Welcome to the California Statewide Codes and Standards Enhancement (CASE) Team's Stakeholder Meeting on

Grid Integration Topics

We'll get started shortly.

In the meantime, please fill out the polls below.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Pacific Gas and Electric Company

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2022 TITLE 24 CODE CYCLE, PART 6

First Utility-Sponsored Stakeholder Meeting

Grid Integration Topics

Statewide CASE Team

September 10, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Meeting Guidelines

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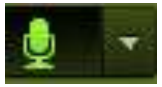

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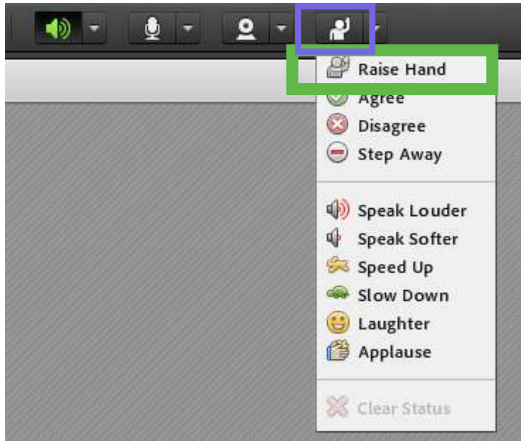
Meeting Guidelines

Participation Guidelines

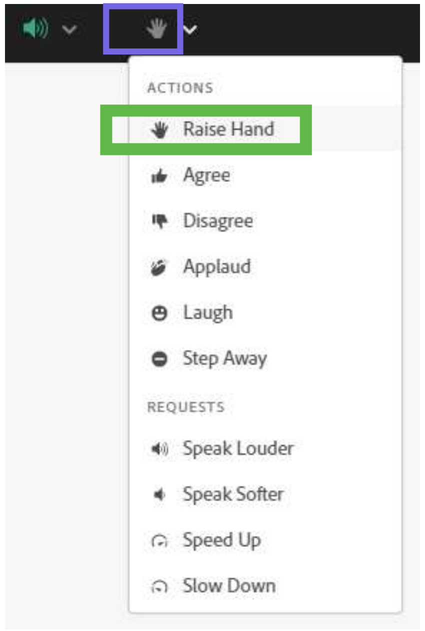
- **Questions & Comments**
  - Click ***"Raise Hand"*** if you would like to speak. Those with a hand raised will be called on by the speaker.
  - All questions and comments are also welcome via the chat window.

- **Other Meeting Feedback**
  - Provide live meeting feedback from the **top toolbar drop-down**.



Above: *feedback view for Adobe Connect app users.*

Below: *feedback view for HTML users.*



Meeting Ground Rules

- **We want to hear your thoughts**
  - Supporting and opposing viewpoints are welcome
- **When making comments**
  - Unmute yourself
  - Clearly state your name and affiliation prior to speaking
  - Speak loudly for phone audio
  - Place yourself back on mute
- **Calls are recorded** for note development, recordings will not be publicized
- Notes and presentation material will be posted on Title24Stakeholders.com

Agenda

1	**Meeting Guidelines**	*8:30 am*
2	**Opening Remarks** from the California Energy Commission	*8:35 am*
3	**Overview & Welcome** from the Statewide Utility Team	*8:40 am*
4	**Presentation I:** Single Family Grid Integration	*8:45 am*
5	**Presentation II:** Nonresidential Grid Integration	*10:15 am*
6	**Presentation III:** Multifamily All Electric Package	*11:20 am*
7	Wrap Up and Action Items	*12:20 pm*
8	Closing	*12:25 pm*

Opening Remarks: California Energy Commission

Payam Bozorgchami

Project Manager

California Energy Commission

Policy Drivers: Building Standards

The following policy documents establish the goal for new building standards:

- **2008 CPUC/CEC Energy Action Plan** – ZNE for Residential buildings by 2020 and nonresidential buildings by 2030
- **SB 100** – Clean electricity by 2045
- **B-55-18** – Governor Jerry Brown’s Executive Order to achieve carbon neutrality
- **AB 3232** – Assess the potential for the state to reduce the emissions of greenhouse gases from the state’s residential and commercial building stock by at least 40% below 1990 levels by January 1, 2030

9

2022 Standards Schedule

ESTIMATED DATE	ACTIVITY OR MILESTONE
November 2018 - April 2019	Updated Weather Data Files
November 2018 - July 2019	Measures Identified and Approved (Internal at the Energy Commission)
November 2018 - July 2019	Compliance Metrics Development
April 24, 2019	Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data workshop
November, 2019	Final Metrics Workshop
November, 2019	Research Version of CBECC Available with new weather data files and updated Metrics
July 2019 - March 2020	Utility-Sponsored Stakeholder Workshops
March, 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
March - August 2020	Commission-Sponsored Workshops
July, 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
July - September 2020	Express Terms Developed
January, 2021	45-Day Language posted and set to list serve, Start of 45-Day review/comment period
January, 2021	Lead Commissioner Hearing
April, 2021	Adoption of 2022 Standards at Business Meeting
May - November 2021	Staff work on Software, Compliance Manuals, Electronic Documents
May - November 2021	Final Statement of Reasons Drafted and Approved
October, 2021	Adoption CalGREEN (energy provisions) - Business Meeting
December, 2021	CBSC Approval Hearing
January, 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January - December 2022	Standards Training (provided by 3rd parties)
June 1, 2022	6 Month Statutory Wait Period Deadline
January 1, 2023	Effective Date

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More information on pre-rulemaking for the 2022 Energy Code at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Title 24, Part 6 Overview

Kelly Cunningham
Codes and Standards
Pacific Gas & Electric

Statewide Utility Codes and Standards Team

- **Actively supporting the California Energy Commission** in developing proposed changes to the California Energy Code (Title 24, Part 6)
- Achieve significant energy savings through the development of **feasible**, **enforceable**, **cost-effective, and non-proprietary** code change proposals for the 2022 code update, and beyond

Requirements for a Successful Code Change Proposal

The utilities support the California Energy Commission by proposing changes to the Energy Code that are:

Feasible | Cost effective | Enforceable | Non-proprietary

Utility-Sponsored Stakeholder Meetings

- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- Sign up to receive email notifications

First Round Utility-Sponsored Stakeholder Meetings

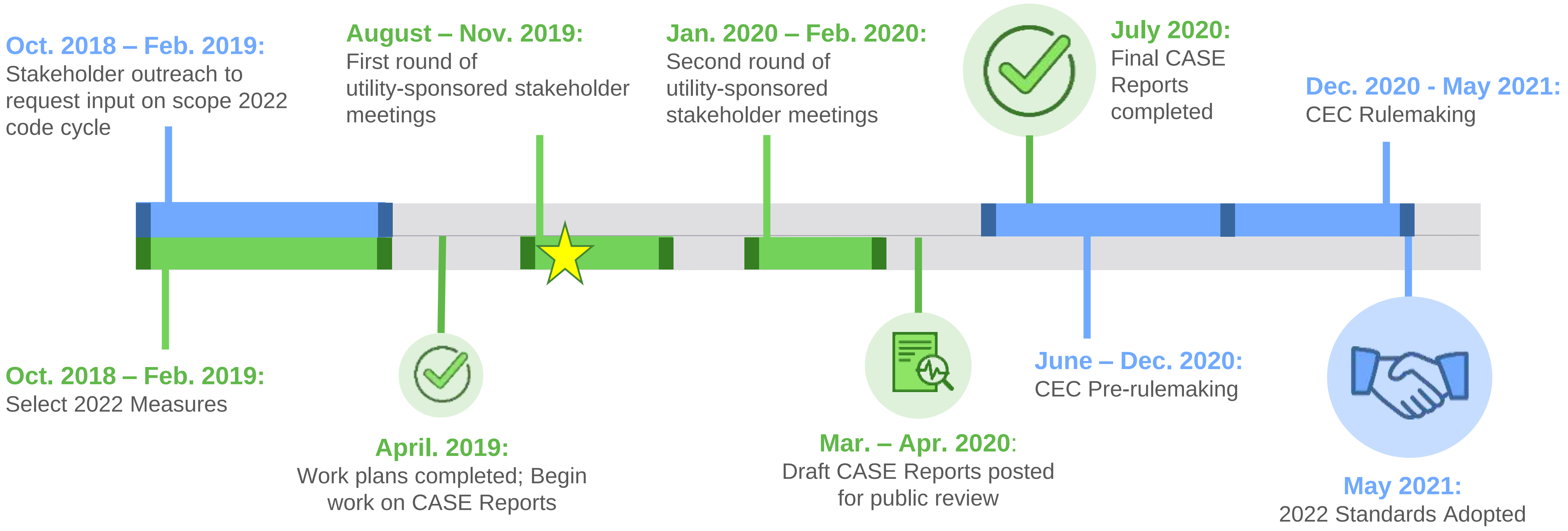
Meeting Topic	Building Type	Date
Grid Integration	SF/NR	Tuesday, September 10, 2019
Lighting Part 2: Indoor Lighting	NR	Thursday, September 12, 2019
Covered Processes Part 1: Controlled Environment Horticulture	NR	Thursday, September 19, 2019
Multifamily & Nonresidential Water Heating	MF/NR	Thursday, October 3, 2019
Single Family HVAC	SF	Thursday, October 10, 2019
Nonresidential HVAC Part 1: Data Centers, Boilers, & Controls	NR	Tuesday, October 15, 2019
Nonresidential Envelope	NR	Thursday, October 24, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Tuesday, November 5, 2019
Nonresidential HVAC Part 2: Air Distribution, & Controls	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019

Sign up for all meetings at title24stakeholders.com/events/

2022 Code Cycle – Key Milestones

CEC Milestone

Utility Team Milestone



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Learn how to comply with California's building and appliance energy efficiency standards

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offers **No-Cost**

Tools · Training · Resources

to help you decode Title 24, Part 6 and Title 20

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This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities Commission.

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www.LocalEnergyCodes.com

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Single Family Grid Integration

Codes and Standards Enhancement (CASE) Proposal

Single Family Residential | Controls

Bob Hendron and Kristin Heinemeier, *Frontier Energy*

David Zhang, *Energy Solutions*

Ben Larson, *Ecotope*

September 10, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

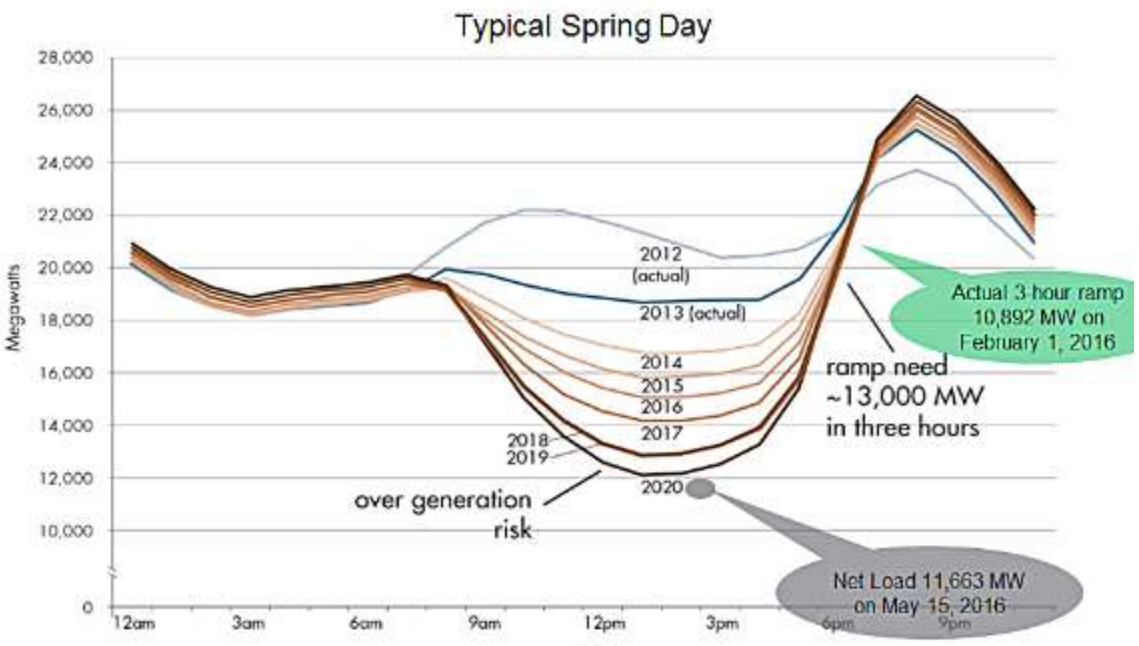
1	Background	*2 min*
2	Batteries	*22 min*
3	Heat Pump Water Heater Load Shifting	*22 min*
4	HVAC Load Shifting	*22 min*
5	Home Energy Management	*22 min*

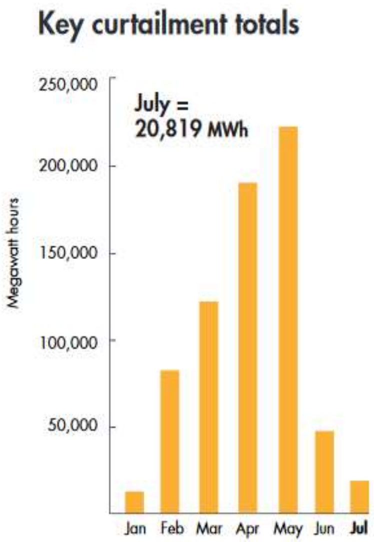
Background

- Context and History
- Code Change Proposal Summary

Context and History

- Maintaining grid stability continues to grow in importance as renewables increase, driven by state policies such as SB 32 and SB 100
- Shift household electricity use from peak periods to off-peak periods (align with PV)
- Technological advances allow for peak demand reduction through several means:
    - Energy storage
    - Rescheduling of loads
    - Turning off non-critical devices





Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Residential Single Family	Grid Integration	Compliance options	Yes

Expand compliance options for grid integration technologies that provide flexibility in electricity demand in response to utility signals and/or programming by homeowners without sacrificing comfort or functionality.

- Four submeasures under consideration
- Emphasis on compliance flexibility and fair credits
- Objective qualification criteria

Submeasure A: Batteries

Submeasure B: Heat Pump Water Heater Load Shifting

Submeasure C: HVAC Load Shifting

Submeasure D: Home Energy Management

Background

- 2019 Code Requirements
- Code Change Proposal

2019 Code Requirements

Title 24, Part 6, Residential Compliance Manual, Chapter 7.5 / Reference Appendices, JA12

Requirement Category	Single Family Building Requirement
Performance	• Round Trip Efficiency (RTE) – Minimum 80 percent • Storage Capacity - at least 5kWh
Controls Strategy	• Time-Of-Use (TOU) Control • Advanced Demand Response (DR) Control • Basic Control
Other Requirements	• Installation and Control Strategy Verification • Self Utilization Credit for Single Family PV Coupled Storage • Safety tested with UL1973 and UL9540 • Interconnection complies with Rule 21 / NEM

Items in black considered for code change

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**
- **Description of change**
  - Update Time-of-Use (TOU) and Advanced Demand Response battery control strategies to better utilize the battery system during periods of peak energy demand / high electricity costs
  - Develop procedure for testing and verifying battery round trip efficiency (RTE)
  - Increase minimum RTE requirements for battery systems

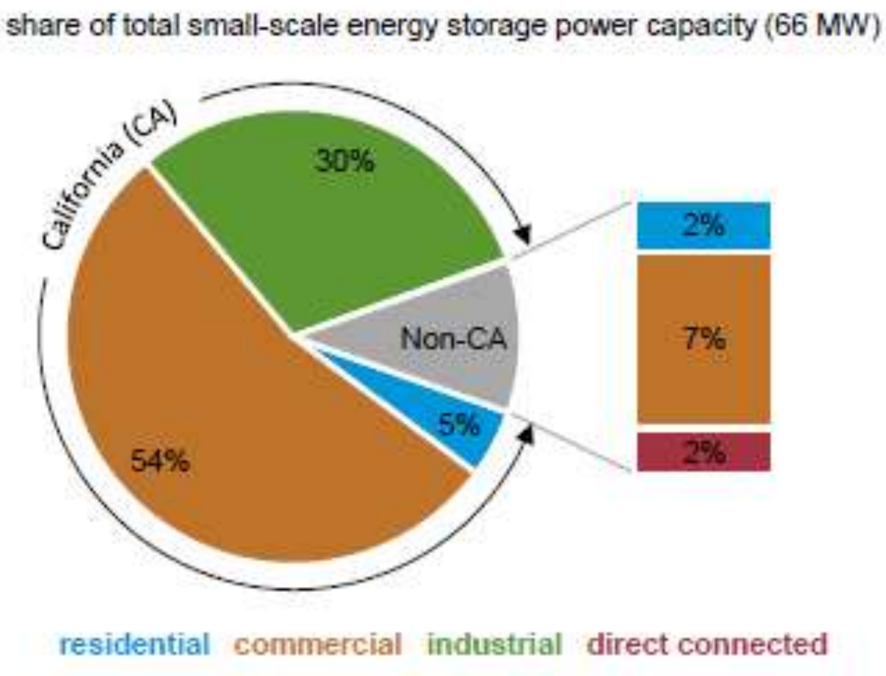
Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - EIA estimated 66 MW of installed small-scale storage capacity in the United States in 2016[1]
    - 90 percent in California, but only 5 percent residential[1]
  - The SGIP 2017 Annual Evaluation showed 49 percent of rebates awarded to residential installations amounting to ~2 MW[2]
  - Current incentives through SGIP utilize Performance Based Incentives[2]

