

Statewide Codes and Standards

2022 Multifamily New Construction
Preliminary Results
July 7, 2022



Agenda

- Introduction and Overview
- Cost-effectiveness Study
 - Methodology
 - Code Changes
 - Costs
 - 2022 Analysis Results
 - Next Steps
- Initial Considerations

Note: We will be recording the webinar; presentation and recording will be available online.



Program Objective: Facilitate Adoption of Reach Codes



Prepare cost-effectiveness analyses



Draft model language



Develop adoption and implementation resources and tools



Provide technical support to staff



Communicate study results to stakeholders



Publish reach codes newsletter and other resources

Cost-effectiveness Analyses

Objective: Identify cost-effective, non-preempted measure packages

- Support widely applicable requirements potentially adopted anywhere in the state
- Two cost-effectiveness metrics: On-Bill and TDV
- Consistent with Title 24, Part 6
- Generally conservative assumptions.
- The study is NOT:
 - an example of best design practices or
 - a list of specific measures required



2022 Multifamily Code Compliance Metrics

Three metrics – Must comply with each

- Time Dependent Valuation (TDV energy)
 - TDV Efficiency - efficiency measures
 - TDV Total – efficiency, PV, storage combined
- Source Energy Use (proxy for GHG)

Reach Code Policy Options

- Set requirements based on compliance margins (vs absolute values)
- Add **Efficiency, Renewables, and Load Flexibility** to improve cost-effectiveness





Methodology

General Approach

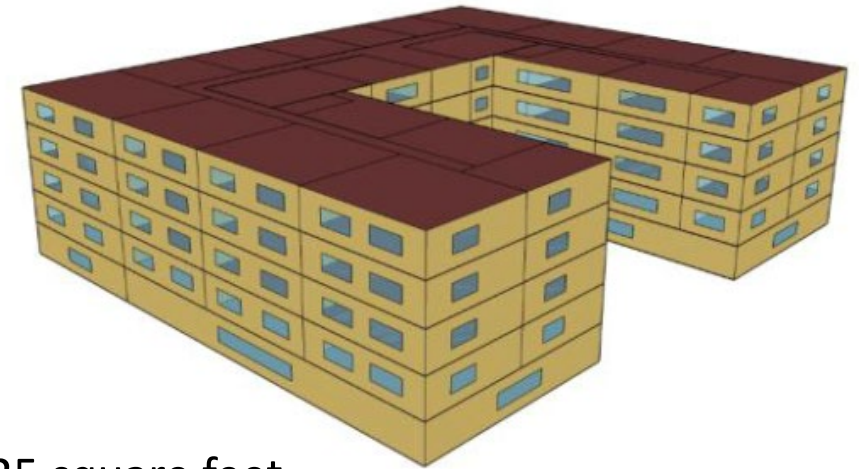
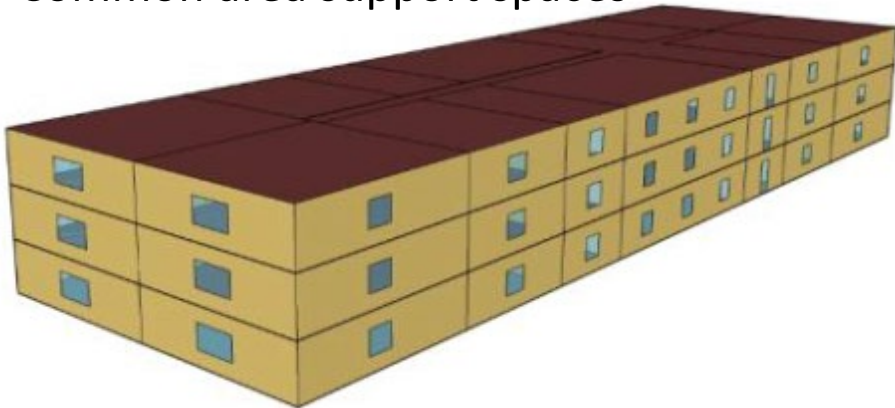
- Consistent with other Statewide reach code studies
- Builds on 2022 code cycle development & 2019 reach code analysis
 - Multifamily Restructuring
 - Multifamily All Electric Package
- 2022 prescriptive requirements as starting point
- CBECC 2022 Beta version
- Cost-effectiveness evaluated over 30-year analysis period

