$13.81	$2.84	$0.85	$17.50	$0.00	$2.06
6	$13.27	$1.73	$0.39	$15.39	$13.37	$2.61	$0.85	$16.83	$0.00	$1.44
7	$13.29	$1.73	$0.39	$15.41	$13.37	$2.61	$0.85	$16.83	$0.00	$1.42
8	$13.38	$1.78	$0.39	$15.55	$13.64	$2.75	$0.85	$17.24	$0.00	$1.69
9	$13.39	$1.79	$0.39	$15.56	$13.55	$2.70	$0.85	$17.10	$0.00	$1.54
10	$13.41	$1.80	$0.39	$15.60	$13.64	$2.75	$0.85	$17.24	$0.00	$1.64
11	$13.52	$1.85	$0.39	$15.76	$13.90	$2.89	$0.85	$17.64	$0.00	$1.87
12	$13.41	$1.79	$0.39	$15.59	$13.90	$2.89	$0.85	$17.64	$0.00	$2.05
13	$13.48	$1.83	$0.39	$15.70	$13.81	$2.84	$0.85	$17.50	$0.00	$1.80
14	$13.66	$1.93	$0.39	$15.98	$13.99	$2.93	$0.85	$17.77	$0.00	$1.80
15	$13.52	$1.86	$0.39	$15.77	$13.46	$2.66	$0.85	$16.97	$0.00	$1.19
16	$13.76	$1.98	$0.39	$16.13	$13.99	$2.93	$0.85	$17.77	$0.00	$1.64

Large School Cost

- AWHP with FPFC has somewhat higher incremental costs
  - Less distribution ductwork avoided costs with the school layout, compared to office
  - Reduced cost savings from DOAS, due to much higher ventilation load per square foot than the large office building
  - AGIC is not included, other gas appliances in the prototype

Incremental Costs: Medium Office

Climate Zone	Baseline First Cost	Baseline Replacement Cost	Baseline Maintenance Cost	Baseline Total	VRF+DOAS First Cost	VRF+DOAS Replacement Cost	VRF+DOAS Maintenance Cost	VRF+DOAS Total	AGIC Avoided Cost $/sf	Incremental Cost $/sf
1	$27.08	$3.00	$0.88	$30.96	$25.67	$3.90	$0.34	$29.91	$0.43	($1.49)
2	$27.96	$3.46	$0.88	$32.30	$27.77	$4.36	$0.34	$32.47	$0.43	($0.26)
3	$27.92	$3.44	$0.88	$32.24	$27.69	$4.34	$0.34	$32.36	$0.43	($0.31)
4	$28.12	$3.54	$0.88	$32.55	$28.11	$4.48	$0.34	$32.92	$0.43	($0.06)
5	$27.68	$3.31	$0.88	$31.88	$27.18	$4.17	$0.34	$31.69	$0.43	($0.62)
6	$28.04	$3.50	$0.88	$32.42	$27.94	$4.42	$0.34	$32.70	$0.17	$0.10
7	$28.12	$3.54	$0.88	$32.55	$28.11	$4.48	$0.34	$32.92	$0.18	$0.20
8	$28.29	$3.64	$0.88	$32.81	$28.44	$4.59	$0.34	$33.37	$0.18	$0.38
9	$28.25	$3.62	$0.88	$32.75	$28.36	$4.56	$0.34	$33.26	$0.17	$0.34
10	$28.45	$3.72	$0.88	$33.06	$28.78	$4.70	$0.34	$33.82	$0.17	$0.59
11	$28.41	$3.70	$0.88	$32.99	$28.70	$4.67	$0.34	$33.70	$0.43	$0.28
12	$27.96	$3.46	$0.88	$32.30	$27.77	$4.36	$0.34	$32.47	$0.18	($0.00)
13	$28.20	$3.59	$0.88	$32.67	$28.28	$4.53	$0.34	$33.15	$0.43	$0.05
14	$28.69	$3.85	$0.88	$33.42	$29.28	$4.86	$0.34	$34.49	$0.17	$0.90
15	$28.77	$3.89	$0.88	$33.54	$29.45	$4.92	$0.34	$34.71	$0.43	$0.74
16	$29.25	$4.14	$0.88	$34.27	$30.46	$5.25	$0.34	$36.05	$0.43	$1.35

Medium Office Cost

- VRF System
  - Cost savings from a single system for cooling and heating
  - Cost savings for avoided ductwork
- AGIC is included – avoided costs of $0.15/sf to $0.40/sf, based on utility, if no other gas uses

Cost Effectiveness: Benefit to Cost Ratio (BCR)

Measure is cost-effective if BCR > 1

Where incremental cost is < 0 and LSC savings > 0, then BCR = infinite

Climate Zone	Large Office	Medium Office	Large School
1	203.5	Infinite	2.1
2	Infinite	Infinite	2.3
3	Infinite	Infinite	1.4
4	Infinite	Infinite	2.6
5	Infinite	Infinite	1.1
6	Infinite	8.0	1.9
7	Infinite	21.4	3.2
8	Infinite	13.6	3.6
9	Infinite	17.4	4.1
10	Infinite	9.5	4.0
11	Infinite	36.9	5.1
12	Infinite	Infinite	3.9
13	Infinite	197.2	4.5
14	Infinite	10.8	3.9
15	Infinite	17.6	7.3
16	Infinite	4.4	3.0

Performance Approach Options for Compliance

Large Office:

- Packaged AWHP + FPFC + DOAS
- Natural Gas boiler + FPFC + DOAS with HRV, economizer, ventilation and window measure

Medium Office:

- VRF + DOAS
- Natural gas boiler + Fan coil with split DX cooling coil and hot water hydronic coil + DOAS, with HRV, ventilation, and economizer measures, and window improvements in CZ 1.