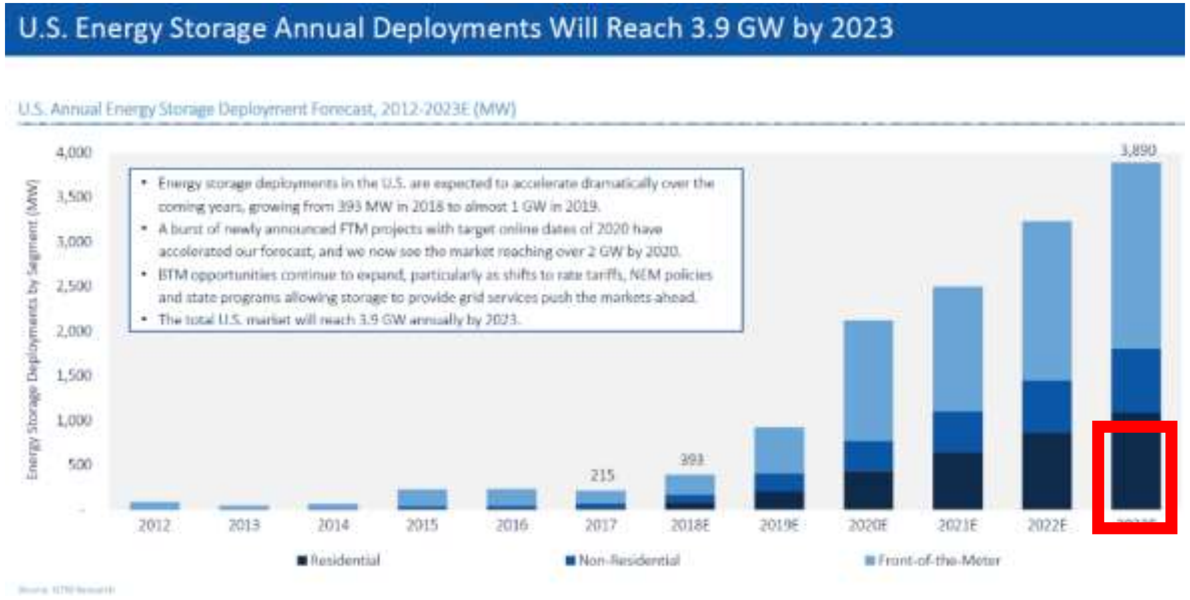
EIA Small Scale Battery Storage Trends[1]



[1]EIA, U.S Battery Storage Market Trends, May 2018, https://www.eia.gov/analysis/studies/electricity/batterystorage/
[2]CPUC, 2017 SGIP Advanced Energy Storage Impact Evaluation, Sept. 7th, 2018, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/2017_SGIP_AES_Impact_Evaluation.pdf

Market Overview and Analysis

GTM Executive Summary on Energy Storage Projections



- Residential Energy Storage in the US projected to exceed 1,000 MW by 2023[1]
- California projected to maintain majority of residential and behind-the-meter (BTM) installations
- Battery costs declined 15 percent per year from 2012 to 2017 – totaling a 5-year 50 percent reduction[2]

[1] GTM Research, U.S. Energy Storage Monitor: Q3 2018 Executive Summary, Sept 2018, http://roedel.faculty.asu.edu/sec598f18/pdf/US_ESM_Q3_2018.pdf

[2] McKinsey & Company, The New Rules of Competition in Energy Storage, June 2018, https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-new-rules-of-competition-in-energy-storage

Market Overview (Cont.) and Potential Market Barriers

- California shifting over 20 million customers to Time-of-Use rates[1]
- Battery storage companies raised $1.4 billion combined in capital funding in the first six months of 2019[2]
- Continued growth expected across the United States

- Potential Market Barriers
  - Although costs have fallen, battery storage systems maintain relative high capital costs
  - Single Tesla Powerwall listed at ~$6,500[3] with 13.5kWh usable battery capacity
  - Soft costs: Permitting offices / discrepancies on how code is interpreted by officials

[1] Utility Dive, California Utilities Prep Nation's Biggest Time-of-Use Rate Rollout, Dec 2018, https://www.utilitydive.com/news/california-utilities-prep-nations-biggest-time-of-use-rate-roll-out/543402/
[2] Utility Dive, Battery Storage Companies Set $1.4B Record in Venture Capital Funding: Report, July 2019, https://www.utilitydive.com/news/battery-storage-companies-set-14b-record-in-venture-capital-funding-repo/559379/
[3] Tesla, Powerwall Specs, July 2019, https://www.tesla.com/powerwall

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Battery Round Trip Efficiency (RTE)

- Most available data shows 85 - 90 percent RTE[1] for lithium ion storage, also investigating lead acid and flow batteries
- Minimum RTE requirement (80 percent) could be increased with minimal impact to the battery market design
- Efficiency losses can be due to:
  - Parasitic Loads (System cooling, communications, and power electronic loads) (2 – 3 percent)[2]
  - AC-DC conversion losses (3 – 5 percent)[3]

Manufacturer	AC-AC RTE	Notes
Tesla Powerwall 2	90 percent[4]	
LGChem RESU 10H [9.8kWh]	89 percent	95 percent DC-DC RTE, 97 percent Inverter / Rectifier Efficiency[5]
Sonnen Eco	86 percent[6]	
Enphase IQ	90 percent	96 percent DC-DC RTE, 97 percent Inverter /Rectifier Efficiency[7]

[1] HOMERPro, https://www.homerenergy.com/products/pro/index.html
[2] 2017 SGIP Advanced Energy Storage Impact Evaluation, Sept. 7th, 2018, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/2017_SGIP_AES_Impact_Evaluation.pdf
[3] Utility Interactive Inverters, Go Solar California, July 15th, 2019, https://www.gosolarcalifornia.ca.gov/equipment/documents/Utility_Interactive_Inverter_List_Simplified_Data.xlsx
[4] Tesla Powerwall 2 Datasheet, https://www.tesla.com/sites/default/files/pdfs/powerwall/Powerwall%202_AC_Datasheet_en_northamerica.pdf
[5] LG Chem RESU10H, https://www.ecodirect.com/LG-Chem-RESU-10H-SEG-9-8-kWh-Lithium-Ion-Battery-p/lg-chem-resu-10h.htm
[6] Tech Specs sonnenBAtteri eco, http://alternateenergycompany.com/home/pdf/sonnen/sonnen_eco_tech_specs.pdf
[7] Enphase AC Battery Data Sheet, https://enphase.com/sites/default/files/downloads/support/AC-Battery-DS-EN-US_1.pdf

Time of Use (TOU) Control Strategy in CBECC-Res

- Default TOU control strategy does not align with CA TOU periods in CBECC-Res
- Default TOU battery discharge time starts at either 6pm or 7pm for July – Sep.
- California TOU Periods
  - Most common TOU tariff defines peak period to be from 4pm – 9pm
  - Peak periods apply during the Summer (June – Sep.) and Winter (Oct. – May)
  - Alternative TOU tariffs define peak periods to be from 3pm- 8pm and 5pm – 8pm
  - Default TOU rates began March 2019 for SDG&E[1] and will start Oct. 2020 for PG&E[2] and SCE[3]

CBECC-Res TOU Default Discharge for Climate Zone 9

Time Of Use Peak Period

[1] SDG&E Time-of-Use Pricing Plans, 2019, https://www.sdge.com/whenmatters#plans
[2] PG&E TOU Rate Plans, 2019, https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/time-of-use-base-plan/time-of-use-plan.page
[3] Rate Plan Options from Southern California, 2018, https://pages.email.sce.com/RatePlanOptions/en

Advanced Demand Response (DR) Control

- Batteries must be capable of responding to demand response signals (JA12)

- A growing number of residential Demand Response aggregators[1] means that demand response control could become more common

- Advanced DR Control:
  - **Current:** Activates on days with peak TDV > 10TDV/kBTU
  - **Future:** ?

[1] CPUC Consumer FAQ on DR Providers, February 15th, 2019, https://www.cpuc.ca.gov/General.aspx?id=6306

Self Utilization Credit

- Option for homes with on-site solar and storage
- Credit can be used for tradeoffs against building envelope and efficiencies of the equipment installed in a building
- New combined solar and behind the meter storage use cases are increasing:
  - Community Scale Solar (fasted growing segment for solar projects)[1]
  - Community Solar
  - Microgrids

What are some benefits / drawbacks of offering self utilization credits to these new use cases?

[1]RMI, Progress and Potential for Community Scale Solar, 2018 https://rmi.org/insight/progress-potential-community-scale-solar/

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- CBECC-Res will be used for all energy analysis
- Building Prototype: 2,100ft^2 and 2,700ft^2 one-story homes
  - Two Versions: Electric Water Heater and Gas Water Heater
  - **What weighting of each prototype model version should be used for modeling?**
- Sensitivity Analysis of 2022 TDV savings to:
  - Battery Sizing
  - Battery Charging / Discharging Efficiency
  - Control System
  - Self Utilization Credit
  - Climate Zone (All climate zones will be evaluated)

Assumptions for Energy and Cost Impacts Analysis

- Battery Size: 13.5kWh (Tesla Powerwall 2)
- Round Trip Efficiency (RTE)
  - Baseline: 80% (Minimum RTE Requirement in JA12)
  - Proposed: X percent
- Cycles per year: 350
- Capacity Retention: 70 percent over 10 years
- Period of evaluation: 30 years
- Control System
  - Baseline: Basic, Time-of-Use, Advanced DR
  - Proposed: Time-of-Use (new), Advanced DR (new)
- Statewide savings = Per Unit Savings * Forecasted Number of Homes with Single Family Battery Storage

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Battery control strategies meet the options in JA12
- Solar PV is present

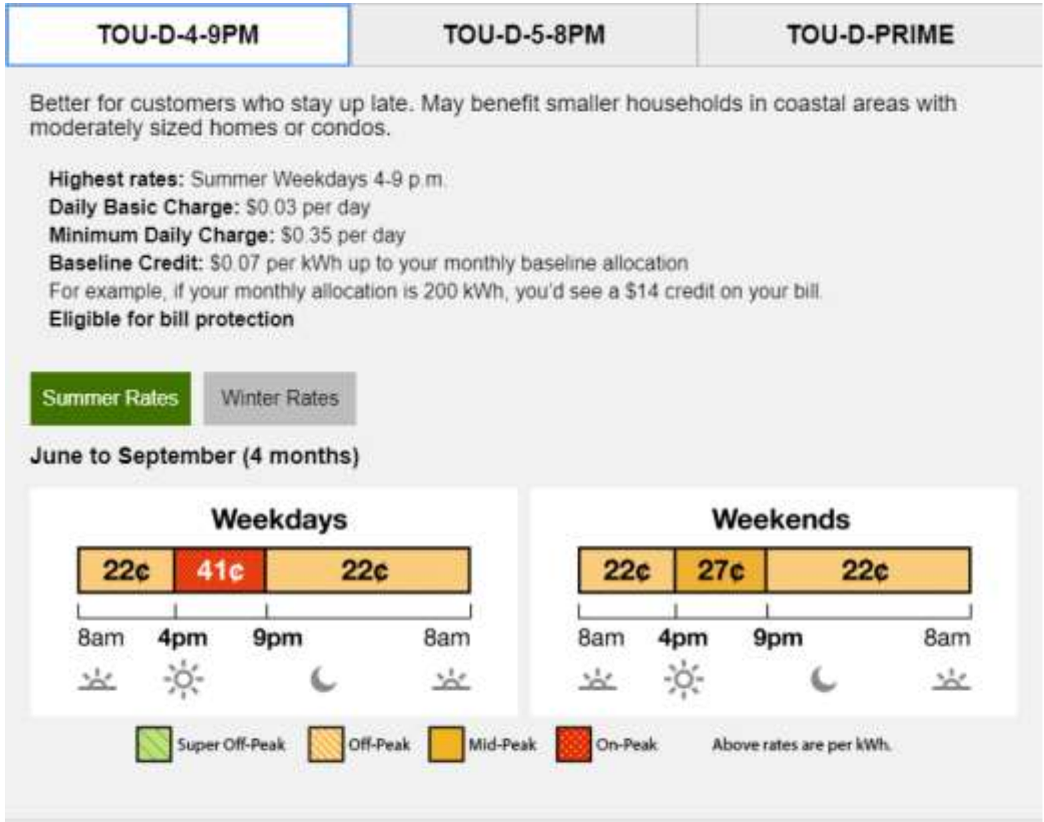
Proposed Conditions

- Increased minimum RTE
- Optimized control strategies

Initial Data and Findings

- Less energy lost by increasing the minimum battery round trip efficiency
  - 5 percent increase in RTE efficiency can result in a ~200 kWh increase in throughput in the first year*
  - Encourage improvements to parasitic losses
- Demand savings to utility, cost savings to customer by aligning TOU rates with battery control strategy
  - $450-$550/year in energy bill savings to consumer**

SCE TOU-D-4-9PM[1]



*Assumes 13.5 kWh initial capacity, 80% RTE, 350 cycles per year
**Assumes battery meets peak demand. Modeled using CBECC-Res for mixed-fuel and all-electric home in Lancaster, CA, SCE's TOU-D-4-9PM schedule

[1] SCE, TOU Rate Comparisons, https://www.sce.com/residential/rates/Time-Of-Use-Residential-Rate-Plans

Incremental Cost Information

- Proposed technology costs are **not expected to differ** from base case technology costs since proposed measures are not significantly changing product design
- Compliance and verification costs **may increase**, to be evaluated for the second meeting through interviews with building designers, Title 24 energy consultants, manufacturers, contractors, and subject matter experts

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Design battery system to meet JA12 requirements
- Customer talks with a contractor about programming the battery to meet energy goals

2. Permit Application Phase

- Same as current permit application phase
- Complete and submit permitting application forms to the local jurisdiction

Compliance Verification Process

3. Construction phase

- Same as current construction process
- Compliant systems are installed by a battery contractor
- Battery control strategy is set by installer

4. Inspection Phase

- New Round Trip Efficiency (RTE) testing method to be included
- Verification of battery control system could be improved

Market Actors

- Battery Manufacturers
  - Pre-program controls strategies, set targets for battery efficiency
- Homeowner
  - Use battery storage system for PV self consumption, load shifting, etc.
  - Battery Storage Installers
  - Install battery storage system equipment, potentially set charge and discharge times / control strategy
- Local Enforcement Agency
  - Verify that all Certificate of Installations are valid
  - Verify that the battery storage system is programmed and operational with a Title 24 compliant battery control system

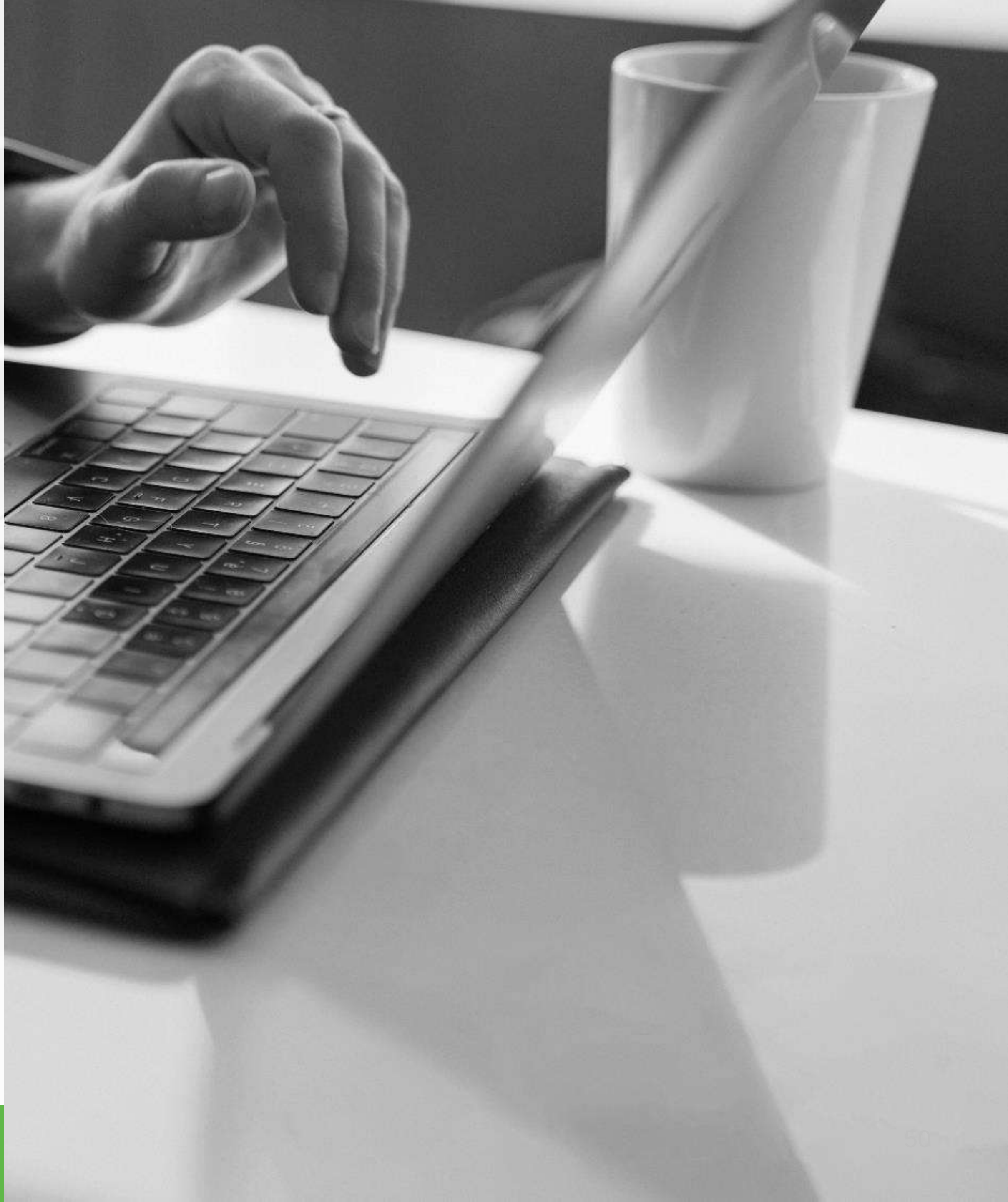
Battery Testing and Verification

- California Energy Commission Energy Storage Working Group is investigating three different test procedures
- Test procedure will be used to verify that battery systems meet minimum performance requirements
- JA12 lacks guidance on verifying battery control strategy

Are there any additional steps or stakeholders that can improve battery verification / testing?