Multifamily Building Prototypes

- 2 of the 4 CEC multifamily prototypes
 - 3-story 36-unit loaded corridor
 - 5-story 88-unit mixed use

3-story

- 39,372 square feet slab-on grade
- Wood framed construction
- Individual HVAC systems, central water heating
- Common area support spaces



5-story

- 140,925 square feet
- 4 stories residential, 1 story commercial over parking garage
- Wood framed construction
- Individual HVAC systems, central water heating
- Common area support spaces

Analysis Baseline

- 2022 prescriptive requirements as starting point
 - Similar requirements across 2 prototypes
 - Heat pump space heating, except
 - CZ16 3-story prototype has gas furnace
 - CZ 1 & 16 5-story prototype has dual fuel heat pump
 - Gas central water heating with solar thermal
 - Minimum efficiency equipment
 - In-unit electric cooking and clothes drying
 - PV prescriptive standard
 - No change from 2019 for the 3-story - sized to offset electric loads in mixed fuel home
 - New PV requirement for 5-story
 - Battery prescriptive standard for 5-story

Packages

All-Electric

- Prescriptive
- Prescriptive & PV

Mixed-Fuel (2022 Baseline)

- Efficiency (3-story)
- Efficiency, PV, & Battery (3 story)

Assumptions & Caveats

- Focus on dwelling units and common area spaces only
 - Commercial spaces not evaluated
- Utility costs based on residential rates
- Impacts combined across all residential uses
- Results are preliminary
- CBECC 2022 new software that is actively being developed
- Further research on central HPWH solutions for the 2 prototypes
- Utility costs based on NEM 2.0



2022 Energy Code

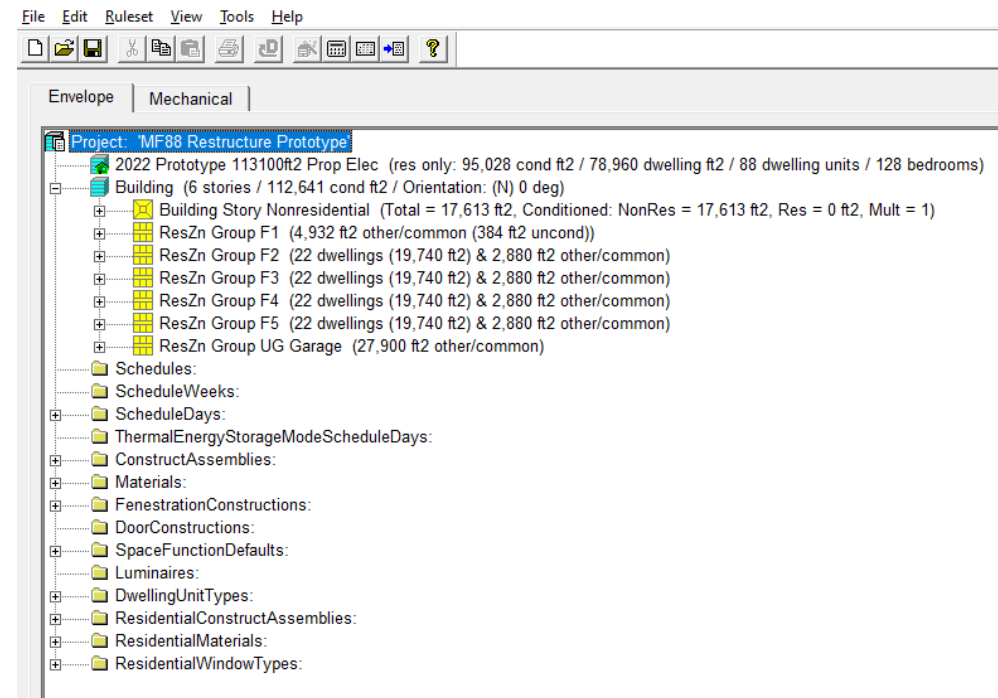
Multifamily Restructuring

- 2022 code combines all multifamily requirements
- Many (not all) requirements aligned between low-rise and high-rise.
 - Alignment ongoing into 2025 code cycle