Large Schools:

- FPFC + DOAS, AWHP
- Natural Gas boiler + FPFC + DOAS with HRV, window, and roof measures, and some additional PV
- Analysis underway to achieve without PV

Options comply with LSC and Source Energy under the 2025 Standard

Comments

Comments on today's workshop due

August 9, 2023, by 5:00 PM

Submit comments to CEC Docket 22-BSTD-01

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

Contact: Bach.Tsan@energy.ca.gov

Thank You!

85

2025 Energy Code – Pre-Rulemaking

Heat Pump Requirements for Single Zone Rooftop Air-Conditioning Alterations

Bach Tsan P.E., Senior Mechanical Engineer, Building Standards Branch

July 27, 2023

Agenda

- Baseline Overview
- 2022 Prescriptive Code
- 2025 Proposal
- Energy Savings Methodology
- Energy Impact Results
- Cost Analysis
- Larger Systems

2022 Alterations Prescriptive Code

- Title 24 Part 6 2022 Alterations Prescriptive Approach provides the following exception:
  - *Exception 1 to Section 141.0(b)2C:* alterations, single zone space conditioning equipment is not required to meet heat pump requirements per Section *140.4(a)2.*

Proposed Requirements Title 24 Part 6

California Energy Commission is proposing code changes in Nonresidential Building Space Conditioning Alterations to rooftop package units below 65,000 Btu/h.

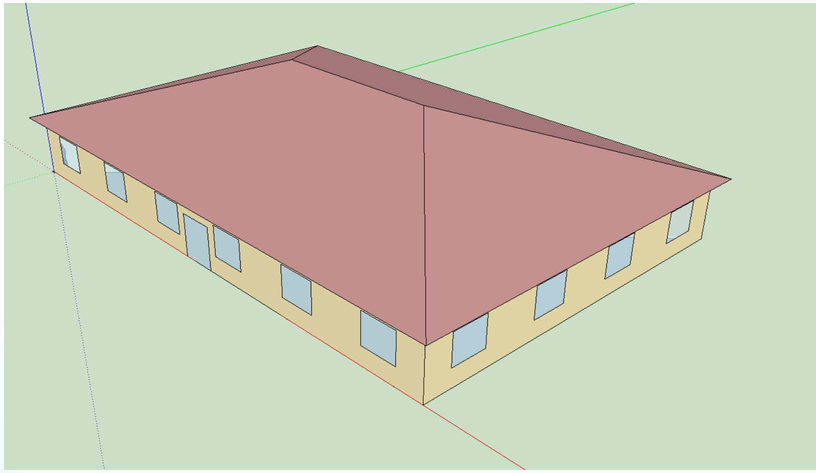
- Prescriptively require gas-fired single zone rooftop unit replacements to be heat pump-based in Alterations

Methodology

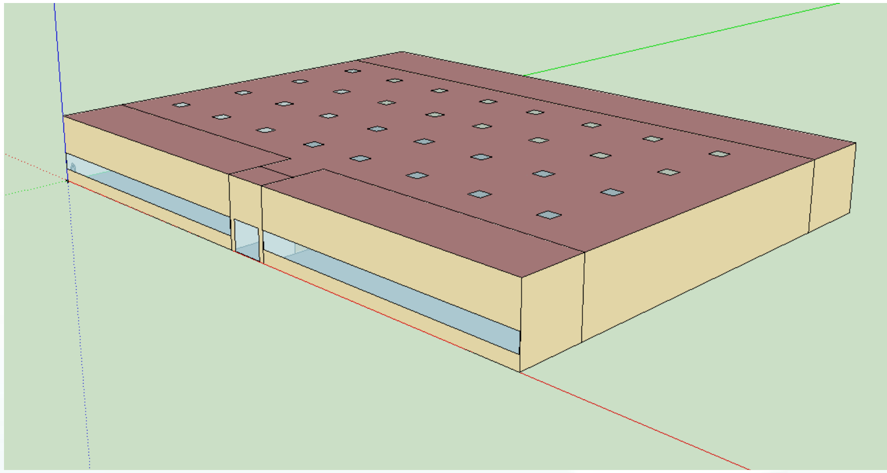
- Similar to Newly Constructed Buildings: Use 30-year period of analysis to calculate cost-effectiveness of any proposed measure
- LCC analysis steps
  1. Calculate Benefits:
     - Use LCC factors to calculate NPV of savings over 30 years
  2. Calculate incremental measure Costs:
     - Incremental first cost
     - Incremental maintenance cost
     - Incremental replacement cost
     - Incremental residual value
  3. Calculate Benefit to Cost ratio (B/C ratio)