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

Please take a minute to review the draft code language available in the **resources tab**

Title 24, Part 6, Residential Compliance Manual, Chapter 7.5 / Reference Appendices, JA12

- “Single Charge-discharge cycle AC to AC (round-trip) efficiency of at least ~~80~~ X percent.”
- Reference a test procedure for validating battery round trip efficiency
- Possibly require documentation verifying that the battery control system is Title 24 compliant

CBECC – Res Software Updates

Please take a minute to review the draft code language available in the **resources tab**

CBECC-Res Software Model

- Potentially update ‘default’ TOU control strategy start time based on 2022 TDV values / CA TOU periods
- Potentially update Advanced DR control strategy calculation process
- Potentially update default charging and discharging values

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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Submeasure A: Batteries

Submeasure B: Heat Pump Water Heater Load Shifting

Submeasure C: HVAC Load Shifting

Submeasure D: Home Energy Management

Background

- 2019 Code Requirements
- Code Change Proposal

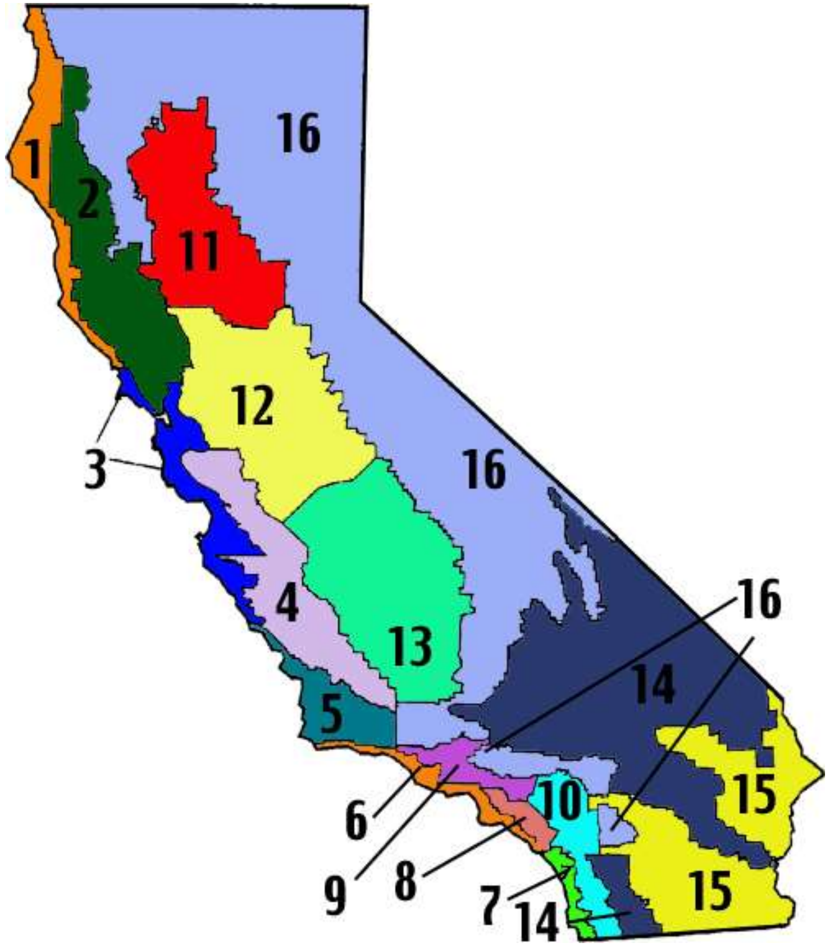
Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Multifamily, Single Family	Grid Integration	Compliance Option	Yes

- Review and enhance 2019 credit (not yet implemented in compliance software)
- Update eligibility criteria, as needed
- Compliance Option- Not a requirement!

Context and History

- **Why are we proposing this measure?**
  - Heat Pump Water Heaters (HPWH) are gaining traction in California
    - Efficient option and a key component of state's decarbonization strategy
  - Opportunity to improve 2019 load shifting HPWH credit and expand verification requirements (as needed)



https://www.researchgate.net/profile/Maximilian_Auffhammer/publication/242224522/figure/fig1/AS:298686706929664@1448223868163/California-Energy-Commission-building-climate-zones.png

2019 Code Requirements

- Title 24, Part 6
  - Appendix JA13 – Qualification Requirements for Heat Pump Water Heater Load Shifting System (in draft form; to be finalized next few months)
    - Specifies qualification requirements (safety, performance, control, demand management functionality)
    - 2 Performance Levels
      - Minimum Level: Time-of-Use Control
      - Optional level: Advanced Demand Response Control
- Existing Model Code Requirements: None
- Other regulatory considerations
  - Provide guidance for Alternative Calculation Method algorithm changes

Proposed Code Change Overview

- See the proposal summary in **resources tab**
- Potential changes anticipated for this compliance option:
  - **Review and enhance JA13** including expanding credit and enhancing eligibility criteria or minimum criteria to better represent technology changes
    - Explicitly identify CTA-2045 as the required interface
    - Move from Opt-in approach (anticipated for 2019) to Opt-out for 2022
  - Revise **2019 compliance option credit magnitude** to better reflect Duck Curve benefits (pending review of 2022 TDV)
  - Potentially require **HERS verification** to ensure controls properly set up (for expanded credit)

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview

- National HPWH market is estimated to be on the order of 72,000 units per year (2017) [1]
- Pacific Northwest is an active market (~9 percent of all electric units installed in the Pacific Northwest in 2017 were HPWHs) [2]
- Bonneville Power Administration and Portland General Electric sponsored a 2018 residential pilot study testing HPWHs operating in a demand response mode using CTA-2045 [3]
- California market is small, but growing with increasing interest in electrification
- Numerous California utilities and municipalities offering incentives ranging from $200-$2,000 (in some cases higher if retrofit from gas water heating) [4]

1 https://neea.org/img/documents/HPWH_MPER4_FINAL.pdf
2 https://aceee.org/sites/default/files/pdf/conferences/hwf/2019/2d-granda.pdf
3 https://www.bpa.gov/EE/Technology/demand-response/Documents/20181118_CTA-2045_Final_Report.pdf
4 https://programs.dsireusa.org/system/program?fromSir=0&state=CA

Market Trends and Barriers

- Trends
  - Builders paying more attention to all-electric HPHWs; load shifting benefits being demonstrated
  - 2019 Title 24, Part 6 Standards levels the playing field for HPWHs
- Barriers
  - Customers accustomed to gas water heaters and commonly higher recovery rates
  - HPWH technology unfamiliar to homeowners (and some plumbers)
  - Higher first cost; also high electric rates (relative to natural gas) in much of state
    - TOU rates <u>will</u> benefit customer economics with load shifting
  - Added costs for challenging retrofits (e.g. space constraints, 220V availability)

Do you agree with this description? What else should we know?

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Research has been underway looking at load shifting impact (see links below)
- Compliance option proposal does not require change in standard design practices other than specified unit demonstrating compliance with JA13
- How will load shift signals be implemented?
  - TOU rates input? Utility or aggregator demand response signals?
- Barriers and Potential Solutions
  - Industry still transitioning in terms of communications and controls approach to load shifting
  - Activities and legislation in Pacific Northwest pushing the CTA-2045 approach

https://ecotope-publications-database.ecotope.com/2018_001_HPWHLoadShiftingModelingStudy.pdf
https://aceee.org/sites/default/files/pdf/conferences/hwf/2018/2a-delforge.pdf
https://www.etcc-ca.com/reports/lab-testing-heat-pump-water-heaters-support-modeling-load-shifting
https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22642.pdf

Poll

Is there a need to update Section 110.12(a)1 to explicitly recognize CTA-2045 as a viable DR control option?

A. Yes, needs to be explicitly recognized.

B. No, not necessary.

C. Not sure.

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Energy cost savings

Methodology for Energy and Demand Impacts Analysis

- Statewide CASE Team awaiting implementation of 2019 CBECC-Res load shifting algorithm
  - Assumptions to be developed based on algorithm
- Interim solution: Use Ecotope's HPWHsim software [1]
  - Evaluate 2,100 and 2,700 ft^2 prototype homes in all 16 climate zones
  - Evaluate various load shift strategies (including tank over-heating) and assess impacts
  - Look at Duck Curve seasonality to assess sensitivity to TDV variations
    - 2022 TDV becoming available soon (will impact current load shift findings)
    - Retail rate adder in TDV currently undervalues load shift benefit
    - Forward looking utility marginal costs approach suggest larger benefits

[1] https://ecotope-publications-database.ecotope.com/2018_001_HPWHLoadShiftingModelingStudy.pdf

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code

Proposed Conditions

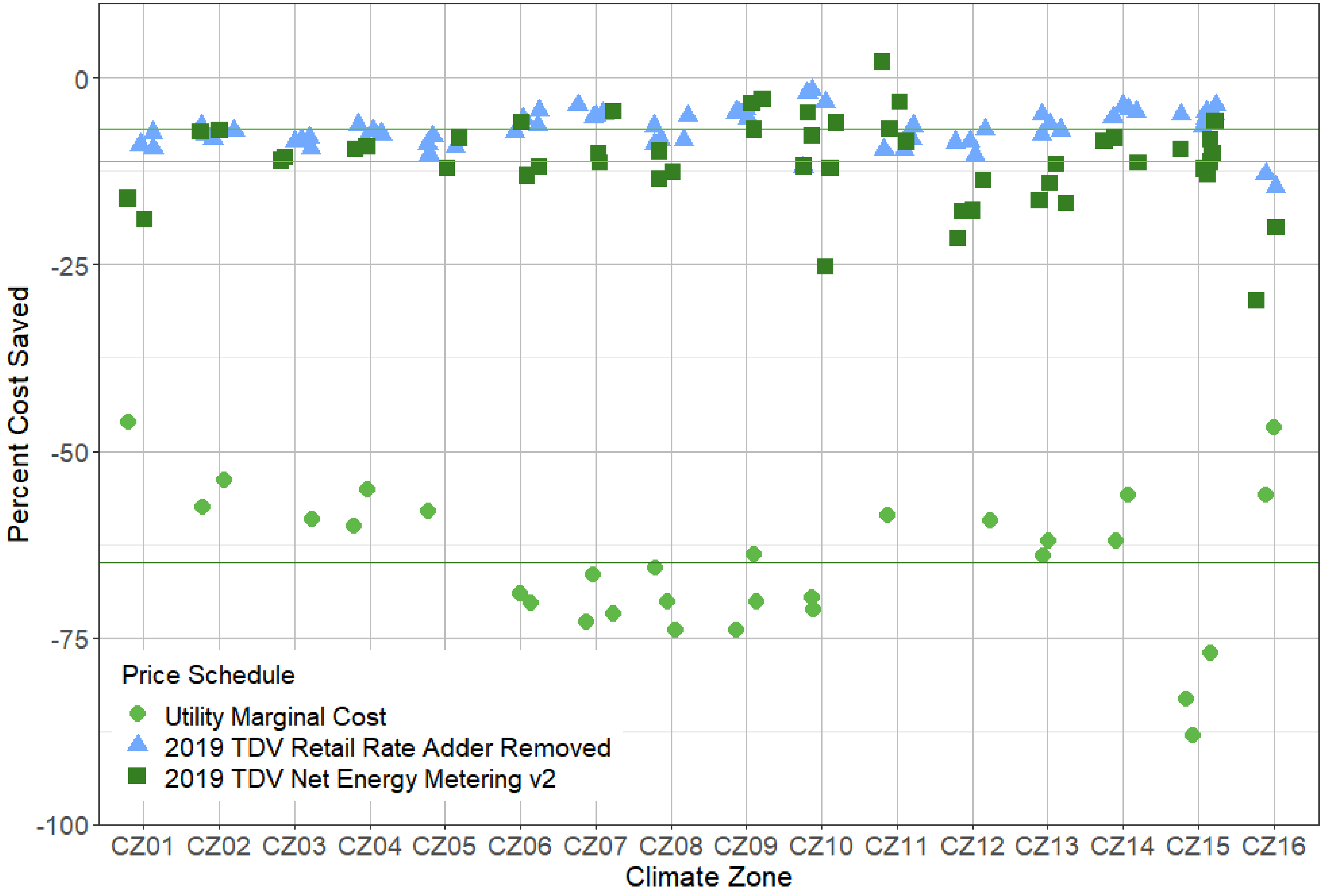
- To be determined

Initial Data and Findings

- Awaiting delivery of 2019 CBECC-Res software with load-shifting algorithm (expected in next few months…)

Initial Data and Findings

Looking at 2019 TDV impacts and alternative 2024 PG&E marginal electric cost



Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- With builder interest in either HPWH or all-electric design approach, energy consultant specifies HPWH meets JA13 minimum requirements and is certified by the Energy Commission

2. Permit Application Phase

- Energy consultant includes load-shifting HPWH in compliance run
- Plans examiner verifies specified unit meets JA13 requirements

Compliance Verification Process

3. Construction phase

- Plumber installs and commissions specified HPWH and thermostatic mixing valve
  - Future HPWH products may include built-in mixing valve

4. Inspection Phase

- Building inspector or HERS Rater verifies unit model number with compliance documents
- HERS Rater verifies the unit is configured for HPWH load shifting
- For 2019, occupant has to Opt-in; for 2022, considering an Opt-out approach

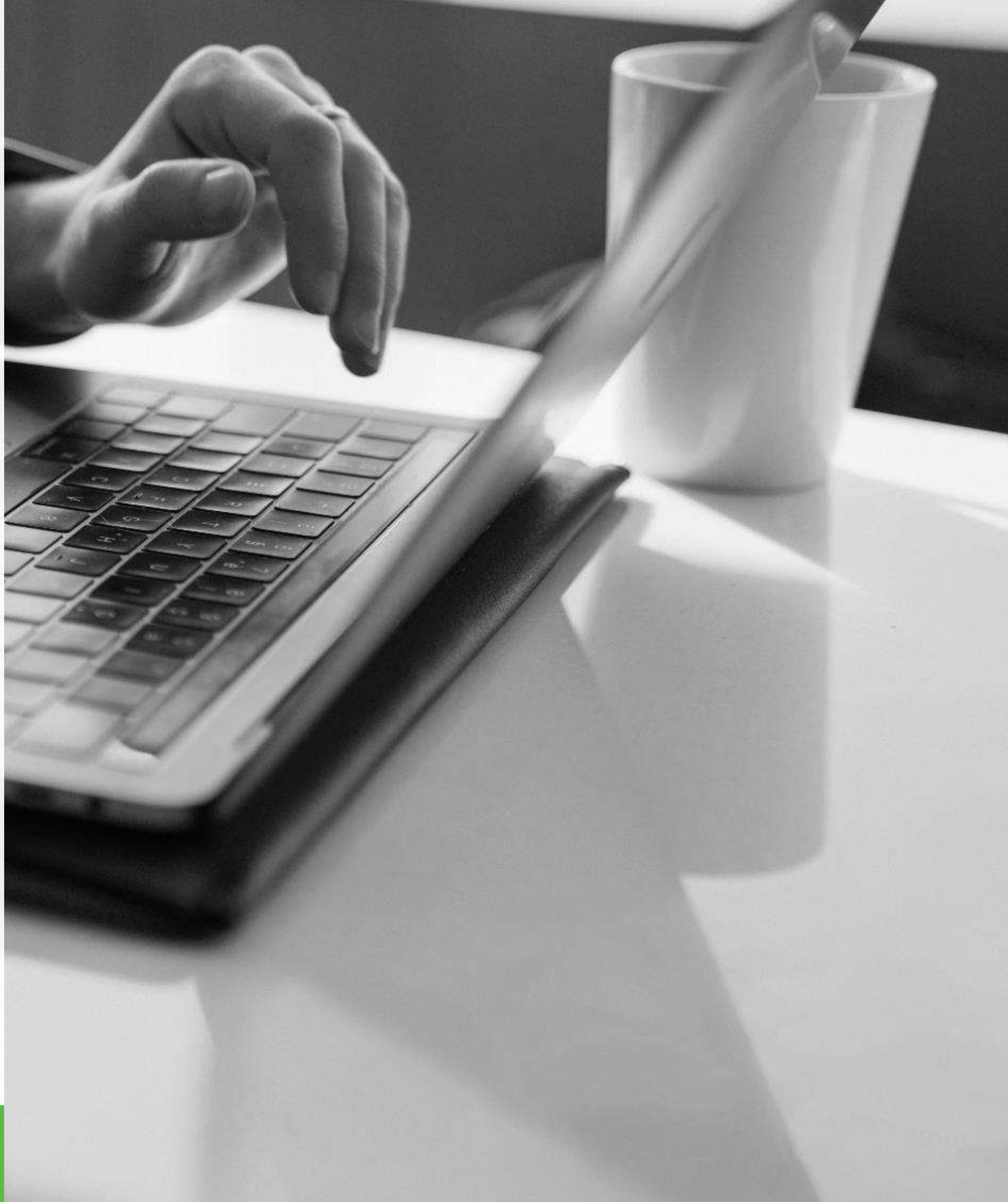
Market Actors

- Utilities
- 3rd party aggregators
- Manufacturers
- Plumbing distributors
- Architects
- Building inspectors
- HERS Raters
- Plumbers & plumbing designers
- Energy consultants
- Building occupants

Are we missing any market actors?

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

- We will be reviewing JA13 and providing updates as needed
  - Include CTA-2045 as a recognized alternative under 110.12(a)1
  - Move towards Opt-out implementation plan for 2022
  - Plan to implement expanded credit for tank over-heating above setpoint
- If HERS Rater involvement is needed, Reference Appendices will be modified to add load shift HPWH verification requirements. RA4.4 covers water heating measures.