CBECC 2022

- All multifamily buildings evaluated in same software
- CBECC-Com has been re-branded as “CBECC” and handles multifamily and commercial.
- Models dwelling units and common area spaces in California Simulation Engine (residential engine)



2022 Code & Heat Pump Baseline

- Heat pump space heaters are prescriptive baseline
 - Gas furnace in CZ16 for ≤ 3 story
 - Dual fuel heat pump in CZ 1 & 16 for >3 story
- Central HPWHs compared to central HPWHs, not gas system
- Mandatory requirements
 - Pre-wiring required for gas appliances
 - Higher ventilation rate for gas stoves

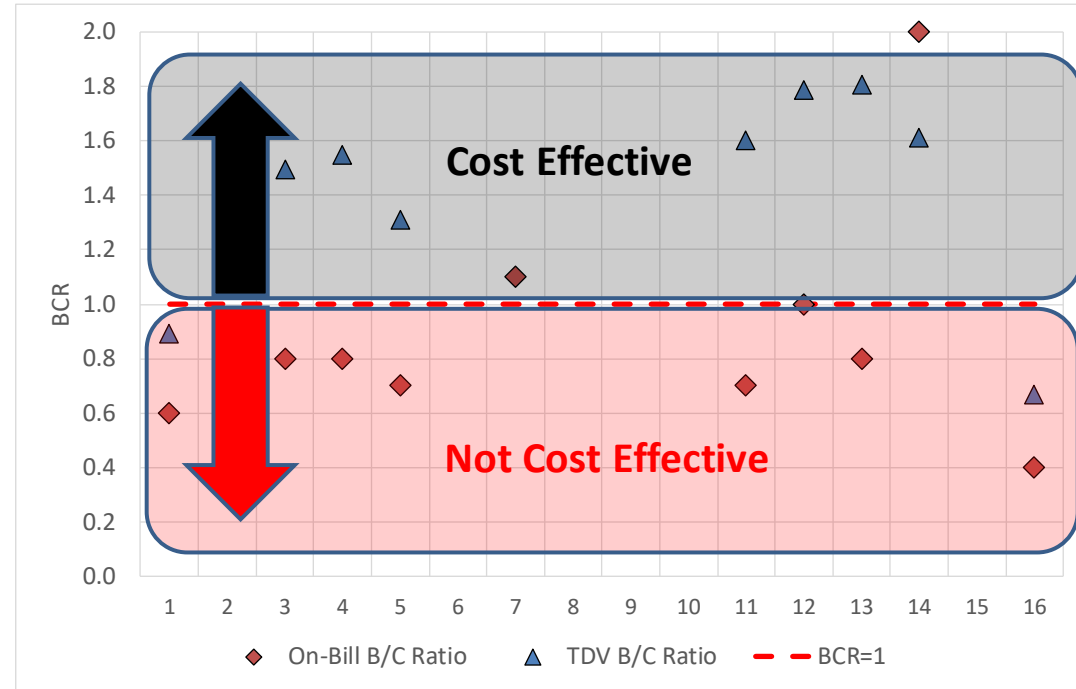




Costs

Cost Effectiveness

- Two methodologies
 - On-bill customer based
 - IOU TOU rates based on region + SMUD & CPAU
 - Escalation based CPUC En-Banc through 2030
 - Time Dependent Valuation (TDV) per CEC approach
- 30-year evaluation period
- Net Present Value (NPV) & Benefit-to-Cost Ratio (BCR)



$$NPV = PV \text{ of benefit} - PV \text{ of cost}$$

$$BCR = \frac{PV \text{ of benefit}}{PV \text{ of cost}}$$

Central Water Heating

Measure	Central Gas System (total first cost)	Central HPWH System (total first cost)	First Inc. Cost (per unit)	Replacement Inc. Cost (per unit)	Lifecycle Inc. Cost (per unit)
3-Story Loaded Corridor	CZ 1-9 20% solar fraction: \$173,772	\$211,531	\$1,049	\$332	\$1,381
	CZ 10-16 35% solar fraction: \$182,810		\$798	\$203	\$1,001
5-Story Mixed Use	CZ 1-9 20% solar fraction: \$279,163	\$439,218	\$1,819	\$1,058	\$2,877
	CZ 10-16 35% solar fraction: \$300,883		\$1,572	\$951	\$2,523