Software Used & Prototypes

- CBECC 2025 & EnergyPlus 9.4
- Small Office and Medium Retail Prototypes
  - Existing building of vintage year 2000s



Small Office



Medium Retail

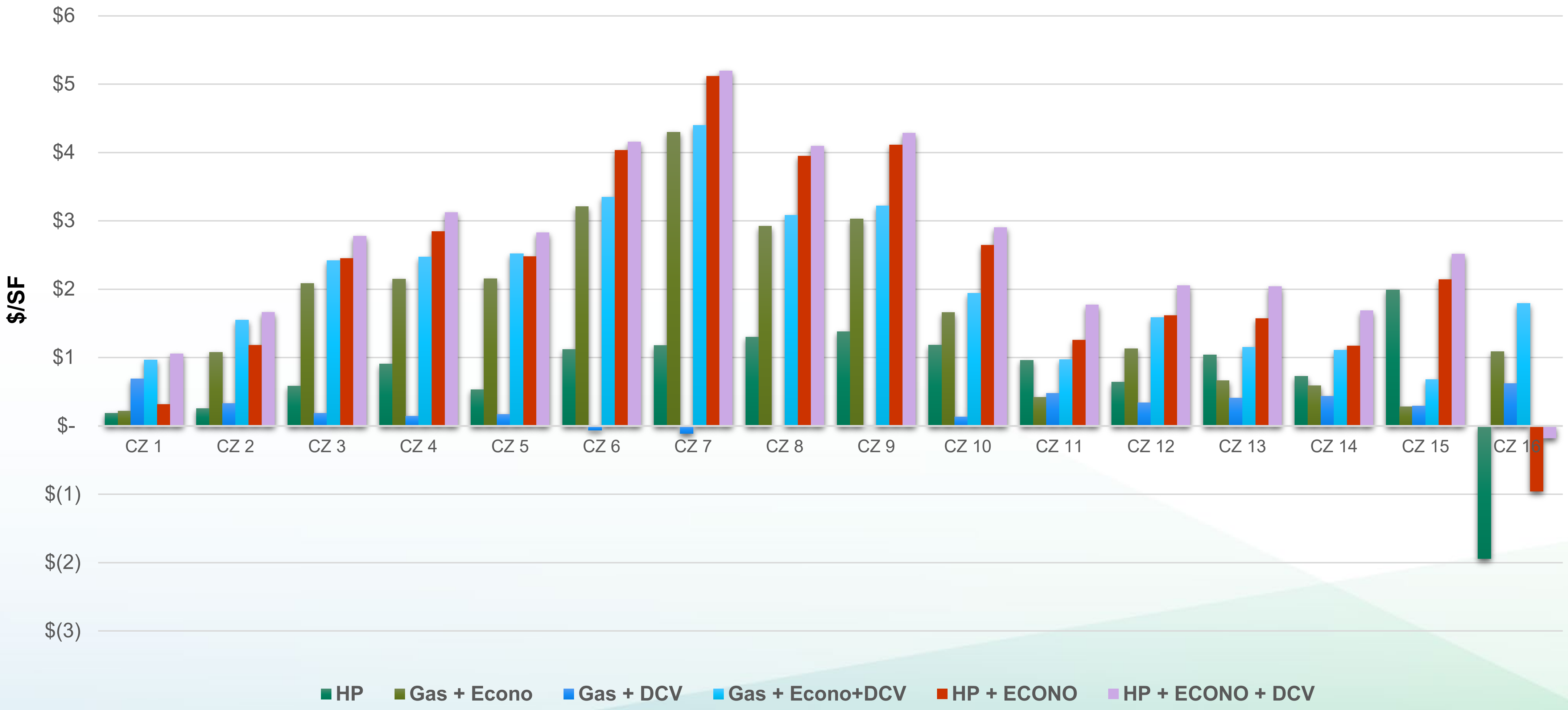
Key Assumptions

	Small Office	Medium Retail
Model	CBECC Alterations	CBECC Alterations
Lighting	Existing: Per T24 2016 prescriptive Building Category 0.8W/SF w/ daylighting control	Existing: Per T24 2016 Prescriptive Area Category Retail: 1.2W/SF, Entry: 0.95W/SF, Back Space: 0.6W/SF w/ daylighting control
Envelope	Existing: per T24 2005 Table 143-A	Existing: per T24 2005 Table 143-A
HVAC	New: SZAC RTU Size <65kBtuh **HP: SEER 14 HSPF 8.2** • *CZ-1-15 electric resistance heater for supplemental heating* • *CZ-16 furnace for supplemental heating* **DX/Gas: SEER 13, Burner Efficiency 81%**	New: SZAC RTU Size <65kBtuh **HP: SEER 14 HSPF 8.2** • *CZ-1-15 electric resistance heater for supplemental heating* • *CZ-16 furnace for supplemental heating* **DX/Gas: SEER 13, Burner Efficiency 81%**
Ventilation	CBECC default T24 2022 120.1(c)3 - 0.15cfm/sf	CBECC default T24 2022 120.1(c)3 - 0.25cfm/sf
	Measure Description	
Economizer Control	Differential dry bulb	Differential dry bulb
DCV	T24 2022 120.1(c)3 & 120.1(d)4	T24 2022 120.1(c)3 & 120.1(d)4
Supply Fan variable speed control	Variable volume fan: down to 50% air flow	Variable volume fan: down to 50% air flow