Software Updates

- CBECC-Res modeling capabilities not currently available
  - Expect software version to be available in the next few months
- Possible that modeling changes will be proposed by Statewide CASE Team to provide enhanced credit (pending review of 2022 TDV hourly schedules)

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Submeasure A: Batteries

Submeasure B: Heat Pump Water Heater Load Shifting

Submeasure C: HVAC Load Shifting

Submeasure D: Home Energy Management

Submeasure C: HVAC Load Shifting

Pre-Cooling for Demand Flexibility

Thermostats for Energy Efficiency and DR

Background and Code Change Proposal

Pre-Cooling for Demand Flexibility

- 2019 Code Requirements
- Motivations for Modifications
- Summary of Modifications
- Code Change Proposal
- Validation

2019 Code Requirements: Pre-Cooling for Demand Flexibility

Residential ACM • Precooling credit for Demand Flexibility	Credit towards Solar Electric Generation and Demand Flexibility Design Rating (Not Energy Efficiency)
	Requires an Occupant Controlled Smart Thermostat (OCST - per JA5)
	Credit de-rated to 70 percent of calculated savings because of the “occupant dependent” nature
	Modeling assumptions: • House is precooled in hours preceding the highest TOU period, and then coasts thru the highest period • Pre-cooling setpoint and cooling start time are determined by the forecast average outdoor temp (SP=77°F when daily max is 86°F, SP=73°F when daily max is 102°F)
Joint Appendix 5	Describes required features of OCST, including responses to Demand Response Events and Signals

Motivation for Modifications – Pre-Cooling

- Pre-Cooling Credit has not been thoroughly articulated or documented
- Requires a DR thermostat, which is not necessary for TOU optimization
- Difficult to ensure that occupant-adjustable functionality is employed
- Provide basis for derating factor
    - Compliance software de-rates credit to 70 percent
- Find ways to improve the derating factor
- Modeling assumptions need to be updated

Summary of Modifications – Pre-Cooling

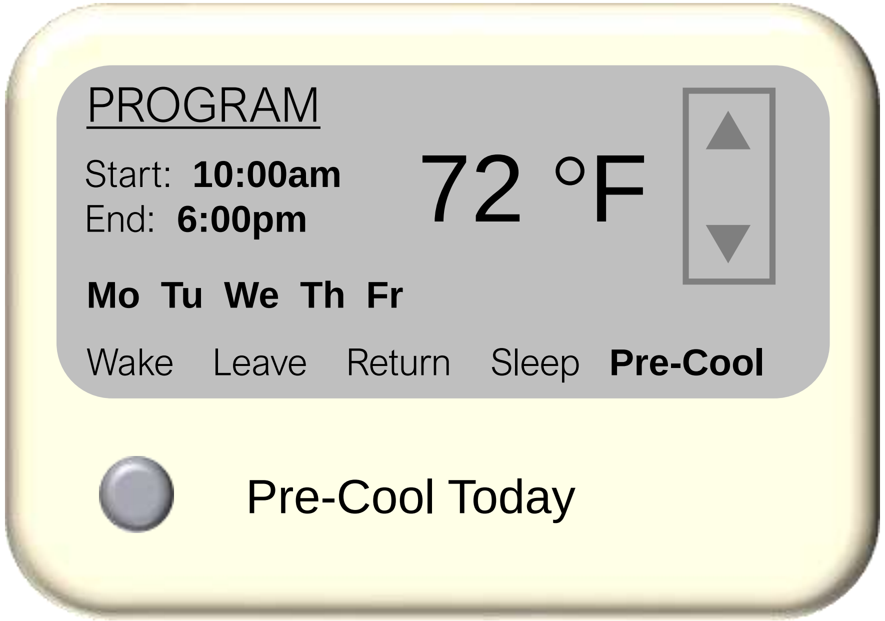
- Allow programmable thermostat with suitable features as alternative to OCST
- Provide better-founded derating factor
- Update modeling assumptions
- Provide thermostat HERS verification, default settings, and labeling to improve efficacy

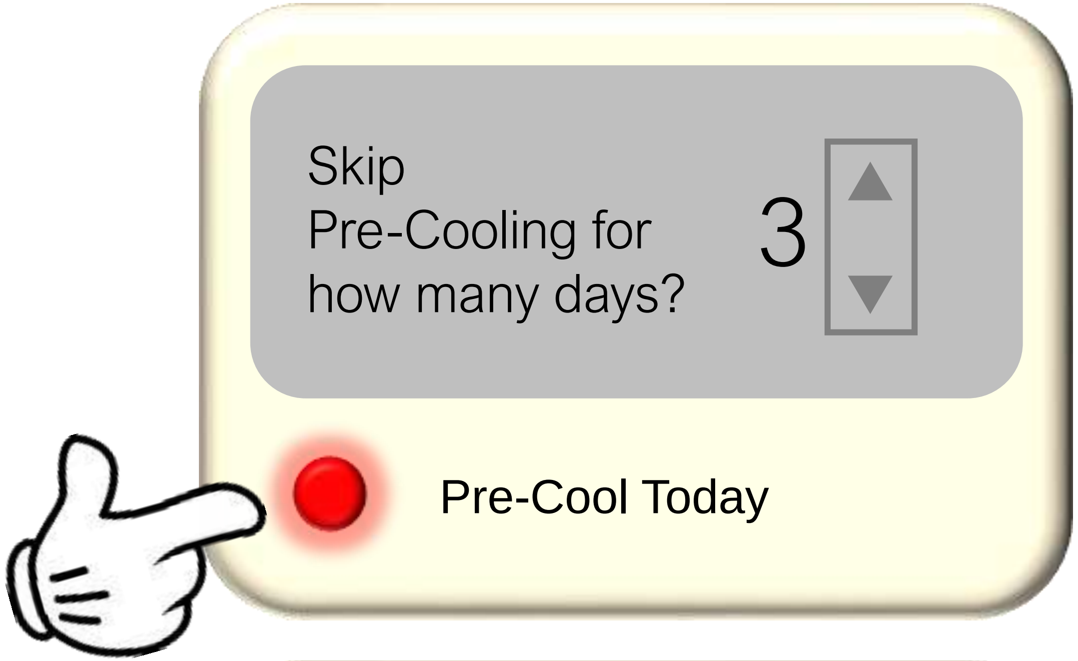
Thermostat Features for Pre-Cooling Efficacy and Usability

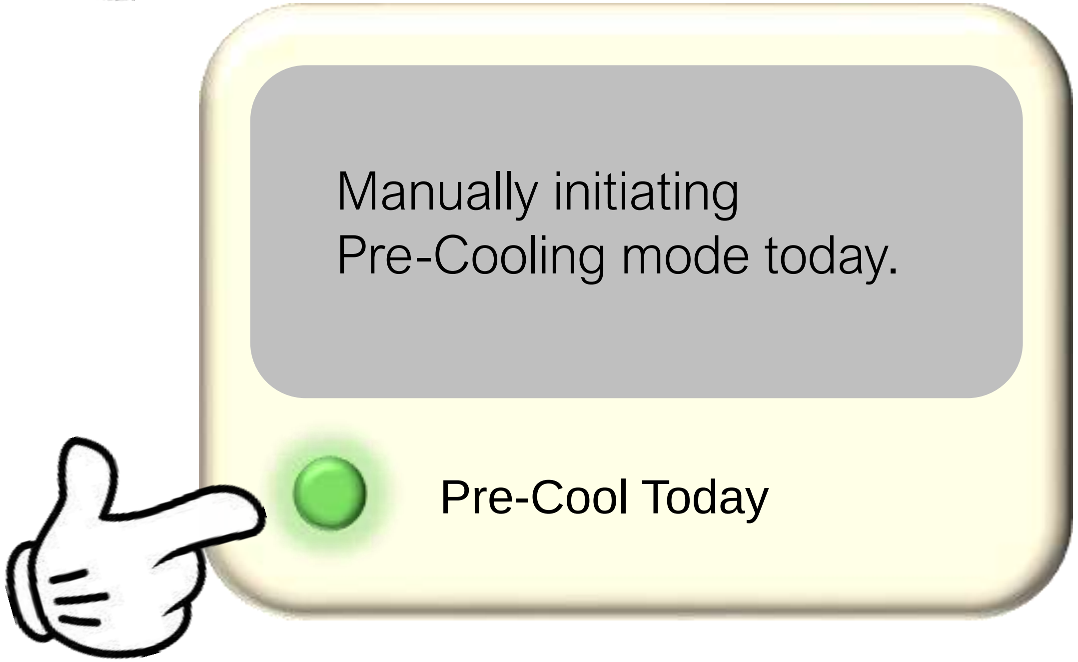
- Increase number of schedules (include one named “Pre-Cool”)
- Adaptive recovery to reach pre-cooling setpoint prior to start of TOU Peak period
- Easier to set and confirm programmed schedules
- Harder to permanently override a programmed schedule
- Easier to temporarily override a programmed schedule
- “Pre-Cooling” or “Demand Response” modes that allow occupant to Opt In or Opt Out (button?)
- Diagnostic when schedule differs from “intended” schedule: local or remote annunciation
- Instruction, messaging, feedback: eg, clear indication of Pre-Cooling Mode

[1]Draft report: “Approaches to Zero Net Energy Cost Effectiveness in New Homes.”

Examples of Thermostat Pre-Cooling Functionality



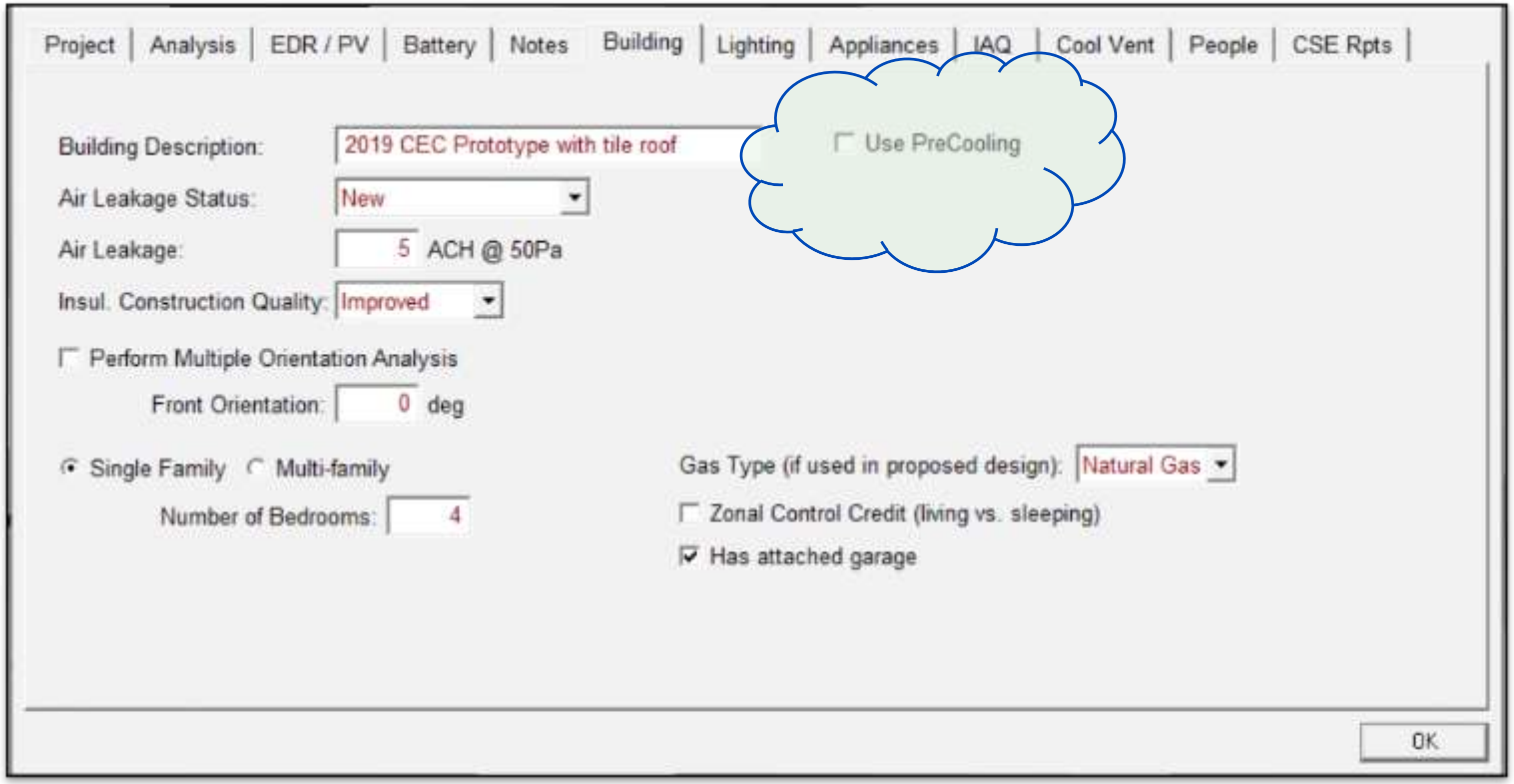




How likely is it that homeowners will temporarily or permanently override Pre-Cooling functionality?

Proposed Code Change Overview – Pre-Cooling

- **Current:**
  - CBECC-Res Implementation of Pre-Cooling for Demand Flexibility
    →
  - Requires OCST (JA 5)
  - Calc with 70 percent derating factor
- **Proposed:**
  - Require new thermostat functionality (akin to JA 5)
  - Calc with new de-rating factor
  - HERS tests to confirm



Validation – Pre-Cooling

- Thermostat Functionality
  - Conduct a survey to identify range of acceptable features for TOU optimization
  - Enhance efficacy and usability by identifying ways to improve messaging, instruction, user interface design, etc.
  - Develop minimum thermostat requirements to improve the derating factor
- Derating Factor
  - Conduct a survey to estimate:
    - Expected rate of optimum programming
    - Persistence of optimum programming and
    - Incidence of short-term and long-term overrides

Validation – Pre-Cooling (cont.)

- Modeling Assumptions
  - Identify assumptions that went into prior modeling
  - Review each assumption and update if warranted
  - Redo modeling
  - Optimize for bill minimization
- Acceptance Tests, Defaults, and Labeling
  - Default settings to ensure thermostats are shipped or installed with best settings
  - Simple inspections to confirm thermostats are using optimum settings for each climate zone
  - Labeling requirement for thermostats that have pre-cooling or demand responsive capabilities, to make it easier to verify compliance

Background and Code Change Proposal

Thermostats for Energy Efficiency and Demand Response

- 2019 Code Requirements
- Motivations for Modifications
- Summary of Modifications
- Code Change Proposal
- Validation

2019 Code Requirements – Thermostats for Energy Efficiency and Demand Response

Section 110.10(b)1A	Demand Responsive Controls (along with other energy efficiency measures) provide exemption to solar zone requirements
Section 110.12	Describes mandatory requirements for Demand Responsive Controls, including reference to JA 5
Section 110.2(c)	Requires Thermostats, with Setback Capabilities
Section 150.1(c)	Demand Responsive Controls required in some cases, as part of the winter charge exception in the refrigerant charge adjustment and verification methods

Motivation for Modifications – Thermostats

- Thermostats have come a long way and Title 24 has not kept up
  - Smart Thermostats
  - Connected Thermostats
  - Demand Responsive Controls
  - Improved User Interface
- Reconsider the existing maximum 4°F temperature setback requirement
- Consider applying requirements for Demand Responsive Controls in additional residential situations
- Incorporate features that facilitate Pre-Cooling (described earlier)

Proposed Code Change Overview - Thermostats

- See the proposal summary and mark-up language in **resources tab**
- Identify and evaluate potential new Smart Thermostat compliance options or new Eligibility Criteria
- Consider requirements that parallel ENERGY STAR ® Program Requirements for Connected Thermostat Products:
    - Collect data, especially runtime
    - Feedback on savings
    - Studies of field savings to be certified

Validation - Thermostats

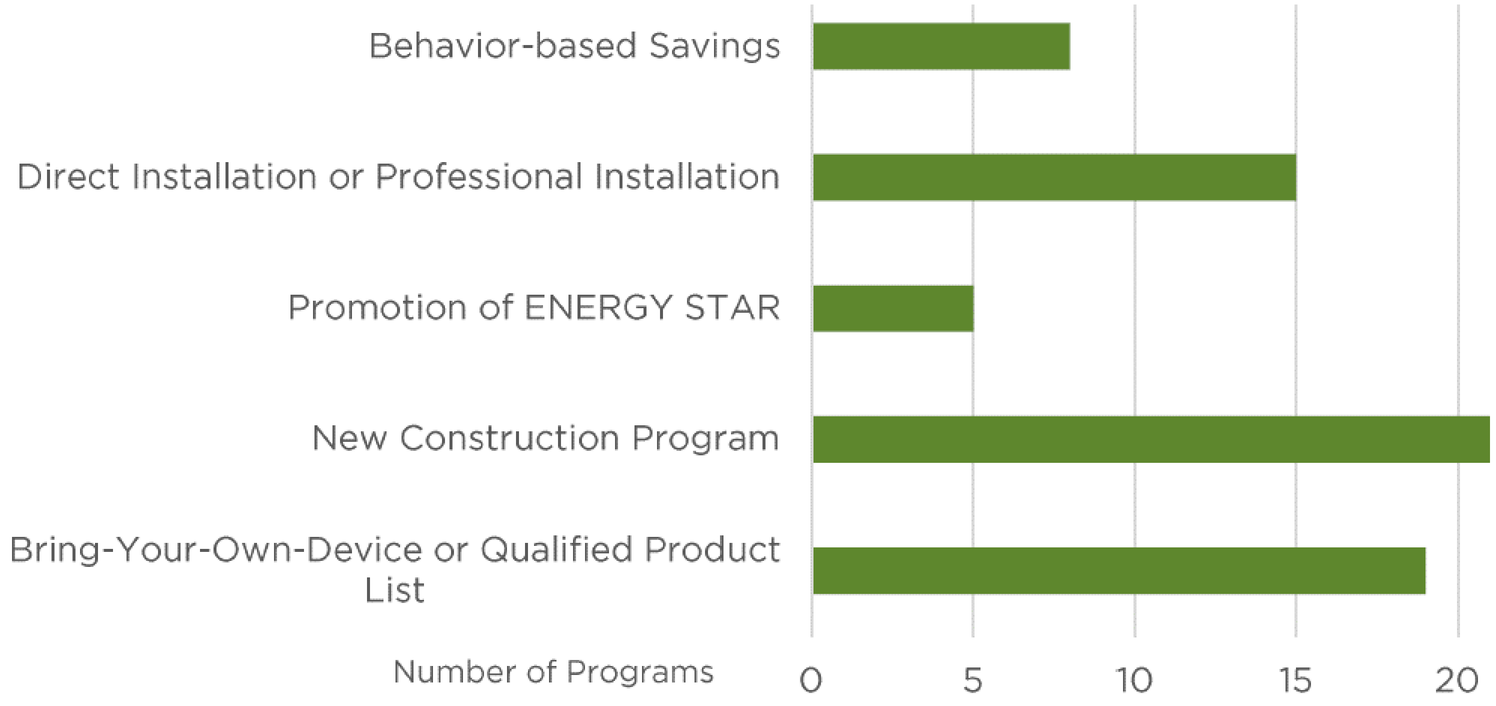
- Identify features that are generally successful:
  - Engage with stakeholders
  - Emphasize usability and realized savings
  - Review Smart Thermostat Program results
  - Estimate savings

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Current Market Conditions and Trends

- The market for smart thermostats is growing rapidly: Smart thermostats accounted for 40 percent of 10 million thermostats sold in the US in 2015
- Cost for smart thermostats is coming down: about $150–$250 (down from $400)
- CEE documented 106 thermostat programs across 38 US states and Canada



Sales data source: http://www.parksassociates.com/blog/article/pr0715-smart-thermostats;
Chart: CEE Connected Thermostats Program Guide https://library.cee1.org/system/files/library/13813/CEE_ConnectedThermostats_ProgramGuide_15Jan2019.pdf

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Analysis of Optimum Pre-Cooling Schedules

- LBNL/E3 conducted an analysis of optimum cooling schedules and associated savings[1]
  - Base Case: Setback while unoccupied, Setpoint = 78°F when occupied
  - Optimum Pre-Cooling (hypothetical): Pre-Cooling schedule and temperature that led to lowest TDV cost each day, looking back at temperatures, loads, and TDV
  - Set Pre-Cooling Schedules and Temperatures: Parametric runs for 72°F and 75°F Pre-Cooling with different schedules to identify best schedules and temperatures for each CZ
  - Calculated 30-Year NPV savings compared to Base Case
  - Also calculated 30-Year NPV savings assuming TDV values and two TOU Rate Structures

[1]Draft report: "Approaches to Zero Net Energy Cost Effectiveness in New Homes."