- System design & costs based on the 2022 All-Electric Multifamily Compliance Pathway CASE Report
 - https://title24stakeholders.com/wp-content/uploads/2021/04/2022-T24-Final-CASE-Report_MF-All-Electric_updated_V2.pdf

Replacement costs assume:

- Water heater equipment & tanks replaced at year 15
- Solar thermal collectors replaced at year 20
 - Glycol replaced every 9 years

Heat Pump Space Heaters

Measure	Gas System (first cost per unit)	Heat Pump System (first cost per unit)	First Inc. Cost (per unit)	Replacement Inc. Cost (per unit)	Lifecycle Inc. Cost (per unit)
Heat pump vs gas furnace/AC	\$20,667	\$16,776	(\$3,891)	\$859	(\$3,032)
Heat pump vs dual fuel heat pump	\$21,245	\$16,597	(\$4,647)	(\$1,725)	(\$6,373)

- System costs based on the 2022 All-Electric Multifamily Compliance Pathway CASE Report & recent equipment research

Replacement costs assume:

- Gas furnace / AC replaced at year 17.5. Heat pump and dual fuel heat pump replaced at year 15.

Gas Infrastructure Costs

Item	3-Story (Total)	5-Story (Total)	Sources/Notes
TDV Calculations			
Plan Review	\$2,316	\$1,864	Palo Alto. 5-story assumes cost split between residential and commercial spaces (80/20)
Service Extension	\$6,750	\$6,750	Data from PG&E, assumes in-fill & joint trenching
Meter – DHW only	\$3,600	\$3,600	Data from PG&E: \$3,600 per small commercial
Meter – Gas DHW & space heat	\$25,200	\$56,400	meter, \$600 per dwelling unit
Total Cost – DHW only	\$12,666	\$12,214	
Total Cost – DHW + space heat	\$34,266	\$65,014	
On-Bill Calculations – less deductions			
Gas extension rules – deduction	\$(3,375)	\$(3,375)	50% discount per utility gas extension rules
Total Cost – DHW only	\$9,291	\$8,839	
Total Cost – DHW + space heat	\$30,891	\$61,639	

- Costs align with 2019 reach code reports and based on data from PG&E 2019 memo and Space and Water Heating Electrification in Palo Alto: Code Feasibility and Cost Effectiveness Analysis
- In-building electric and gas infrastructure costs included in individual measures

PV & Battery Costs

Measure	Performance Level	Lifecycle Incremental Cost	Source & Notes
PV	First Cost, per Watt	\$3.61	Tracking the Sun 2021. \$3.90/W California cost less average ITC of 7% (22% in 2023, 0% in 2024/2025)
	Inverter replacement, per Watt	\$0.14 (Present Value)	E3 2019 Solar PV CASE report. Replacement at years 10 and 20.
	Maintenance, per Watt	\$0.31 (Present Value)	E3 2019 Solar PV CASE report
Battery	First cost, per kWh	\$694	2020 Battery Reach Code report
	Replacement cost, per kWh	\$505	2020 Battery Reach Code report. Replacement at years 10 and 20.

Efficiency Measures (3-story only)

Measure	Performance Level	Lifecycle Incremental Cost (per dwelling unit)	Source & Notes
High Performance Window (U-Factor/SHGC)	0.24/0.50 vs 0.30/0.35 (Cold Climate)	\$426	2019 Statewide High Performance Window report
Cool Roof - Aged Solar Reflectance	0.70 vs 0.63	\$24	2022 Nonresidential High Performance Envelope CASE report
Low Pressure Drop Ducts	0.35 vs 0.45 W/cfm	\$44	½ hour of labor
Verified Low Leakage Ducts in Conditioned Space	HERS tested <=25 cfm vs 12% total leakage	\$132	1-1/2 hour of labor