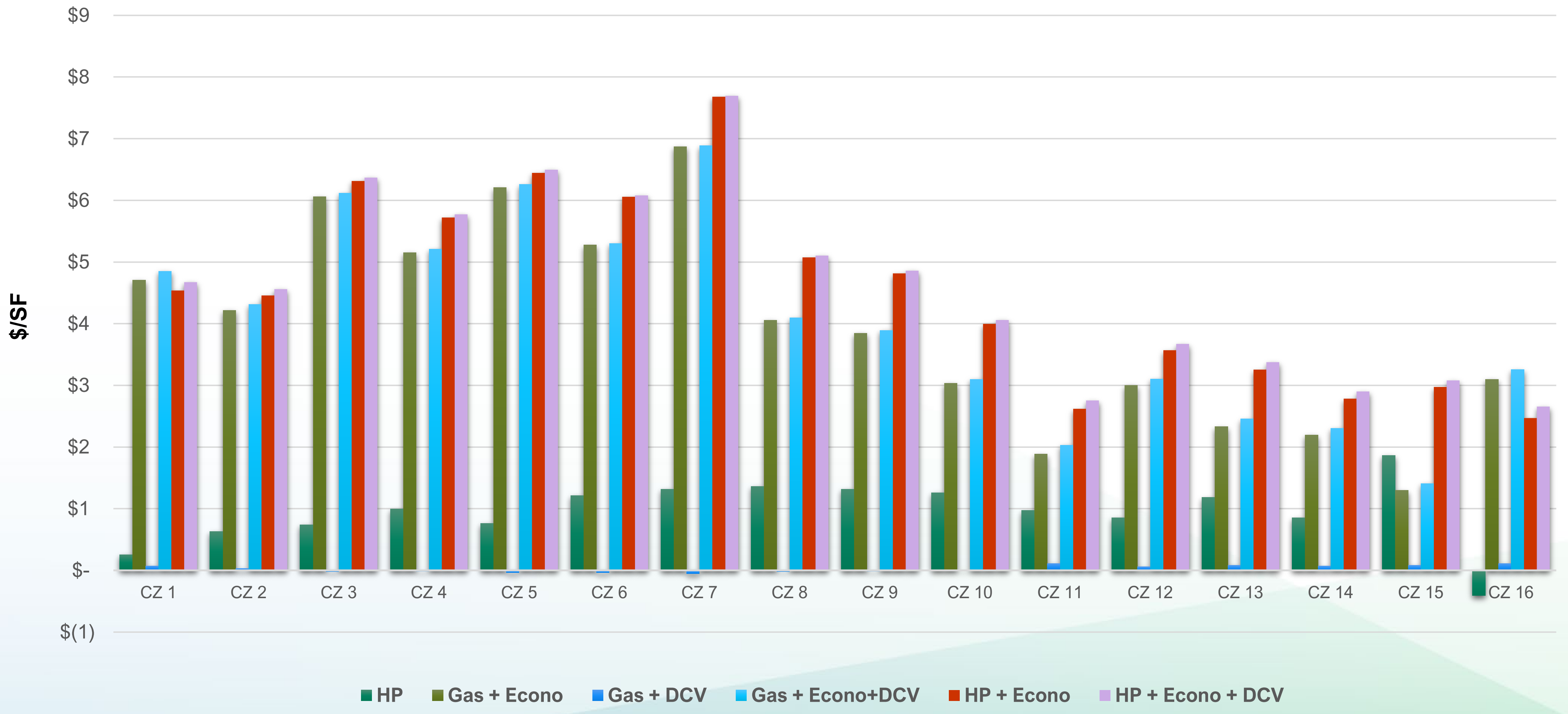
Energy Impact – SMALL OFFICE

Climate Zone	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	LSC Energy Savings ($/SF)	Annual Source Energy Savings (kBtu/ft2)
1	(4720)	581	$0.2	7.1
2	(1856)	287	$0.3	3.2
3	(1082)	228	$0.6	2.8
4	(627)	189	$0.9	2.3
5	(1134)	216	$0.5	2.5
6	766	57	$1.1	0.9
7	884	39	$1.2	0.7
8	959	61	$1.3	0.9
9	924	74	$1.4	1.1
10	346	108	$1.2	1.4
11	(1743)	330	$1.0	3.8
12	(1522)	279	$0.6	3.1
13	(680)	226	$1.0	2.6
14	(1675)	300	$0.7	3.2
15	1914	34	$2.0	0.7
16	(8704)	814	($1.9)	8.9

30-Year Long-Term System Cost (LSC) Savings – SMALL OFFICE



30-Year Long-Term System Cost (LSC) Savings – MEDIUM RETAIL



LSC Results Discussion

Overview

- Heat Pump shows LSC savings against gas baseline for both Small Office and Medium Retail except CZ-16
- Mixed Fuel flexibility pathway with design specified or field installed options are proposed
  - *Economizer for unit sizes even <54,000Btuh*
  - *Variable speed fan operation*
  - *Demand Controlled Ventilation*

Detailed

- Heat Pump requires higher SEER 14 vs. DX cooling w/ SEER 13
- Fan power static pressure allowance for heat pump w/electric resistance heater < DX/Gas heating RTUs
- LSC doesn’t offer as much advantage on heat pump heating vs. natural gas especially when heat pump performance degrades in cold winter days.