Optimal Pre-Cooling Findings

- A regular schedule (easily programmed) provided much of savings from *hypothetical* optimal (requiring forecasts)
- Very little savings in Climate Zones 6, 16, 15, 1, 3 and 5
- 10am-6pm was the best timing for all Climate Zones (or very close to the best)
- 72°F was the best Pre-Cooling temperature for all Climate Zones except 7 and 8 (where 75°F was better)
- Even flat setpoint all day (no setback/no pre-cooling) was lower cost than BASE (though not as low as pre-cooling)
- Pre-Cooling uses more kWh
- Optimized for maximum TDV savings, but very little *bill* savings under two TOU rates analyzed (not sufficiently differentiated)

30-YEAR NPV Savings, Compared to BASE (TDV)

	OPTIMAL PRE-COOLING	10am-6pm PRE-COOLING
CZ11	25%	23%
CZ13	21%	18%
CZ12	21%	18%
CZ10	20%	15%
CZ09	19%	12%
CZ14	18%	15%
CZ08	16%	8%
CZ04	14%	10%
CZ07	10%	4%
CZ02	7%	4%
CZ06	5%	1%
CZ16	3%	1%
CZ15	2%	-1%
CZ01	0%	0%
CZ03	0%	0%
CZ05	0%	0%

Need Additional Analysis of Life Cycle Impacts Under TOU

- Homeowners can be expected to create pre-cooling schedules that minimize their bills
- We will analyze impacts on bills under several scenarios:
  - Pre-Cooling schedule optimized for minimum TDV
  - Pre-Cooling schedule optimized for minimum bills, based on:
    - Current TOU rates
    - Upcoming expected TOU rates
    - Plausible future TOU rates
  - Impacts on homes with different relative system sizing and thermal mass
- Encourage development of thermostat Optimization Mode to test home thermal response and analyze TOU rates to identify optimal Pre-Cooling schedule

Should modeling consider the potential for future more differentiated TOU rates?

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impact Analysis

- Revisit current CBECC assumptions:
  - Pre-Cooled period precedes the highest TOU period, and then coasts thru the highest period. Start time determined by forecasted average outdoor temperature
  - Pre-Cooling Setpoint determined by the forecasted average outdoor temperature: 77°F when daily max is 86°F, SP=73°F when daily max is 102°F
- Consider replacing with optimal timing and setpoints from LBNL/E3 analysis:
  - Pre-Cooling period is 10am-6pm
  - Pre-Cooling Setpoint of 72°F or 75°F, depending on Climate Zone
- Estimate savings reliability and persistence
- Analyze impacts on bills for different TOU rates: Confirm there is no significant bill penalty with insufficiently-differentiated TOU rates
- Proof of savings and cost-effectiveness are not required for compliance options

Assumptions for Energy Impact Analysis

- Consider behavioral impacts on assumed Pre-Cooling period and setpoint
- Occupant Behavior: Frequency of permanent and temporary overrides, and impact on Derating Factor
- Other Assumptions:
  - Weather
  - House Design
  - Sizing
  - Thermal Mass
  - Normal Thermostat Settings
  - Optimization Objectives
  - Installation Quality

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Assumptions on normal thermostat behavior
- Baseline assumptions: house design, sizing, thermal mass, installation quality…

Proposed Conditions

- Optimization objectives: min bill, min E, min TDV
- Optimization constraints: max temp, min temp
- Optimum or expected pre-cooling start time and setpoint based on behavioral analysis

Methodology for Energy Impact Analysis: Thermostats

- Review Manufacturer energy savings estimates
  - ENERGY STAR Program Requirements for Connected Thermostat Products requires runtime field documentation (manufacturer studies based on data collected by thermostats)
    - Cooling: 10 percent reduction
    - Heating: 8 percent reduction
- Field studies are critical: Savings depend on user interaction with the thermostat, which can only be gauged with a field study
- Consider engaging with manufacturers to review their ENERGY STAR analyses and adapt for California use

What methodology should CEC use to evaluate the benefits of the current generation of smart thermostats?

Energy and Cost Impacts

- Initial Data and Findings
- Preliminary Energy Savings Estimates
- Incremental Cost Information
  - Not required for Compliance Options

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Energy Consultant analyzes pre-cooling benefits as a function of climate zone, thermal mass, and sizing and makes recommendation
- Builder/Architect:
  - Specifies pre-cooling
  - Identifies compliant thermostat
  - Verifies thermostat requirements are met and certified by the Energy Commission

2. Permit Application Phase

- Energy Consultant includes pre-cooling in compliance run, and records it on plans and CF1R
- Plans Examiner verifies spec’d unit meets thermostat requirements

Compliance Verification Process

3. Construction phase

- Installer verifies correct thermostat is being installed (label?)
- Installer installs thermostat, and programs it to meet optimum default settings

4. Inspection Phase

- Building Official or HERS Rater confirms correct thermostat model (label?)
- HERS Rater confirms optimum default settings

Market Actors

- Energy consultant/modeler
- HVAC contractor/maintenance technician
- HERS rater
- HVAC supplier
- Thermostat manufacturer

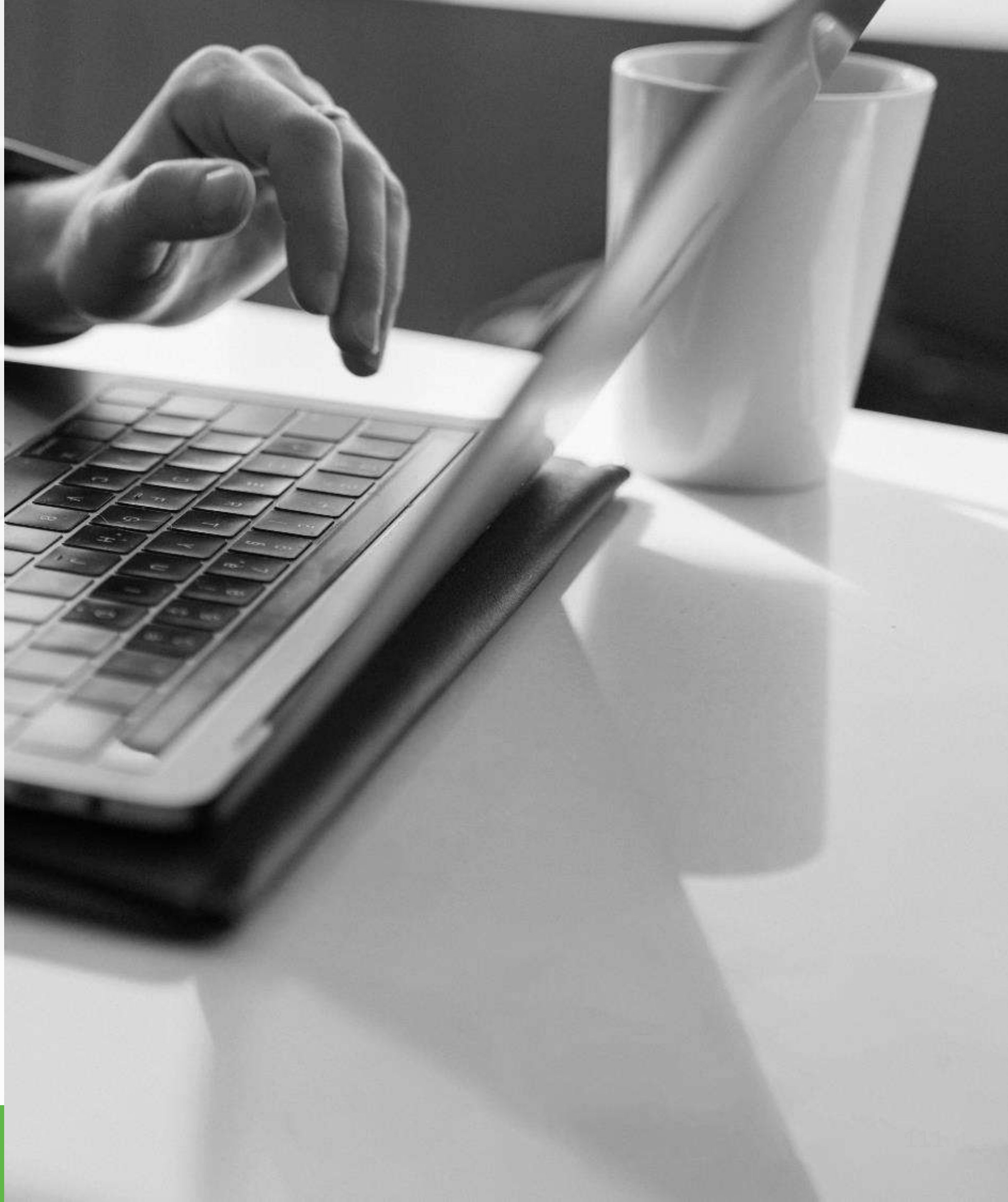
- Energy consultant/modeler
- Designer/responsible person
- Plans examiner
- Builder/responsible person

- Engaging thermostat manufacturers individually and via industry alliances

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Details will be provided in the second grid integration workshop in January/February



Thank You

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: Batteries

Submeasure B: Heat Pump Water Heater Load Shifting

Submeasure C: HVAC Load Shifting

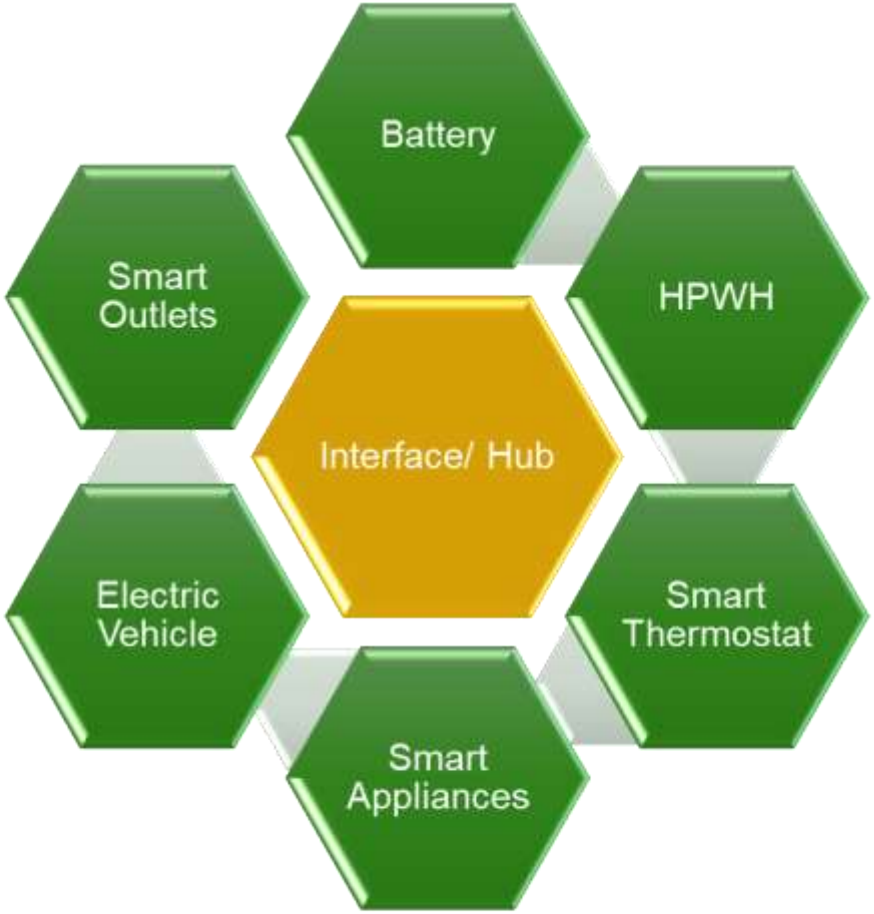
Submeasure D: Home Energy Management

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Context and History

- Home automation benefits:
  - Convenience, home security, ability to monitor and control devices
- Home energy management systems (HEMS):
  - Home automation systems that delay/cease device operation in response to programmed schedules, machine learning, or utility signals
- Over 300 products on the market
- Transience and complexity of market makes it difficult to prove savings



2019 Code Requirements

Code Document	Section	Requirement
Title 24, Part 6	110.9	Mandatory Requirements for Lighting Controls
	110.10(b)1A, Exception 6	Solar zone ≥250 ft^2 unless house has a demand responsive thermostat and a home automation system capable of controlling appliances and lighting
	110.12	Mandatory Requirements for Demand Management
Residential ACM		Default lighting, appliance, and miscellaneous electric loads are specified; no credit for reduced energy use from controls

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**
- Summary of changes
  - Add Residential Appendix RA5: “Qualification Requirements for Home Energy Management Systems”
    - Draw upon ENERGY STAR Program Requirements: Product Specification for Smart Home Energy Management Systems. Eligibility Criteria, Draft 2 Version 1.0
    - Include additional requirements for demand response
    - Require ability to connect to batteries, electric vehicles, HPWHs, and smart thermostats
    - Require minimum number of connected devices
    - Require one or more smart appliances be present

Proposed Code Change Overview (Continued)

- Summary of changes (continued)
  - Call out RA5 in 110.10(b)1A and other codes sections that reference home automation or an energy management system
  - Possibly allow de-rated credit as an energy efficiency measure using the performance path, or an adjustment to the default electricity use for lighting, appliances, and plug loads

Poll

How much credit do you believe is appropriate for home automation, excluding smart thermostats, batteries, and hot water storage?

a) No credit, the technology is unproven or not standardized

b) Maintain as a partial compliance option for meeting solar zone area

c) Allow as a full compliance option for meeting solar zone area if the system meets strict qualification criteria

d) Treat as an energy efficiency measure that can be traded off against other building features

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- The market is emerging for products with home automation capabilities beyond smart thermostats
  - 18 percent of households have a home automation device*
  - 12 percent smart appliances**
  - 7 percent plug load controls**
  - 5 percent lighting controls**
- Several central home automation systems are beginning to gain traction
  - Primarily promoted based on convenience and safety, not energy savings or demand responsiveness

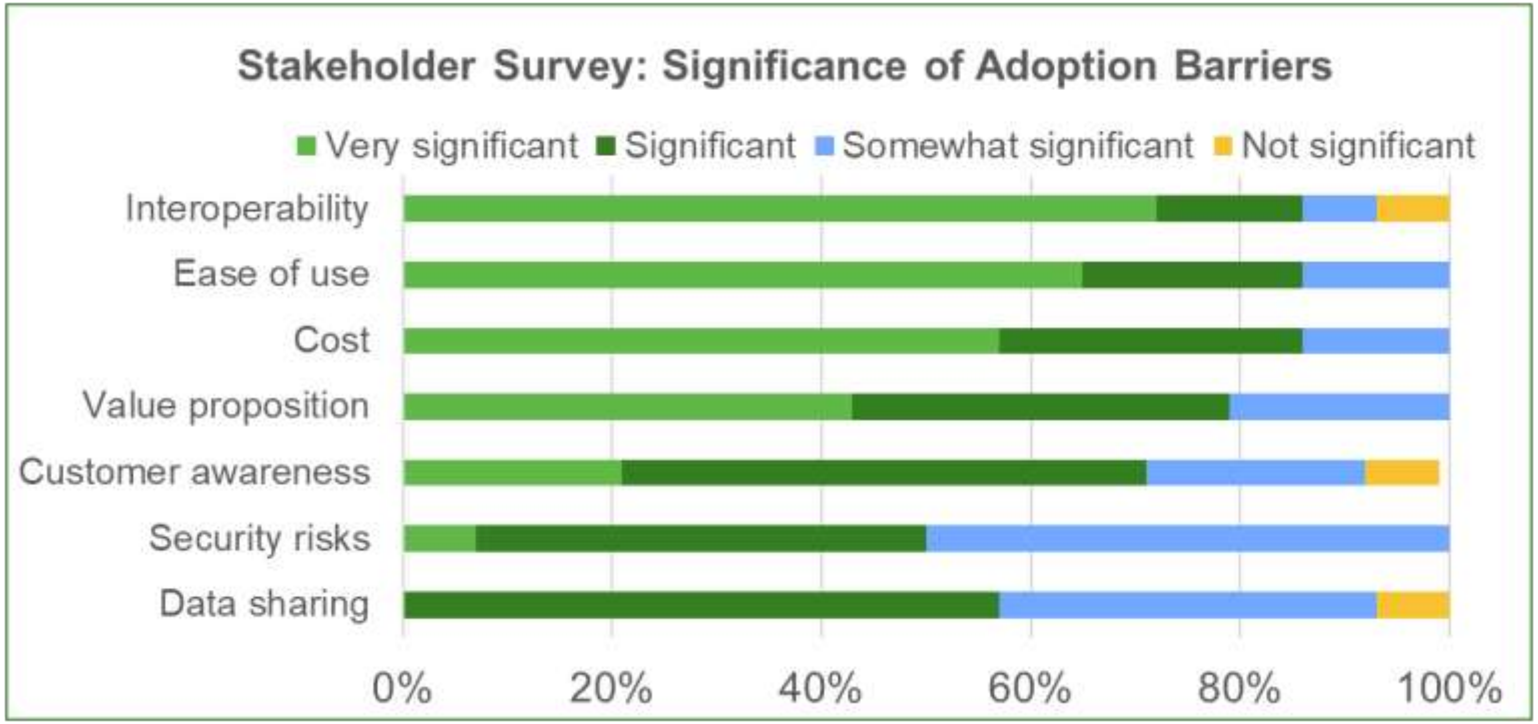
* Emily Kemper, CLEAResult/** Beth Karlin, See Change Institute. Better Buildings Peer Exchange: Getting Smarter Every Day: Leveraging Smart Home Technologies to Advance Home Performance Projects, April 25, 2019

Market Overview and Analysis (Continued)