Results

3-Story All-Electric Prescriptive

- Prescriptive package
 - Represents electrification of central water heating only in CZs 1-15
 - CZ16: Also includes heat pump space heating versus gas furnace
- Sanden central HPWH
- Increase in utility cost except for CPAU/SMUD

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	15%	26%	>1	\$3,511	>1	\$6,012
2	PGE	16%	24%	1.5	\$506	3.8	\$2,903
3	PGE	15%	27%	1.4	\$454	3.8	\$2,902
4	PGE	17%	22%	1.7	\$750	3.8	\$2,911
4	CPAU	17%	22%	5.9	\$5,556	3.8	\$2,911
5	PGE	17%	30%	1.6	\$725	3.9	\$3,010
5	PGE/SCG	17%	30%	0.2	(\$849)	3.9	\$3,010
6	SCE/SCG	17%	27%	0.7	(\$282)	3.8	\$2,838
7	SDGE	18%	31%	0.7	(\$308)	3.9	\$2,978
8	SCE/SCG	16%	21%	0.7	(\$310)	3.6	\$2,727
9	SCE/SCG	16%	21%	0.7	(\$346)	3.6	\$2,668
10	SCE/SCG	15%	19%	0.0	(\$710)	4.2	\$2,064
10	SDGE	15%	19%	0.0	(\$1,223)	4.2	\$2,064
11	PGE	14%	17%	1.0	\$8	4.1	\$2,026
12	PGE	15%	20%	1.1	\$93	4.3	\$2,153
12	SMUD/PGE	15%	20%	5.1	\$3,031	4.3	\$2,153
13	PGE	13%	15%	0.9	(\$87)	3.8	\$1,850
14	SCE/SCG	16%	19%	0.1	(\$696)	4.4	\$2,213
14	SDGE	16%	19%	0.0	(\$1,247)	4.4	\$2,213
15	SCE/SCG	15%	11%	0.4	(\$468)	3.9	\$1,898
16	PGE	36%	24%	1.6	\$1,129	>1	\$3,945

3-Story All-Electric Prescriptive & PV

- Increases PV capacity to offset 90% of electricity use
- Cost-effectiveness improves substantially

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	24%	26%	2.1	\$11,508	1.3	\$3,497
2	PGE	24%	24%	2.4	\$10,568	1.7	\$4,875
3	PGE	24%	27%	2.5	\$10,142	1.7	\$4,747
4	PGE	24%	22%	2.5	\$9,737	1.8	\$5,240
4	CPAU	24%	22%	1.9	\$5,971	1.8	\$5,240
5	PGE	27%	30%	2.6	\$10,181	1.8	\$5,195
5	PGE/SCG	27%	30%	2.4	\$8,607	1.8	\$5,195
6	SCE/SCG	25%	27%	1.9	\$4,073	2.0	\$4,651
7	SDGE	28%	31%	3.5	\$14,476	1.8	\$4,722
8	SCE/SCG	24%	21%	1.9	\$4,342	2.0	\$5,081
9	SCE/SCG	23%	21%	1.9	\$3,960	2.1	\$4,700
10	SCE/SCG	23%	19%	1.9	\$4,104	1.9	\$4,186
10	SDGE	23%	19%	4.2	\$14,545	1.9	\$4,186
11	PGE	22%	17%	2.4	\$9,384	1.6	\$3,926
12	PGE	22%	20%	2.5	\$9,131	1.7	\$4,070
12	SMUD/PGE	22%	20%	1.7	\$4,294	1.7	\$4,070
13	PGE	20%	15%	2.5	\$8,013	1.7	\$3,721
14	SCE/SCG	25%	19%	2.1	\$5,333	2.1	\$5,137
14	SDGE	25%	19%	5.1	\$20,208	2.1	\$5,137
15	SCE/SCG	20%	11%	1.8	\$2,808	2.0	\$3,325
16	PGE	43%	24%	3.7	\$14,226	2.2	\$6,448