Cost Analysis

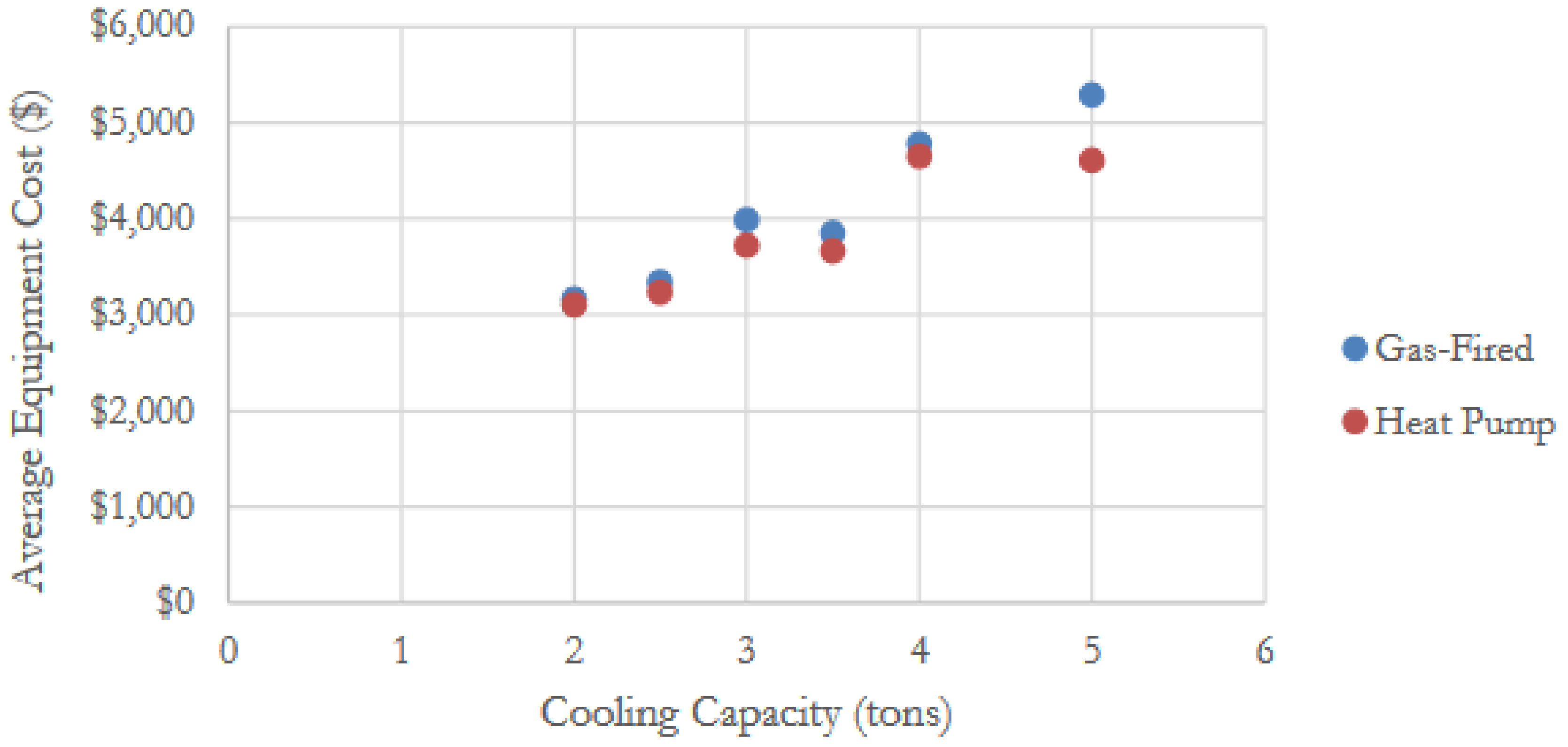


Figure 5 – Comparison of Equipment Costs for Code-minimum heat pump and gas-fired RTUs