- Rapid technology changes make it difficult to anticipate future trends
- Wide range of product offerings (300-500) will likely be narrowed down to a few winning technologies

Market Barriers

- User-friendliness of interfaces
- Rapid obsolescence
- Few incentive programs



Credit: Ford et al. 2016***

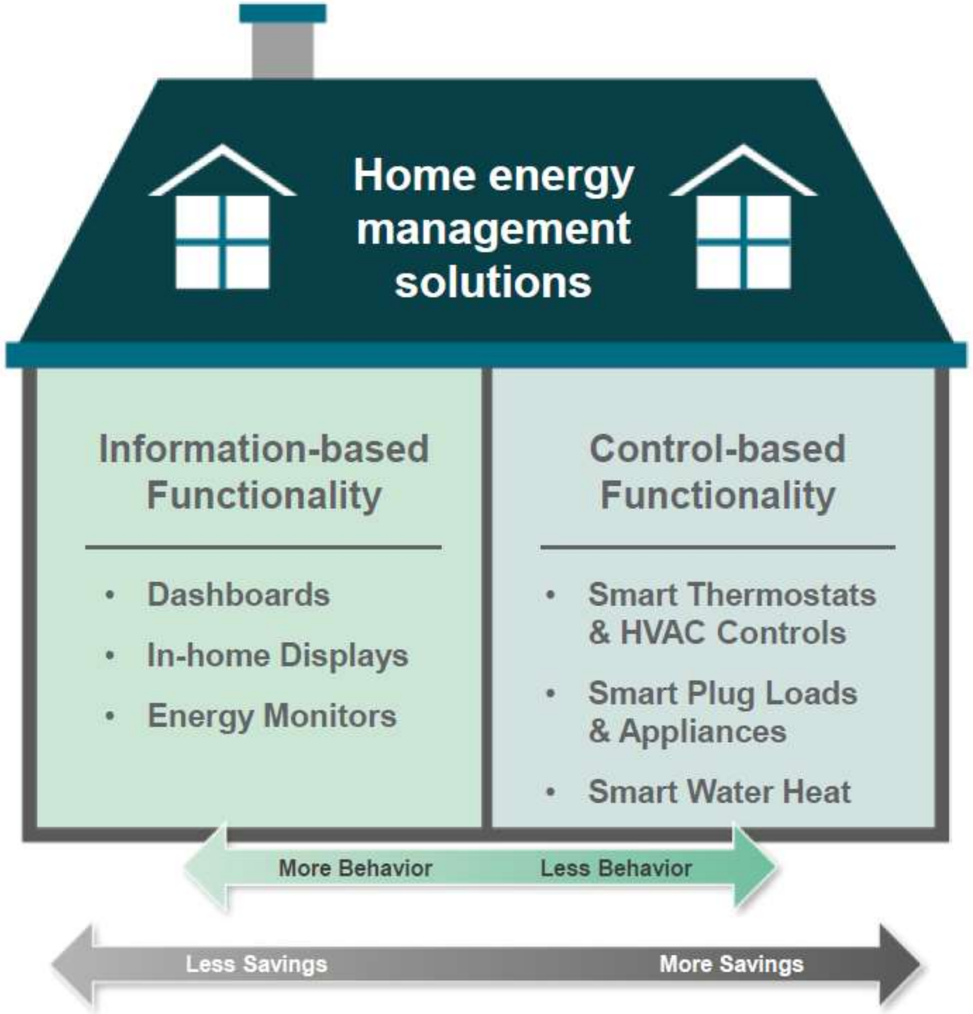
* Emily Kemper, CLEAResult/** Beth Karlin, See Change Institute. Better Buildings Peer Exchange: Getting Smarter Every Day: Leveraging Smart Home Technologies to Advance Home Performance Projects, April 25, 2019/***Rebecca Ford et al. 2016. "Assessing Players, Products, and Perceptions of Home Energy Management". PG&E ET Report.

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Energy savings and peak demand impacts must be proven and quantified
- Savings are highly dependent on the combination of devices connected
- Savings driven by occupant behavior
  - Initial programming, remote interactions, demand response overrides
- Control algorithms needed for optimizing demand response between batteries, water heating, HVAC, lighting, and plug loads



Souce: Emily Kemper, CLEAResult

Technical Barriers and Potential Solutions

- Lack of standardization (communications, features)
  - The market is trending toward hubs that can translate data across products and the grid
  - Energy Star SHEMS qualification requirements under development
- Persistence of savings
  - Review of existing field studies
  - Homeowner survey

What other technical challenges (if any) must be overcome before HEMS is a viable Title 24 compliance option?

(Please provide thoughts in the public Chat Room)

ENERGY STAR Draft Eligibility Criteria for Smart Home Energy Management Systems (SHEMS)

- Should provide 3 functions:
  - Occupancy detection
  - Reduction of standby power
  - Energy use feedback to occupants

- Minimum connected devices
  - Energy Star smart thermostat
  - Two lighting control devices
  - Either smart power strip, smart plug, or home energy submetering system

Poll

In general, would you support the use of ENERGY STAR product specifications as the basis for Title 24 home automation system requirements?

a) Yes, don’t reinvent the wheel
b) Yes, leverage most of what EPA has done with a few minor adjustments
c) No, but we should use some of the language where it makes sense
d) No, Energy Star has its own objectives and we should develop a specification from scratch.

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Energy cost savings

Methodology for Energy and Demand Impacts Analysis

- Future work
  - Determine if positive energy and/or demand savings have been proven
  - Determine if savings is large enough to justify a compliance trade-off with solar zone area
  - Identify an accurate methodology to analyze savings through modeling
  - Analyze TDV savings for all prototype residential buildings in each CA climate zone using Energy Plus (CBECC-Res does not currently have the necessary flexibility)

Assumptions for Energy and Demand Impacts Analysis

- Assumptions are needed for the following system attributes, based on literature reviews, stakeholder inputs, and homeowner survey
- Occupant behavior
  - Correlation of occupancy with local lighting and plug loads
  - Frequency of override
  - Responsiveness to recommended actions for saving energy or reducing bills
- Technology attributes
  - Common connected devices
  - Operational characteristics and efficiency of those devices
  - Impact of home automation on those operational characteristics
- Savings persistence

2023 Construction Forecast

- Construction forecasts will be performed once details of the measure have been defined

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Time of use rates
- No central home automation system
- Battery, grid-enabled heat pump water heater, smart thermostat, are present

Proposed Conditions

- Add smart appliances, smart lighting, and smart plugs/outlets to baseline
- Introduce overall control logic

Initial Data and Findings

- Current studies are highly variable, but indicate whole house electricity savings of 10-15 percent are possible (excluding smart thermostat)*
- Peak demand impacts are even more variable
- Results of energy analysis will be presented at a later date
- Cost-effectiveness analysis is not required for compliance options

* Estimation by CASE author based on literature review

Incremental Cost Information

- Cost data is not required for compliance options
- Cost is difficult to quantify because of the variety of features
- Costs remain relatively high for a complete home energy management system, but there is reason to believe costs will decrease as the market grows and the range of systems narrows

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

Designer specifies HEMS attributes

- Connected devices
- Control logic
- User interface

2. Permit Application Phase

Document compliance with code requirements

- Title 24, Part 6
- Residential Appendix RA5
- Energy modeling
- Compliance forms

Compliance Verification Process

3. Construction phase

Verify hard-wired components

- Details TBD

4. Inspection Phase

Commission/verify system operation

- Details TBD

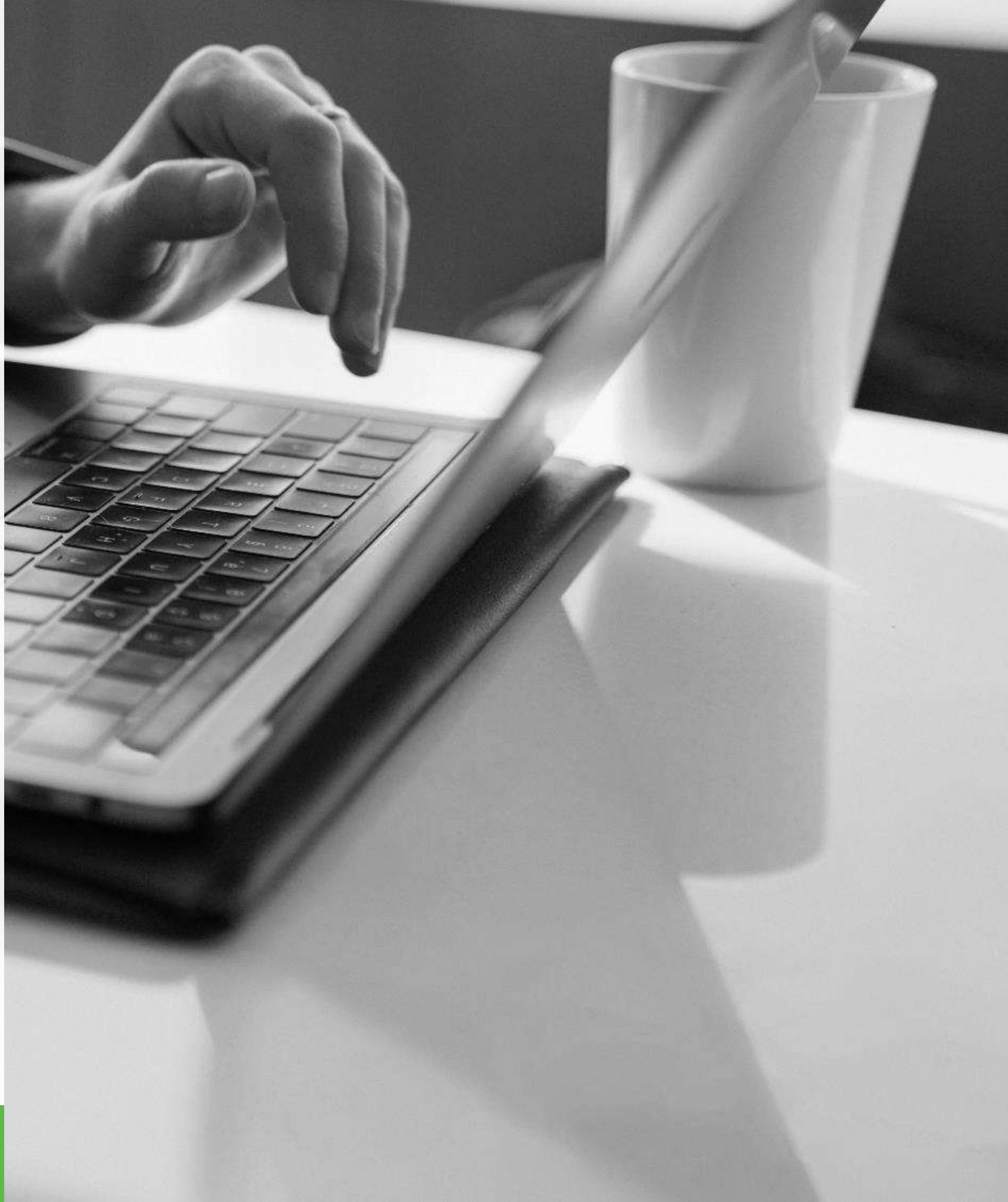
Market Actors

- Homeowners (initial programming, ongoing interaction)
- Home energy management product manufacturers/service providers
- Builders
- Electricians
- Plans examiners
- HERS Raters

- Input invited from all market actors affected by possible HEMS measures

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Possible Draft Code Change Language

- Specific language is under development
- See the proposal summary with mark-up language in **resources tab**

Software Updates

Current Modeling Capabilities

- Default electricity use for appliances, lighting, and plug loads

Proposed Modeling Capabilities

- If justified based on field studies, add several options for reduced electricity use and revised schedules for end-uses that may be connected to a qualified HEMS
- Add or expand options for battery control, HPWH load shifting, HVAC load shifting, and EV charging when controlled by a central HEMS

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by September 24th, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Bob Hendron, *Frontier Energy*
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2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Nonresidential Grid Integration

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Demand Management

David Jagger, Jessica Peters, Christine Riker, Kitty Wang,
Energy Solutions
September 10, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Nonresidential Grid Integration
2. Compressor Capacity Control for Load Management
3. Demand Responsive Lighting
4. Introduction to Compliance Options to Encourage Load Management

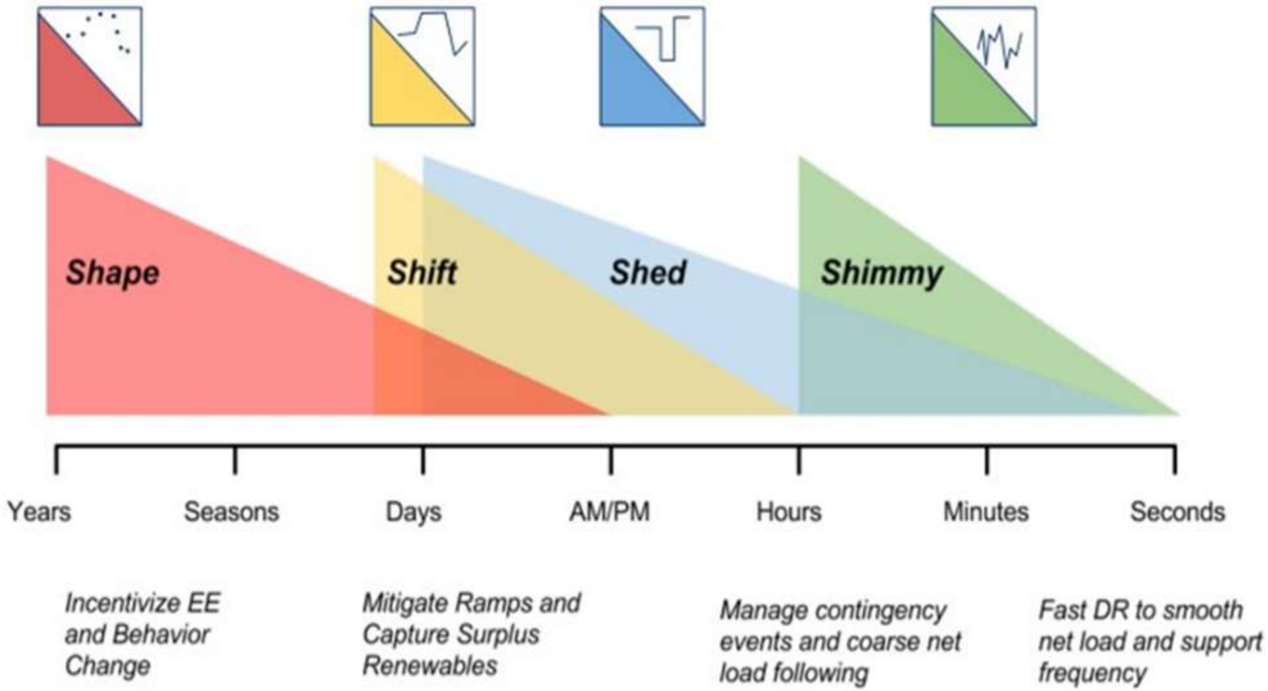
Demand Management

Goal: Adjust code requirements so facilities with demand management controls are more likely to use their controls to participate in demand management programs

Why are demand management programs important?

Flexible loads and controls can be used for day-to-day load management and peak demand reduction enable:

- Grid resiliency and reliability
- Increased renewable energy adoption
- Time-of-use rates, demand charges, and demand management programs to manage grid congestion
- Reduced need for inefficient/ high emissions peak generation plants



Demand Management in Nonresidential Buildings

The commercial and industrial sectors accounts for the majority of California's energy consumption*

- Commercial and Industrial: 41.8 percent
- Residential: 18.7 percent
- Transportation: 40.3 percent

Key nonresidential considerations:

- Larger energy use represents more potential for flexible demand
- A range of operating hours and operation flexibility well suited for current and future demand peaks and valleys
- Load shape and technology variation allow nonresidential buildings to take advantage of different demand management products (shift, shimmy, etc.)

*According to the Energy Information Administration in 2017

Submeasure A: Compressor Capacity Control for Load Management

Submeasure B: Demand Responsive Lighting

Submeasure C: Compliance Options to Encourage Load Management

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	HVAC	Mandatory	No

Buildings Impacted

- All nonresidential buildings that have Direct Digital Control (DDC) to the zone

Description of Change: Add variable speed compressors control functional testing to automated demand shed controls acceptance test procedure under section NA7.5.10

Context and History

Why are we doing this?

- All code-compliant buildings have HVAC controls capable of day-to-day load management
- Occupants can still use these controls for normal operation
- Current code specifies temperature adjustment as the main strategy for “demand responsive control”
- Current code is silent on other load management strategies for HVAC systems
- Goal is to establish a pathway to compliance of load management requirements for HVAC with variable speed compressors, using capacity limit control strategy
- Ideally, eliminate need to program the controls after code inspections

Context and History

Common HVAC Strategies for "Demand Responsive Control"

Load Management Strategy	Pro	Con	Recommend?
Directly resetting temperature with a thermostat	• Existing code requirement • Ubiquitous technology in wide use	• Indirectly controls load	Existing Code
Cycle Compressor	• Control strategy directly impacts load consumption • Can be tied to thermostat feedback	• Negligible load savings if compressor already cycling or off due to mild weather • Reduced equipment life • Difficult to balance load control with occupant comfort	N
Lock out second stage compressor	• Energy reduction direct output of control strategy	• See cycle compressor above	N
Limit compressor operating capacity	• Control strategy directly impacts load consumption • Can be tied to thermostat feedback • More granular control for comfort	• Limited to HVAC systems with variable speed technologies • Reduced load savings if compressor operating at low speed due to mild weather	Y

Do you agree with the pros and cons?

2019 Code Requirements

- See the full text in the accompany document in **resources tab**

Adjust operating temperature by 4 degrees or more	**Section 110.12(b)1 and 110.12(b)2:** ***remotely*** increase operating cooling temperature setpoint or heating temperature setpoint ***in all non-critical zones from centralized*** contact or software ***point*** **Section 110.12(b)3:** ***remotely*** revert to original operating levels from centralized contact or software point
Controls programmed for adjustable rate of change	**Section 110.12(b)4:** for temperature increase, decrease, and reset
Automated demand shed control	**Section 110.12(b)5:** Upon receipt of a demand response signal, the space conditioning systems shall conduct a centralized demand shed

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**

Update Acceptance test procedure	Add capacity limiting control of refrigerant compressor to acceptance test procedure along with thermostat setpoint reset programming

Poll

Do you agree with adding compressor capacity control (with thermostat feedback of temperature change) to acceptance testing of automated demand responsive controls?*

a) Yes, allow compressor capacity control

b) No, do not allow

*Upon receipt of an OpenADR signal, HVAC controls can either adjust thermostat setpoints by 4 degrees or adjust compressor operating capacity--for applicable HVAC systems with thermostat feedback of temperature change to 4 degrees--in non-critical zones.