5-Story All-Electric Prescriptive

- Prescriptive package
 - Represents electrification of central water heating only in CZs 2-15
 - CZs 1,16: Also includes heat pump space heating versus dual fuel heat pump
- Colmac central HPWH
 - Lower performance, higher incremental cost

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	3%	4%	1.8	\$1,805	>1	\$5,520
2	PGE	3%	5%	0.0	(\$4,032)	0.6	(\$1,126)
3	PGE	3%	5%	0.0	(\$4,249)	0.5	(\$1,271)
4	PGE	3%	5%	0.0	(\$3,692)	0.7	(\$747)
4	CPAU	3%	5%	1.9	\$2,555	0.7	(\$747)
5	PGE	4%	6%	0.0	(\$4,059)	0.6	(\$1,099)
5	PGE/SCG	4%	6%	0.0	(\$5,602)	0.6	(\$1,099)
6	SCE/SCG	4%	5%	0.0	(\$4,103)	0.7	(\$918)
7	SDGE	5%	6%	0.0	(\$7,953)	0.7	(\$825)
8	SCE/SCG	4%	5%	0.0	(\$4,374)	0.8	(\$433)
9	SCE/SCG	-6%	0%	0.0	(\$5,109)	0.4	(\$1,638)
10	SCE/SCG	1%	3%	0.0	(\$4,974)	0.3	(\$1,706)
10	SDGE	1%	3%	0.0	(\$11,591)	0.3	(\$1,706)
11	PGE	1%	3%	0.0	(\$4,257)	0.3	(\$1,622)
12	PGE	3%	4%	0.0	(\$4,387)	0.2	(\$1,827)
12	SMUD/PGE	3%	4%	0.9	(\$249)	0.2	(\$1,827)
13	PGE	1%	3%	0.0	(\$4,201)	0.3	(\$1,767)
14	SCE/SCG	2%	3%	0.0	(\$5,066)	0.4	(\$1,494)
14	SDGE	2%	3%	0.0	(\$7,482)	0.4	(\$1,494)
15	SCE/SCG	3%	3%	0.0	(\$3,833)	0.6	(\$1,016)
16	PGE	8%	-7%	0.9	(\$273)	1.2	\$692

5-Story All-Electric Prescriptive & PV

- Increases PV capacity to offset 90% of electricity use
- Cost-effectiveness improves substantially

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	16%	4%	6.4	\$15,020	5.3	\$11,643
2	PGE	12%	5%	3.0	\$5,681	3.8	\$7,554
3	PGE	14%	5%	4.0	\$8,398	4.1	\$8,412
4	PGE	11%	5%	2.4	\$4,000	3.3	\$6,290
4	CPAU	11%	5%	3.0	\$5,660	3.3	\$6,290
5	PGE	16%	6%	3.4	\$6,754	3.5	\$6,817
5	PGE/SCG	16%	6%	2.9	\$5,211	3.5	\$6,817
6	SCE/SCG	9%	5%	0.7	(\$908)	1.9	\$2,524
7	SDGE	13%	6%	1.8	\$2,287	2.5	\$3,973
8	SCE/SCG	13%	5%	1.5	\$1,286	2.9	\$5,230
9	SCE/SCG	1%	0%	0.7	(\$696)	2.0	\$2,782
10	SCE/SCG	10%	3%	1.3	\$824	2.6	\$3,756
10	SDGE	10%	3%	2.1	\$2,763	2.6	\$3,756
11	PGE	13%	3%	4.7	\$8,998	5.0	\$9,493
12	PGE	11%	4%	3.3	\$5,527	3.7	\$6,420
12	SMUD/PGE	11%	4%	2.9	\$4,502	3.7	\$6,420
13	PGE	12%	3%	4.2	\$7,856	4.2	\$7,592
14	SCE/SCG	10%	3%	1.2	\$561	2.7	\$3,952
14	SDGE	10%	3%	2.4	\$3,375	2.7	\$3,952
15	SCE/SCG	8%	3%	0.9	(\$352)	1.8	\$2,023
16	PGE	20%	-7%	>1	\$18,964	>1	\$13,307