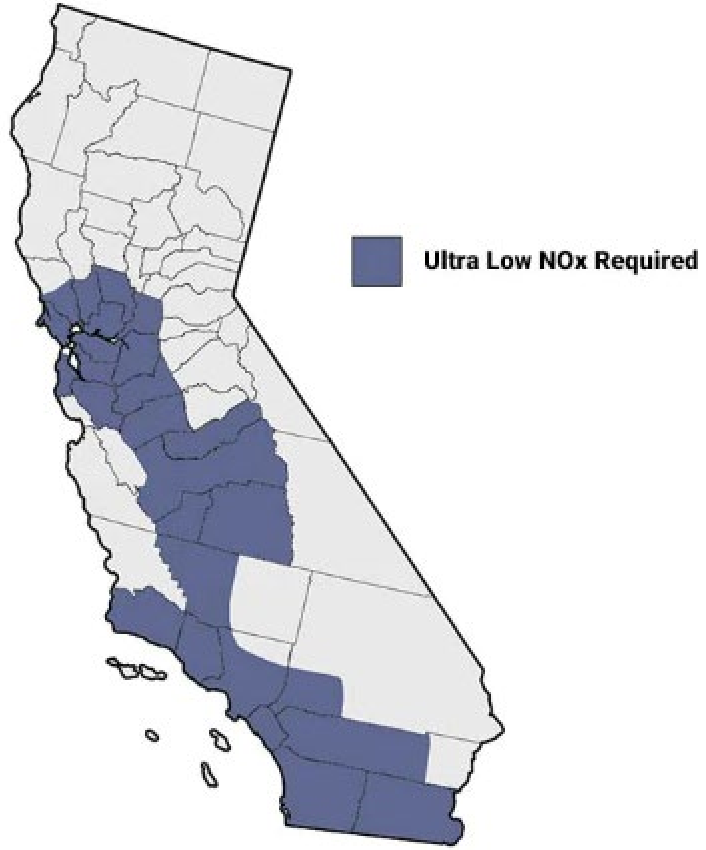
Courtesy: AC to HP Replacement Opportunity ; Earth Justice, NRDC, RMI, and Sierra Club Joint Comments

https://efiling.energy.ca.gov/GetDocument.aspx?tn=249551&DocumentContentId=84193

Total Incremental Cost

Equipment:

- Contacted wholesale providers and distributors on major manufacturer products
- Cost delta between heat pump RTUs and gas/DX RTUs vary with product lines and unit sizes
- Heat pump RTUs including electric resistance heaters show cost savings vs. gas/DX RTUs subject to low-NOx burner requirement: average \$13/ton - \$400/ton in the 2-5ton range



Total Incremental Cost

Installation

- Similar crane lift, curb adapter or weight requirement
- Addition of electric resistance heaters on heat pump RTUs for defrost controls can have different cost impacts in existing buildings

2025 CALGreen Title 24 Part 11 Voluntary - Nonresidential

California Energy Commission is exploring the feasibility of systems greater than 65,000 Btu/h

Scope: Nonresidential Building Space Conditioning Alterations

Purpose: Develop voluntary code requirements for

- Efficient electrically-driven ducted heat pumps
- Gas-fired space heating with efficiency packages

Methodology:

- Analyzing 5-20 tons HVAC packaged units
  - CBECC simulations (Small Office, Retail prototypes)
  - Interviews with designers, contractors, and distributors
  - Cost data collection
- Outputs: Cost-effectiveness and technical feasibility

Questions

- Continued research of heat pump baseline alterations in the small schools prototype for Part 6
- Additional exploration of larger roof top units in Part 11
- [Any questions for the stakeholders that you might have… requests for input]

Comments

Comments on today's workshop due

August 9, 2023, by 5:00 PM

Submit comments to CEC Docket 22-BSTD-01

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

Contact: Bach.Tsan@energy.ca.gov

Thank You!

2025 Energy Code – Pre-Rulemaking

2025 Energy Code – Photovoltaics (PV) and Energy Storage

Muhammad Saeed, P.E., Senior Electrical Engineer

July 27, 2023

2025 PV and Energy Storage

- 2025 Single Family PV Requirements Proposed Changes
- 2025 Low-Rise Multifamily PV Requirements Proposed Changes
- 2025 Non-Residential + HRMF PV Requirements Proposed Changes
- 2022 PV Requirements Cost Effectiveness Update - All Buildings
- 2025 JA12 Requirements
- Energy Storage Capacity In Practice
- 2025 Energy Storage Ready Requirements
- 2025 Determinations (10-109(k))

2025 Single Family PV Requirements Proposed Changes

2022 Existing Standards	2025 Proposed Standards	Sections Affected
Prescriptive PV system size based on the minimum of equation: kWPV = $(CFA \times A)/1000 + (N_{DU} \times B)$	Equation will be updated to reflect 2025 updates to underlying weather and LSC metric. This updated minimum PV system size requirement will still assume a mixed-fuel building.	150.1(c)14
OR, the maximum PV system that can be installed on the roof's Solar Access Roof Area (SARA).	OR, no less than SARA multiplied by "x" w/ft^2 value, where "x" is a minimum amount of generation. (e.g., NR & high-rise multifamily have "x" set to 14 w/ft^2). Considering different values for low & steep sloped roofs.	150.1(c)14
For performance, the PV system standard design is based on the annual load of the mixed fuel building as determined by CBECC-Res simulations.	For performance, the standard design will be based on the prescriptive equation described above. This equation still assumes a mixed fuel building.	ACM Manual
Self-Utilization Credit: Efficiency LSC tradeoff allowed.	Adjusting efficiency tradeoff to account for 2025 updates to underlying weather conditions and LSC values.	ACM Manual

Questions about Single Family Proposed Changes?