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- **HVAC equipment with variable speed compressors include:**
  - Single-zoned: mini-split systems = 1 outdoor unit + 1 indoor unit
  - Multi-zoned:
    - Multi-split systems = 1 condensing outdoor unit + >1 indoor evaporators
      - 0.75 tons to ~ 5 tons (of cooling capacity).
    - Variable refrigerant flow (VRF) = 1 more condensing outdoor unit + >1 indoor evaporators.
      - >5 tons
      - Multi-zoned systems with direct digital controls (DDC) to the zone level.

HVAC Systems and HVAC Controls

Equipment

Rooftop unit (fixed or variable speed compressor)

Controls

Thermostat

Controller

Single Split System (variable speed compressor)

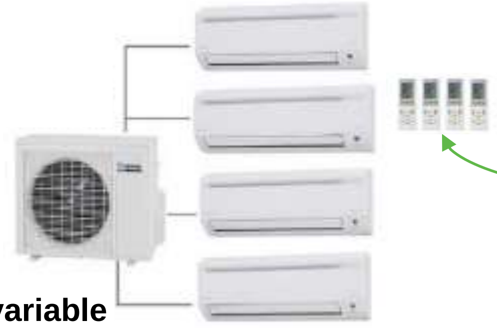
Single zoned systems

Equipment

Variable Refrigerant Flow (VRF) System (variable speed compressor)

Controls

Central Controller and Energy Management Control System (EMCS)



Zone Controllers

Multi-split (variable speed compressor)

Multi-zoned systems

Market Overview and Analysis

- VRF and multi-split systems are ~6 percent of total HVAC sales BUT growing rapidly
- VRFs and multi-splits are mature in Asia and Europe
- 3,500 VRF units sold in California in 2016 with estimated market value of $210 million*
- Single-zoned rooftop units with variable speed compressors are still an emerging market. A handful of major manufacturers (e.g., Carrier, Daikin, Trane, Lennox, York) have variable speed models

*Confidential Market Sources (2017, March 21). Unit sales of VRF systems with 3-phase condensing units in California in 2016. Communication with Energy Solutions.

Image retrieved Sep 3, 2019 from: http://asa.usno.navy.mil/cgi-bin/occnwdo.cgi?dir=2010/occns&file=occn.2010Oct04.Asia&body=Asia

Market Overview and Analysis

- **Market Trends**
  - VRFs and multi-splits are popular in retrofit applications where space restrictions prevent ducting for traditional forced air systems
  - Well suited for multi-zoned applications, especially when zones have large diversity in loads
  - Installer and designer experience with these systems are increasing with greater awareness and installations
  - CA renewables standard and building electrification goals are driving utility interest in VRFs and multi-splits
- **Market Barriers**
  - Variable speed compressor HVAC systems have higher upfront costs
  - Majority of new construction is still rooftop units without variable speed compressors

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- **Technical Considerations**
  - Requiring OCSTs for unitary systems with advanced controllers would be redundant. However these types of installations are currently small in number

- **Technical Barriers and Potential Solutions**
  - Multi-split, and VRF and variable speed unitary HVAC controls do not have compressor capacity limiting programmed for load management use case
  - Some additional engineering development needed to comply with existing code requirements for automated demand shed control (ADSC)

Do you agree with these technical considerations and barriers? What else should we consider?

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- **Per unit impacts**
  - Review case studies of demand savings from variable refrigerant equipment
  - Estimate load impact based on typical average 10 percent demand reduction for events
    - 2.5 percent change in load for each degree of temperature change
  - Cross check impacts against utility Auto Demand Response Program methodologies
- **Statewide impacts**
  - Collect data on unit shipments
  - Estimate quantity of new construction and retrofit
  - Apply annual turnover rate in the building stock for HVAC systems replacement then apply market share for VRFs/multi-splits

Do you have additional input on this energy impact analysis methodology?

Incremental Cost Information

- Statewide CASE Team to collect costs of HVAC equipment with variable speed compressor and controller
  - RS Means or other cost-estimating publications or software
  - Interviews with manufacturers, distributors or contractors
  - Design and other ‘soft’ costs are not part of the measure cost-effectiveness

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Buildings have ability to remotely reset setpoints by 4°F

Proposed Conditions

- Buildings have ability to remotely reset setpoints by 4°F
- Buildings with applicable HVAC systems can remotely adjust the refrigerant compressor speed in response to demand signal with thermostat feedback of 4°F change in non-critical zones

Compliance Verification Process

1. Design Phase

- Design the HVAC system to meet Title 24, Part 6 requirements
- Select control technologies (single zone – OCST; multi-zone with DDC – EMCS)

2. Permit Application Phase

- Plans checker confirms designs are in compliance

Compliance Verification Process

3. Construction phase

- Compliant systems and controls are installed
- Installed compressor capacity limiting control is programmable with thermostat feedback for applicable HVAC systems

4. Inspection Phase

- Complete NRCA-MCH-11-A Automatic Demand Shed Control acceptance document
- Acceptance test technicians perform compressor capacity limit acceptance test for applicable HVAC systems. Perform temperature setpoint adjustment acceptance test for all other HVAC systems.

Do you agree with the proposed compliance verification process during construction phase and inspection phase?

Poll

How many market actors (working with variable speed HVAC equipment) would consider engaging the compressor capacity limiting instead of thermostat setpoint adjustment for demand responsive control?

a) 76-100 percent of market actors
b) 51-75 percent of market actors
c) 26-50 percent of market actors
d) 6-25 percent of market actors
e) 0-5 percent of market actors

Thank You

Questions?

Kitty Wang, *Energy Solutions*

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: Compressor Capacity Control for Load Management

Submeasure B: Demand Responsive Lighting

Submeasure C: Compliance Options to Encourage Load Management

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Indoor Lighting for Demand Management	Mandatory	No

Types of Nonresidential Buildings Impacted

All facilities except for spaces where health or life safety statute, ordinance, or regulation does not permit the lighting to be reduced.

Description of Change: Adjust demand management requirements for lighting systems in response to a shift to solid state lighting.

Context and History

- **Language under review:**
  - 110.12(c) Lighting controls in nonresidential buildings ***larger than 10,000 square feet***, except for spaces with ***lighting power density (LPD) of 0.5 watts per square foot***, shall be capable or automated lighting power reduction in a ***uniformly consistent manner***
- **Why are we proposing this measure?**
  - The quantitative values above were developed in the 2013 Title 24, Part 6 code cycle and need to be updated to reflect current lighting power density standards
  - Reevaluating the cost effectiveness

Area Category Space Types*	2013 LPD (W/ft^2)	2016 LPD (W/ft^2)	2019 LPD (W/ft^2)
Auditorium	1.5	1.4	0.7
Classroom & Training	1.2	1.2	0.7
Dining Area	1.1	1	0.4 – 0.55
Exercise/Fitness	1	1	0.5
Lounges, Breakroom, & Waiting Area	1.1	0.9	0.65
Office Area ≤ 250 square feet	1	1	0.7
Laundry Area	0.9	0.7	0.45
Areas Not Specified	0.6	0.5	0.5

*Listed spaces are a sample of those listed in the area category method

2019 Code Requirements

- See the full text in the accompany document in **resources tab**

10,000 Square Feet Threshold	**Section 110.12(c):** Lighting controls in nonresidential buildings larger than 10,000 square feet shall be capable of automatically reducing lighting power…
0.5 Watts per Square Foot Exemption	**Section 110.12(c) Exemption 1:** Spaces with a lighting power density of 0.5 Watts per square foot or less are not required to install demand responsive controls and do not count toward the 10,000 square foot threshold.
Uniformity Requirement	**Section 110.12(c):** General Lighting shall be reduced in a manner consistent with the uniform level of illumination requirements in Table 130.1-A.

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**

10,000 Square Feet Threshold	1. Amend the 10,000 square foot threshold to new cost effective levels 2. Translate and replace the 10,000 square foot threshold to an equivalent installed wattage
0.5 Watts per Square Foot Exemption	Eliminate or adjust the 0.5 Watts per square foot exemption
Uniformity Requirement	Eliminate this requirement

Poll

Have you worked on an indoor lighting project that actively tried to avoid the Demand Response (DR) lighting requirement? If yes, what exception did you pursue?

Please check all that apply.

a) Installing high efficacy fixtures to reduce Watts per square foot below 0.5
b) In an alteration, not exceeding 80% of the indoor lighting power requirements
c) Other (please write-in your method into the chat window)
d) I have not been involved in a project that actively tried to avoid the DR lighting requirement

Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Outdoor Lighting for Demand Management	Mandatory	No

Description of Change: Review demand management potential for outdoor lighting and potential inclusion as a mandatory measure in the 2022 Title 24, Part 6.

Currently, there is no demand management language for outdoor lighting in the 2019 Title 24, Part 6.

Important Note

This is a brand new measure being considered. Facility scope, potential exemptions, location and method for inclusion within Title 24, Part 6 are still being considered.

Context and History

- **Why are we proposing this measure?**
  - Demand management needs fast responding loads, not only large loads shedding over long periods
  - Utility demand management programs are shifting to evening hours
  - Outdoor lighting in the 2019 Title 24, Part 6 assumes an all solid state lighting system

Area Wattage Allowance (AWA) in Watts per square foot			
Lighting Zone	2013	2016	2019
LZ1	0.035	0.020	0.018
LZ2 – A	0.035	0.030	0.023
LZ2 – C	0.045	0.030	0.025
LZ3 – A	0.090	0.040	0.025
LZ3 – C	0.090	0.040	0.030
LZ4	0.115	0.050	0.030

Linear Wattage Allowance (LWA) in Watts per linear foot			
Lighting Zone	2013	2016	2019
LZ1	0.25	0.15	0.15
LZ2 – A	0.45	0.25	0.17
LZ2 – C	0.45	0.25	0.40
LZ3 – A	0.60	0.35	0.25
LZ3 – C	0.60	0.35	0.40
LZ4	0.85	0.45	0.34

Initial Wattage Allowance (AWA) in Watts			
Lighting Zone	2013	2016	2019
LZ1	340	340	180
LZ2 – A	510	450	250
LZ2 – C	510	450	250
LZ3 – A	770	520	350
LZ3 – C	770	520	350
LZ4	1030	640	400

2019 Code Requirements

Existing Requirements in Title 24, Part 6

Outdoor Lighting Demand Management	**None Exist**
Other Outdoor Lighting Requirements	**Controls:** 1. **Section 110.9** – Mandatory Requirements for Lighting Controls 2. **Section 130.2** – Outdoor Lighting Controls and Equipment 3. **Section 141.0** – Additions, Alterations, and Repairs to Existing Nonresidential, High-Rise Residential, and Hotel/Motel Buildings, to Existing Outdoor Lighting, and Internally and Externally Illuminated Signs. **Lighting Allowance:** 1. **Section 140.7** Prescriptive Requirements for Outdoor Lighting outlines the lighting power allowances (LPAs) for general hardscape and specific applications.

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**

Outdoor Lighting Demand Management	1. Include language for mandatory outdoor lighting demand management capabilities
Additional Documents that will Require Updates	1. Certificate of compliance NRCC-LTO-E 2. Nonresidential compliance manual 3. Demand responsive lighting control acceptance document: NRCA-LTI-04-A 4. Reference appendices section NA7.6.3.2

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis: Indoor & Outdoor

Current Market

Controls:

- Automated demand management can be accomplished from products as simple as a dry contact relay to a networked lighting control system. Products along this spectrum are well established in the market and have their own qualified product lists (QPLs):
  - The Design Lights Consortium (designlights.org) has a QPL for network lighting controls that includes 16 interior and seven exterior systems with demand management capabilities
  - The OpenADR Alliance (openadr.org) has a QPL for dry contact relay devices & integrated systems that are capable of responding to demand management signals

Market Overview and Analysis: Indoor & Outdoor

- **Current Market**
  - Solid State Lighting:
    - An all-LED installation can easily achieve less than 0.5 Watts per square foot in indoor spaces
    - DLC lists 23,570 troffers that have an efficacy (lumens per Watts) greater than 125. With 143 troffers reporting greater than 140!*
    - DLC lists 1,977 outdoor fixtures with an efficacy greater than 140. With 139 reporting greater than 160!*
  - Programs:
    - Utilities across California offer incentives to install automated demand management systems with their Automated Demand Response programs

SMUD PowerDirect® Program

*DLC QPL as of 8/16/2019

Market Overview and Analysis

- **Market Trends**
  - Intelligently controlled lighting market is growing
  - More products are available with advanced capabilities for interior and exterior lighting
  - Prices decreasing
  - Integrated LED controls
  - Networked Lighting Control systems

  - **Market Barriers…**Survey Question!

Poll

What have been significant barriers to indoor lighting demand management implementation?

Please check all that apply.

a) Perceived impact on building tenants, occupants, and/or sales
b) Perceived low benefits after shift to solid state lighting
c) Lack of single stakeholder responsible for end-to-end integration
d) Other (please write-in your method into the chat window)
e) There aren’t any barriers

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations: Indoor & Outdoor

- **Technical Considerations** – *Early Stages of Development*
  - Demand management installations in smaller areas, particularly for alterations
  - Installed versus max potential wattage for exemption threshold
  - Occupancy or daylight dimming fixtures
  - Control capabilities of fixtures in spaces with LPDs less than 0.5 Watts per square foot
  - Control capabilities of outdoor fixtures
  - Title 24, Part 6 indoor lighting wattage allowance varies by building or space type. Need to reasonably equate a new exemption threshold applicable to all building and space types

Technical Considerations: Indoor & Outdoor

- **Technical Barriers** - *Early Stages of Development*
  - Installing control systems in spaces that require extensive space retrofits
  - Outdoor lighting isn’t interconnected
  - Dimming capabilities of outdoor lighting and indoor lighting spaces with LPD less than 0.5 Watts per square foot
- **Potential Solutions** - *Early Stages of Development*
  - Wirelessly connected systems are more ubiquitous and continue to get cheaper and more approachable
  - Encourage installation of systems that control both indoor and outdoor lighting
  - Account for added control costs to enable effective demand management or limit response

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts
  - Key Assumptions
- Cost Impacts

Proposed Methodology for Energy and Demand Impacts Analysis: Interior Lighting

- **Mirror and expand** on the 2013 Demand Responsive Lighting Controls CASE Report:
  - ASHRAE 90.1 building models
  - Develop LPD for each building type based on max allowable LPD and available market data (e.g., CEUS, CSS, and market outreach)
  - Account for occupancy and photosensor impacts
  - Calculate energy reduction potential associated with a 15 percent reduction
  - Calculate the energy and demand savings associated with annual participation hours
- Impacts will **vary by climate zone** based on TDV

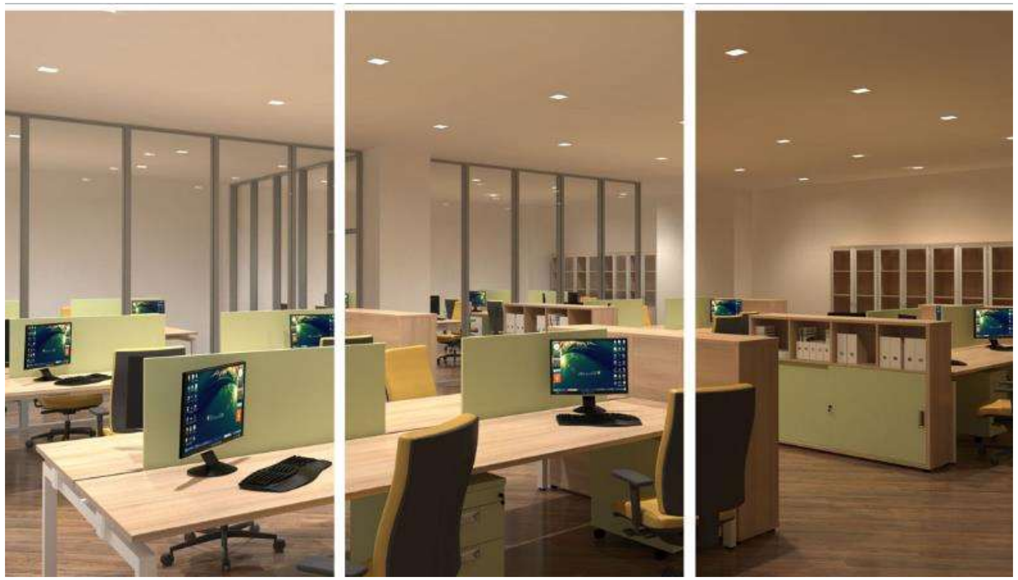

Image source: https://luxreview.com/article/2016/02/10-things-you-must-know-before-you-dim-led-lamps
2013 Demand Responsive Lighting Controls CASE Report: http://title24stakeholders.com/wp-content/uploads/2017/10/2013_CASE-Report_Nonresidential-Demand-Responsive-Lighting-Controls.pdf

Assumptions for Energy Impacts Analysis: Interior Lighting

- **Key Assumptions** *Still in Development*
  - Interior lighting already has the capabilities to participate in demand management events
    - Office buildings represent the most cost prohibitive building type and are a reasonable proxy for cost-effectiveness for all building types
    - New TDV values will show evening hours as more valuable than previous years
    - Demand Management events correlate with top TDV hours in peak pricing window
    - Available lighting power must account for task tuning, photosensor, and occupancy sensor interactions
    - Period of evaluation: 15 years

Definition of Indoor Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2022 Title 24, Part 6 controls
- LPD represented by max allowable LPD of 2022 Title 24, Part 6 or available market data, whichever is lower
- Building occupants are enrolled in a utility demand response program

Proposed Conditions

- Building occupants respond to the top 1 percent of hourly TDV prices
- Building occupants respond by shedding 15 percent of their lighting load
- A specified percentage of building occupants will override their systems participation each event.