3-Story Mixed Fuel Packages

Efficiency

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	1%	4%	4.1	\$587	3.2	\$418
2	PGE	n/a					
3	PGE						
4	PGE						
4	CPAU						
5	PGE						
5	PGE/SCG						
6	SCE/SCG						
7	SDGE						
8	SCE/SCG						
9	SCE/SCG						
10	SCE/SCG	1%	5%	3.3	\$480	3.5	\$527
10	SDGE	1%	5%	5.1	\$876	3.5	\$527
11	PGE	2%	6%	5.6	\$971	5.3	\$912
12	PGE	1%	5%	2.1	\$569	2.1	\$587
12	SMUD/PGE	1%	5%	1.0	\$11	2.1	\$587
13	PGE	2%	6%	5.7	\$1,003	5.6	\$968
14	SCE/SCG	2%	6%	4.8	\$795	5.0	\$850
14	SDGE	2%	6%	18.1	\$3,625	5.0	\$850
15	SCE/SCG	2%	8%	8.0	\$1,488	7.9	\$1,459
16	PGE	6%	7%	2.3	\$817	2.2	\$720

Efficiency, 100% PV, & 100kWh Battery

Climate Zone	Electric/ Gas Utility	Source Energy Comp Margin	Efficiency TDV Comp Margin	On-Bill (per Dwelling Unit)		2022 TDV (per Dwelling Unit)	
				B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	10%	4%	1.4	\$5,249	0.8	(\$1,948)
2	PGE	9%	0%	1.5	\$4,179	0.9	(\$497)
3	PGE	9%	0%	1.4	\$3,618	0.9	(\$591)
4	PGE	8%	0%	1.4	\$3,354	1.0	\$18
4	CPAU	8%	0%	0.6	(\$3,019)	1.0	\$18
5	PGE	10%	0%	1.4	\$3,518	0.9	(\$458)
5	PGE/SCG	10%	0%	1.4	\$3,518	0.9	(\$458)
6	SCE/SCG	9%	0%	1.2	\$1,106	0.9	(\$612)
7	SDGE	11%	0%	2.1	\$7,852	1.0	(\$99)
8	SCE/SCG	9%	0%	1.3	\$1,803	1.0	(\$147)
9	SCE/SCG	8%	0%	1.2	\$1,428	0.9	(\$650)
10	SCE/SCG	10%	5%	1.3	\$2,199	1.0	\$341
10	SDGE	10%	5%	2.3	\$8,632	1.0	\$341
11	PGE	10%	6%	1.6	\$4,790	1.1	\$510
12	PGE	9%	5%	1.4	\$3,560	1.0	\$131
12	SMUD/PGE	9%	5%	0.8	(\$1,670)	1.0	\$131
13	PGE	10%	6%	1.5	\$3,770	1.0	\$275
14	SCE/SCG	11%	6%	1.5	\$3,564	1.2	\$1,418
14	SDGE	11%	6%	2.6	\$11,414	1.2	\$1,418
15	SCE/SCG	10%	8%	1.3	\$1,861	1.0	\$290
16	PGE	11%	7%	1.3	\$2,146	0.9	(\$704)



Summary

Conclusions

- Electrification of central water heating cost-effective in some cases, more challenging in others
 - More cost-effective based on TDV
- All-electric buildings are generally compliant with the 2022 code
- Adding PV to the packages improves On-Bill cost-effectiveness
- ~10% source energy savings are achievable cost-effectively for mixed fuel design