2025 Low-Rise Multifamily PV Requirements Proposed Changes

Existing 2022 Standards	2025 Proposed Standards	Sections Affected
Prescriptive Size based on the minimum of equation: kWPV = (CFA × A)/1000 + (NDU × B)	Equation will be updated to reflect 2025 updates to underlying weather and LSC metric. This updated minimum PV system size requirement will still assume a mixed-fuel building.	170.2(f)
OR, the maximum PV system that can be installed on the roof's Solar Access Roof Area (SARA).	OR, no less than SARA multiplied by "x" w/ft^2 value, where "x" is a minimum amount of generation. (NR & high-rise multifamily have "x" set to 14 w/ft^2). Considering different values for low & steep sloped roofs.	170.2(f)
For performance, the PV system standard design is based on the annual load of the mixed fuel building as determined by CBECC simulations.	For performance, the standard design will be based on the prescriptive equation described above. This equation still assumes a mixed fuel building.	ACM Manual
Self-Utilization Credit: Efficiency LSC tradeoff allowed.	Adjusting efficiency tradeoff to account for 2025 updates to underlying weather conditions and LSC values.	ACM Manual
No Virtual Net Energy Metering (VNEM) exception for low-rise multifamily	Exploring exceptions for small PV system sizes by dwelling unit for non-VNEM projects. Thresholds being analyzed. Also, VNEM will be defined in the standards.	170.2(f)

Questions about Multifamily Proposed Changes?

2025 Non-Residential + HRMF PV Requirements Proposed Changes

Existing 2022 Standards	2025 Proposed Standards	Standards Affected
Prescriptive Size based on the minimum of equation: kWPV = (CFA × A)/1000, where A depends on the building type. PV sizing is based on limiting the exports to 20%.	We are exploring modifying the calculation to determine minimum PV system size by space type, not building type (e.g., multipliers for office areas, corridors, restrooms, etc.). This would expand PV (and energy storage) requirements to all non-residential buildings, unless exceptions are met. The PV sizing will continue to be based on limiting exports to 20%.	140.10, 170.2(f), 170.2(g),
OR, the lesser amount of PV allowed based on Solar Access Roof Area (SARA) multiplied by 14 w/ft^2.	OR, no less than SARA multiplied by “x” w/ft^2 value, where “x” is a minimum amount of generation. Considering different values for low & steep sloped roofs.	140.10, 170.2(f), 170.2(g),

Questions about Non-Residential Proposed Changes?

2022 PV Requirements Cost Effectiveness Update - All Buildings

	2019/2022 Cost Effectiveness Assumptions	2025 Cost Effectiveness Assumptions
Accounting Method	2019, 2022 TDVs	2025 LSCs
Export Compensation	NEM2.0 (Retail – NSCs)	Net Billing Tariff (aka NEM3.0) Avoided Cost determined based on LSCs
Income Tax Credit	0%	30%
Costs Data Source	2016 NREL Data	2022 NREL Data

Questions about Cost-Effectiveness Assumptions?

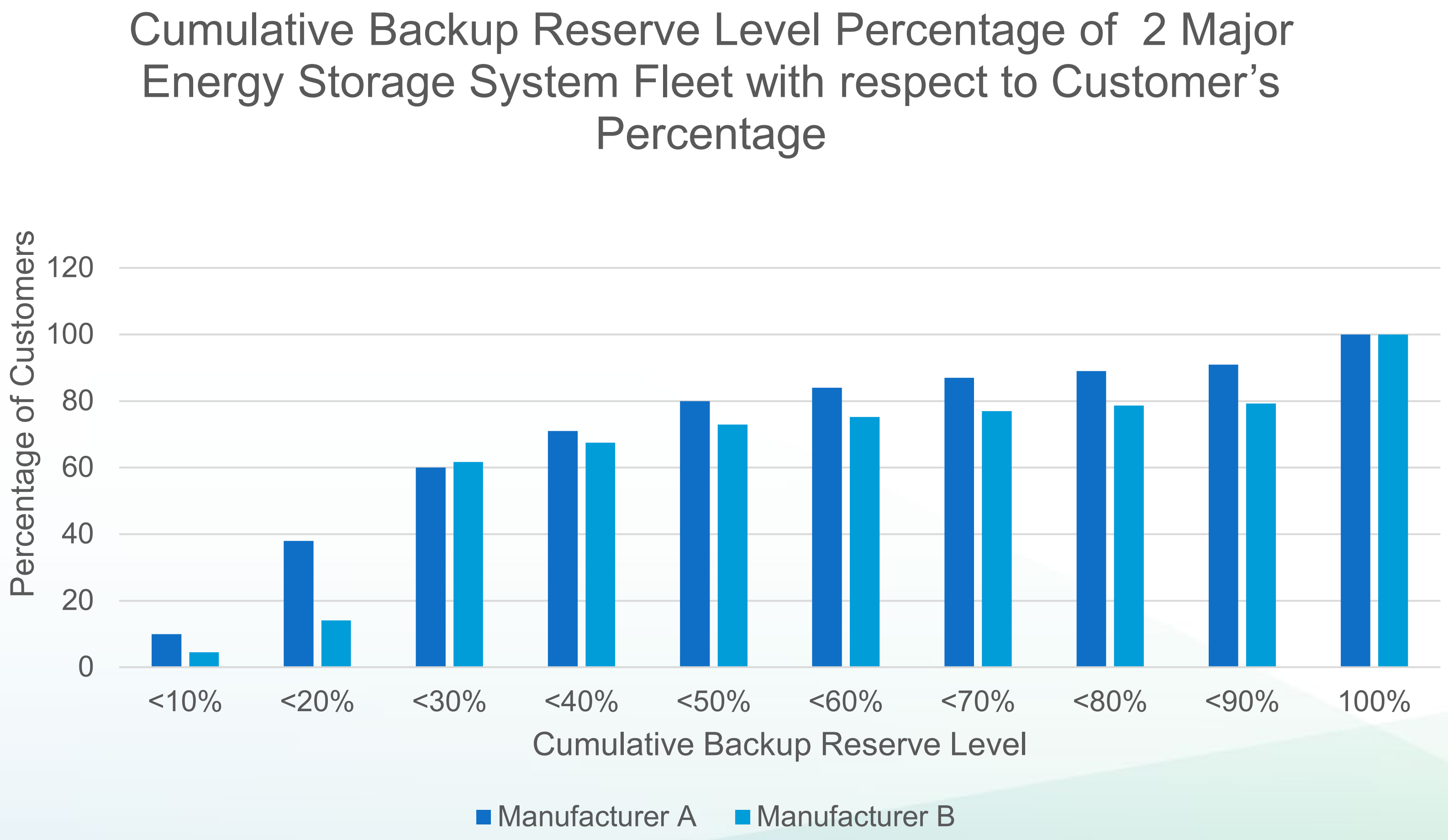
2025 JA12 Requirements

Existing 2022 Standards	Proposed Standards	Standards Affected
<u>Safety Requirements:</u> UL 1973, UL 9540. UL 1741, UL 1741 Supplement A.	**<u>Safety Requirements:</u>** UL 1973, UL 9540. UL 1741, UL 1741 Supplement A and B.	JA12.2.1
<u>Minimum Energy Storage System capacity:</u> Usable capacity could not be < 5kWh.	**<u>Minimum System Requirements:</u>** Minimum usable capacity will recognize combinations of units when total capacity is > 5kWh. Intent is to clarify that smaller energy storage units can be used.	JA12.2.2
<u>Control Requirements for Prescriptive and Performance Compliance Paths:</u> • Same requirement for all energy storage types. • 2 times annual reset required for cycling. • Load shifting capacity not clearly defined.	<u>Single Family Requirements:</u> o If battery reserve is manually set to over 30%, system must automatically reset to max 30% reserves after 72 hours. o Load shifting capacity clearly defined. <u>Non-Residential and Multifamily Requirements:</u> o TBD	JA12.2.3

Questions about JA12 Requirements?

Energy Storage Capacity In Practice

- High Backup Reserve Level:



Energy Storage Capacity In Practice

- 2025 single-family energy storage capacity update
  - As a result of data showing that batteries infrequently discharge below 30%:
    - 2025 proposal to assume 60% cycling, 40% reserve
    - E.g., this means when a 10 kWh energy storage system is modeled, 6 kWh will be simulated as being available for load shifting

Questions about Energy Storage Capacity in Practice?

2025 Energy Storage Ready Requirements

Existing 2022 Standards	Proposed Standards	Standards Affected
Energy storage requirements for newly constructed single-family buildings including ADUs	Consider adding new exceptions to the energy storage ready requirement if: • The existing service from the utility is underground, and the energy storage ready requirements cause a service upgrade, OR • No PV is required for the building.	150.0(s)

Questions about Energy Storage Ready Requirements ?

2025 Community Solar Requirements

Existing 2022 Standards	2025 Proposed Standards	Sections Affected
Building Opt-out. No provision for opt-outs of individual dwelling units that are owner-occupied in multifamily buildings.	For multifamily buildings, an owner of a multifamily dwelling unit can opt-out from a community solar program without requiring the whole building to opt-out (e.g., condominium in multifamily complex).	10-115(a)4D
Location. located on a distribution system of the load serving entity. providing service to the participating buildings.	Clarify that a distribution system will be defined as having ≤ 100 kV.	10-115(a)6
Executive Director Approval of Revised Applications: No public comment period is mentioned.	**Executive Director Approval of Revised Applications:** Clarify that a public comment period will be required.	10-115(c)

Questions about Community Solar ?

2025 Determinations (10-109(k))

10-109(k): Allows CEC to determine that PV system requirements do not apply where cost effectiveness thresholds where public agency rules cause cost effectiveness analysis to not hold for that project.

Existing 2022 Standards	Proposed Standards	Standards Affected
• New application requires CEC business meeting for approval • Revised applications that were previously approved require CEC business meeting for approval	• Revised applications will only require Executive Director approval, following similar strategy for community solar revised applications.	10-109(k), 10-110

Questions about 10-109(k) ?

Thank You!

Comments

- **Comments on Todays Workshop**
- **Due Date: August 09, 2023 By 5:00 PM**

- **Comments to be submitted to:**
  https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=22-BSTD-01

- Thank you for participating!

Next Workshop

Our next workshop is scheduled for Thursday, August 10th, from 9am – 3pm

- Topics covered will include:
  - Nonresidential HVAC system requirements
  - Nonresidential HVAC control requirements
  - Refrigeration systems
  - Controlled environmental horticulture requirements

Draft Codes and Standards Enhancement (CASE) reports can be found at https://title24stakeholders.com/2025-cycle-case-reports/

- Final reports will also be posted when available

Thank you for participating in today’s workshop!