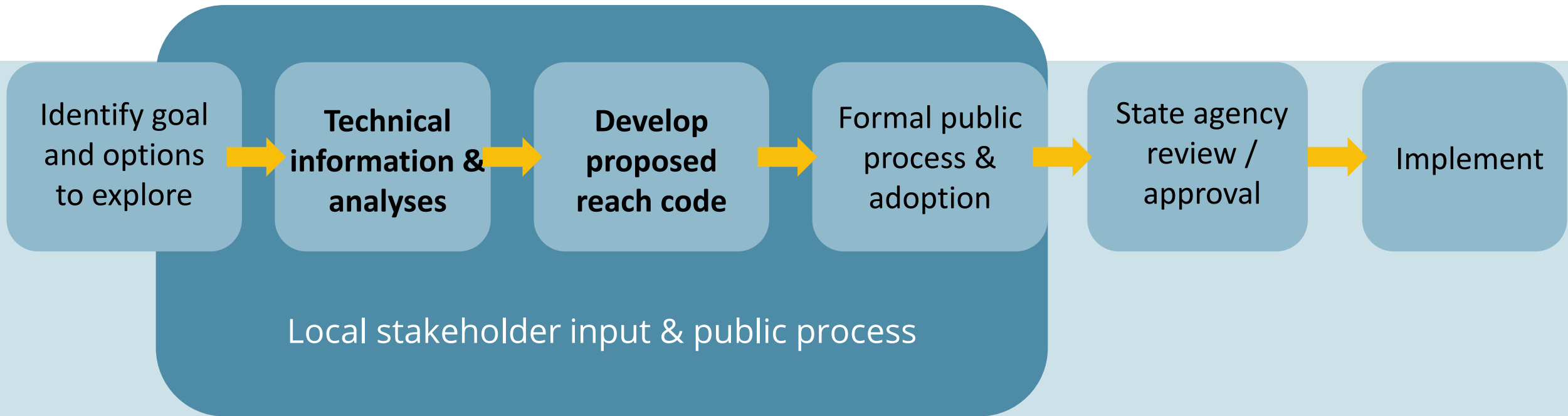
Next Steps

- Update results to CBECC 2022.1.0 (or updated version)
- Investigate central HPWH options for larger multifamily buildings (5-story prototype)
- Evaluate efficiency packages for the 5-story prototype & the all-electric packages.



Initial Considerations

Reach Code Process



New Construction Ordinance Approaches

	Efficiency	Electric-Preferred	Electric Only		Electric Only Plus Efficiency
			Natural Gas Moratorium	Electric Only	
Mechanism	Energy Code	Energy Code	Jurisdictional authority (e.g., Health and Safety)	CALGreen	(Jurisdictional authority or CALGreen) plus Energy Code
Requirements	All new construction exceeds minimum energy code	Only mixed fuel buildings exceed minimum energy code	No new gas infrastructure (Hookups or Piping)	All new construction is electric only	All new construction is electric only AND exceeds minimum
Considerations	Simplicity Preserves choice	Preserves Choice Encourages electric designs	Longest Lasting	Must be renewed	Biggest impact Must be renewed

From a Study to an Ordinance

Explorer.LocalEnergyCodes.com



The screenshot shows the 'Summary for City of Palo Alto' page. The left sidebar contains navigation links: Summary, Building Estimates, Results, Policies, YOUR ACCOUNT, NEXT STEPS, INFO, HELP, and QA TICKETS. The main content area features a 'Summary for City of Palo Alto' header with a 'Share' button. Below the header, it states 'CITY OF PALO ALTO HAS 1 CLIMATE ZONE: 4'. An illustration of a person pointing at data charts is shown. The main content is divided into two columns: 'Existing Buildings' and 'New Construction'. The 'Existing Buildings' section includes a 'Create a policy' button and a link to 'Explore study results'. The 'New Construction' section includes a 'Create a policy' button, a 'Download impact model' link, and a link to 'Key concepts for the 2022 code cycle'. Below these sections is a 'Cost-Effectiveness Studies' section with a 'Study Versions' dropdown set to 'Latest' and a list of studies, including 'Existing Residential Buildings Study' with a 'CREATE POLICY' button.

New features and results:

- 2022 Single family preliminary results
- Citywide forecasts
- Impact Model

**Schedule a
15-minute
walkthrough!**

explorer@localenergycodes.com

Thank You!



We appreciate your time!

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Links from Presentation

- [Support for HPWH Energy Modeling Advancements Project](#)
- [Energy Code Ace Heat Pump Water Heaters Serving Single Dwellings](#)
- [SDG&E Power Your Drive Research Report](#)
- [SDG&E Power Your Drive Program](#)

- [LocalEnergyCodes.com](#)
- [Explorer.LocalEnergyCodes.com](#)
- [2022 Title 24 Multifamily Restructuring report](#)