Methodology for Energy and Demand Impacts Analysis: Outdoor Lighting

- Mirror the 2019 Nonresidential Outdoor Lighting Controls CASE Report:
  - Ten different building and hardscape models supported by real world buildings representing different size, shape, and building types
  - Develop installed wattage based on max allowable and available market data (e.g., CEUS, CSS, and market outreach)
  - Calculate lighting shed potential based on bi-level dimming capabilities and availability due to occupancy and photosensors
  - Calculate the energy and demand savings associated with annual participation hours
- Impacts will vary by climate zone based on TDV

Image Source: https://slideplayer.com/slide/6285345/ ; Lithonia Lighting D-Series LED Area Luminaires Presentation
2019 Nonresidential Outdoor Lighting Controls CASE Report: http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Outdoor-Ltg-Controls_Final_September-2017.pdf

Assumptions for Energy Impacts Analysis: Outdoor Lighting

- **Key Assumptions** *Still in Development*
  - Operating hours based on dusk-to-dawn operation in different climate zones
  - Market data is available to establish occupancy rates of outdoor space types (e.g., Western Exterior Occupancy Survey)
  - Fixtures can be step dimmed by 50 percent per minimum motion sensing control requirement in section 130.2(c)3
  - Demand Management events correlate with top TDV hours in peak pricing window
  - Period of evaluation: 15 years

Definition of Outdoor Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2022 Title 24, Part 6 controls
- LPD represented by max allowable LPD of 2022 Title 24, Part 6 or available market data, whichever is lower
- Building occupants are enrolled in a utility demand response program

Proposed Conditions

- Building occupants respond to the top 1 percent of hourly TDV prices
- Demand management controls:
  - High output power: 100 percent
  - Low output power: 50 percent
- Define average nighttime occupancy by space type per WEOS[1]

[1] Western Exterior Occupancy Survey (WEOS) for Exterior Adaptive Lighting Applications, 2014

Methodology for Cost Impacts: Indoor & Outdoor

- Statewide CASE Team to collect demand responsive lighting incremental costs:
  - Defining pathways to compliance
  - Identify additional control costs for spaces less than or equal to 0.5 Watts per square foot for indoor lighting
  - RS Means or other cost-estimating publications or software
  - Interviews with manufacturers, manufacturer reps, lighting designers, and installers
  - Literature and program review of demand responsive control costs and associated labor

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Design the indoor and outdoor lighting systems to meet Title 24, Part 6 requirements
- Select controlling technologies
- Complete NRCC* forms (indoor = LTI-E; outdoor = LTO-E) & incorporate construction documents

2. Permit Application Phase

- Plans checker confirms designs are in compliance

*NRCC are compliance forms that need to be completed to show Title 24 Part 6 compliance. There are forms for all areas of new buildings. LTI-E and LTO-E are specific to lighting

Compliance Verification Process

3. Construction phase

- Compliant systems and controls are installed
- DR measures are programed

4. Inspection Phase

- Acceptance Test:
    - Indoor (NA7.6.3) and outdoor (newly proposed language, mirroring NA7.6.3) to test demand responsive control; Measuring lighting output or circuit current
- Complete NRCA LTI-04-A: demand responsive lighting control acceptance document

Market Actors

Who would be involved in implementing these measures?

- Lighting Designers
- Contractor/Builder
- Electrician
- Energy Consultant/Modeler
- Plans Examiner
- Building Inspector
- Utility Demand Response Programs
- California Independent System Operation (CAISO)
- Lighting Controls Manufacturers
- Acceptance Test Technicians

Thank You

Questions?

David Jagger, *Energy Solutions*

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: Compressor Capacity Control for Load Management

Submeasure B: Demand Responsive Lighting

Submeasure C: Compliance Options to Encourage Load Management

Interested in reviewing the proposed changes for Load Management in the 2022 California Energy Code?

Attend our Nonresidential Software Improvements Stakeholder Meeting on November 12th

RSVP at title24stakeholders.com/events/

Code Change Proposal – Summary

Add Compliance Options that add or revise features to encourage buildings to pursue grid integration design approaches and technologies.

This submeasure will be discussed in detail at the **November 12th Nonresidential Software Improvements Meeting.**

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Load shifting	Compliance	Yes

- Designers will **not be required** to pursue these options
- Buildings will **receive credit through the performance approach** if they choose to pursue

Context and History

- **Why are we proposing this measure?**
  - To give building owners the opportunity to receive credit when they install technology or design a building to enable greater demand management and potentially load shifting
  - Encourage the market to be retrofit-ready as the technologies mature
- Load shifting technologies being looked at:
  - Battery storage (Pending approval from Energy Commission)
  - Thermal energy storage
  - Demand-response controls on heat pump water heating equipment
  - Credit for DC circuitry when solar or battery systems are also installed on site

Overview: Potential Load Shifting Technologies

- **Battery storage**: Battery storage that enable buildings to use power generated by time dependent renewables during off-peak times
- **Thermal energy storage (TES)**: Technology that allows the transfer and storage of heat energy or, alternatively, energy from ice or water to be used at off-peak times
- **Demand management controls on heat pump water heating equipment**: Utilizes TES capabilities in water heaters to optimize timing of energy use
- **Credit for DC circuitry when solar or battery systems are also installed on site**: Provides an option to acknowledge power savings associated with installing a DC circuit between the DC output of renewables/ batteries and DC building loads such as LED lighting

Pre-cooling for Load Shifting

- Not recommended for nonresidential in 2022 code cycle
  - Research has been based on a noon-6 pm peak with pre-cooling in the morning
  - More research needed to model pre-cooling in the hottest part of the day across all climate zones and applicable building types
  - Need to confirm participant and grid cost-effectiveness using TDV values
- Load shifting compliance option
  - 2019 code cycle implemented HVAC precooling as compliance option for residential (CBECC-Res)
  - The building uses more energy due to efficiency losses, but reduced costs to the grid
- Applicable to specific sectors operating during peak (5-8pm)
  - Retail, grocery, restaurant, hospitality, (not office)

Do you agree with the technology areas we have identified?

What would you most like to see updated in the compliance software to encourage flexibility in buildings?

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
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We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by September 24th, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

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2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Multifamily All Electric Compliance Pathway

Codes and Standards Enhancement (CASE) Proposal

Multifamily | Multiple/Load Shifting

Abhijeet Pande, Dove Feng, *TRC*

September 10, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

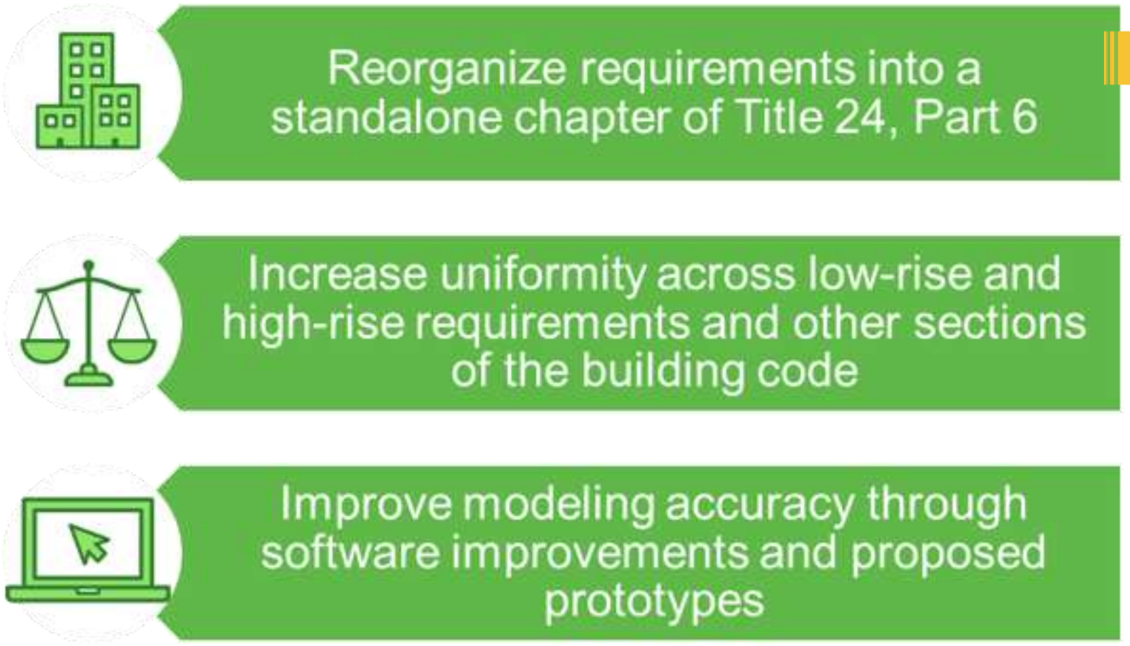
Agenda

1	Background	*15 min*
2	Market Overview and Analysis	*10 min*
3	Technical Feasibility	*10 min*
4	Cost and Energy Methodology	*5 min*
5	Compliance and Enforcement	*5 min*
6	Proposed Code Changes	*5 min*
7	Discussion and Next Steps	*10 min*

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

2022 Focus on Multifamily



- Mimic residential chapter structure
  - 160.0 Mandatory Features and Devices
  - 160.1 Performance and Prescriptive Compliance Approaches
  - 160.2 Additions and Alterations
- Include common area spaces
- Reference to
  - Section 110 for mandatory measures
  - Sections 120, 130, and 140 for nonresidential spaces not exclusive to residents

Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Multifamily	Multiple/ Load-shifting	Prescriptive and performance	Yes

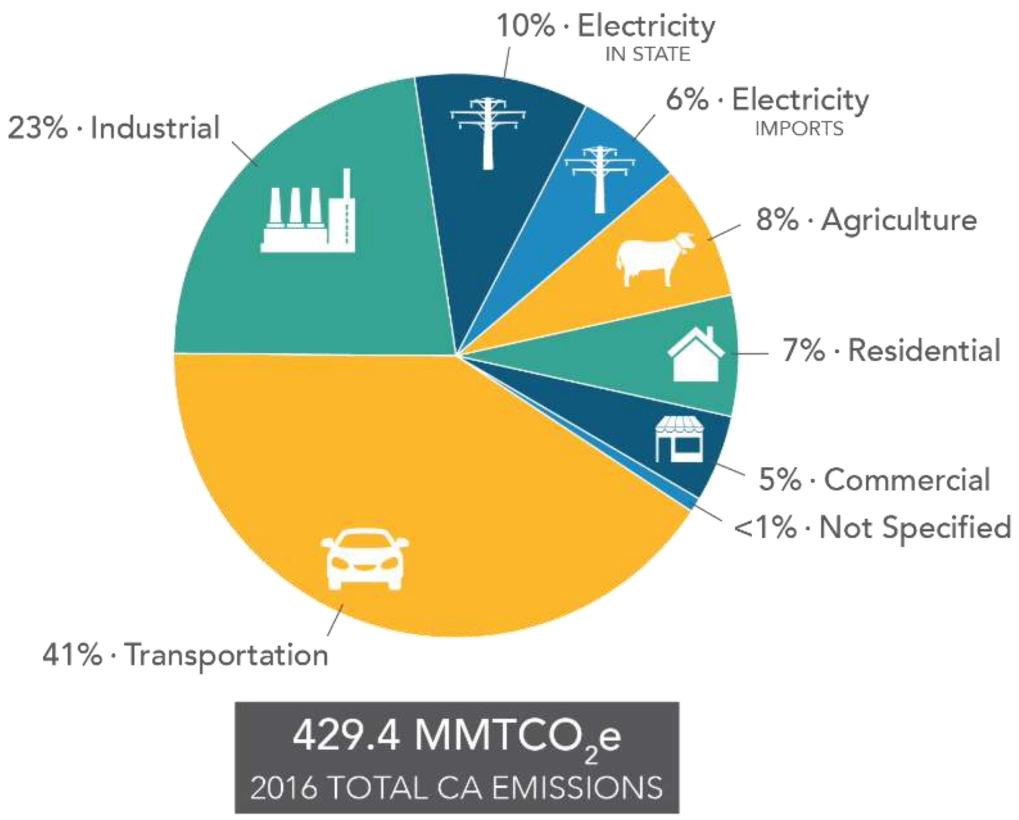
- **Prescriptive and Performance Compliance paths for all-electric buildings**
  - Single all-electric baseline:
    - Fix baseline systems regardless of fuel source of proposed building
  - Dual baselines:
    - All-electric OR mixed-fuel baseline dependent on fuel source of proposed building
- **Update modeling assumptions for appliances and plug loads**
  - Low-rise: Update for heat pump dryer, induction cooktop, communal laundry
  - High-rise: Update receptacle load assumption to match low-rise

- Enable multifamily buildings that are all-electric (i.e. no natural gas appliances) have prescriptive and performance pathway to compliance with Title 24
- Streamline electrification requirements across low-rise, mid-rise and high-rise

Context and History

Why are we proposing this measure?

- Assembly Bill 3232 asks to reduce California building emissions 40 percent below 1990 levels by 2030
- AB1477 sets aside $50M per year to support building decarbonization
- Residential buildings represent seven percent of the State's total GHG emissions
  - Water heaters, space heaters, cooking, clothes washing and drying
  - Multifamily is almost half of all new residential construction
- Emissions from on-site electricity use is less than that of natural gas appliances
  - And will continue to decrease as state moves closer to SB100 goals for 100% renewable electricity

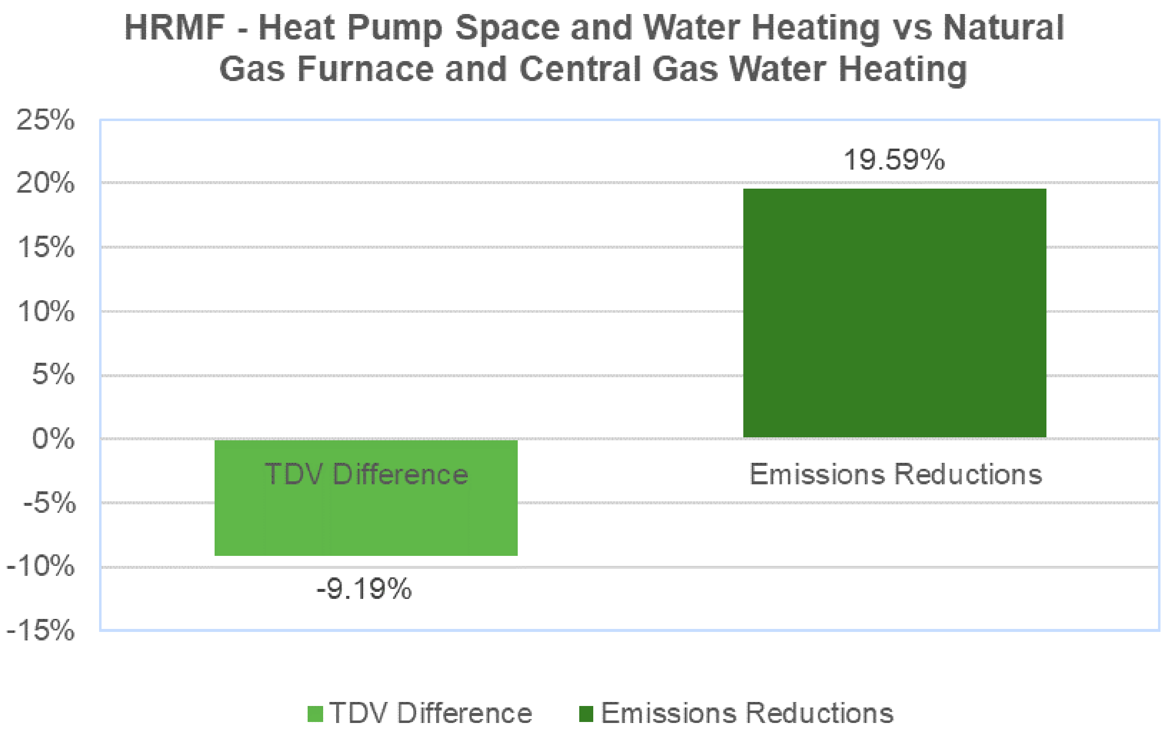


California's Carbon Emissions by Economic Sector

Source: California Greenhouse Gas Emission Inventory - 2018 Edition. California Air Resources Board. https://ww3.arb.ca.gov/cc/inventory/data/data.htm

Context and History

- Time Dependent Valuation (TDV) values electricity at higher value than natural gas, even though electricity generates less overall GHG emissions
- The Alternative Calculation Method (ACM) specifies gas equipment as the baseline system causing potential compliance challenge for some electric water and space heating systems



Source: HRMF Prototype developed by TRC modeled using CBECC-COM 2019

2019 Code Requirements: DHW Baseline

- Allows all-electric prescriptive and performance approach for low-rise multifamily with individual heat pump water heaters (HPWH)

Space Type	Code Section	DHW system Type	Proposed	Standard
Low-rise residential (3 stories or fewer)	- Prescriptive:150.1 (c) 8. A - Performance: RACM[1] 2.9.2	Individual	HPWH or electric resistance	HPWH
	- Prescriptive:150.1 (c) 8. B - Performance: RACM[1] 2.9.3	Central	Any	Gas water heater
Mid and High-rise (4 stories or more)	Prescriptive: 140.5 (b)	Follow low-rise requirements [150.1 (c) 8.][2]		

Central water heating uses gas water heaters as baseline

1. Residential alternative calculation method (ACM) reference manual
2. With exception that buildings with 8 or stories higher are not required to meet the solar thermal requirements

2019 Code Requirements: HVAC Baseline

- Allows all-electric prescriptive and performance approach for low-rise multifamily with electric space heating

Space Type	Code Section	Proposed	Standard
Low-rise residential (3 stories or fewer)	- Prescriptive: Table 150.1-B - Performance: RACM[1] 2.4.1 Table 6	Heat pump	Heat pump
		Furnace	Furnace
Mid-rise residential (4-7 stories)	Performance: NRACM[2] Table 2	Any	Single zone constant volume air conditioner with furnace
High-rise residential (8 stories or more)		Any	Four-pipe fan coil with hot water natural gas boiler

HVAC system baseline is natural gas fired equipment for mid-rise and high-rise

1. Residential alternative calculation method (ACM) reference manual
2. Non-residential alternative calculation method (ACM) reference manual

2019 Code Requirements: Plug loads

- Plug loads include appliances and miscellaneous electric loads (MELs)

Space Type	Software	Current Assumptions
Low-rise residential	CBECC-Res	- Updated in 2016 to include appliances and MELs - Estimate annual energy consumption (AEC) based on number of bedrooms, number of occupants, or conditioned floor area - No modeling algorithm for induction cooktop, heat pump cloth dyers, and communal laundry
Mid- and high-rise residential	CBECC-Com	- Not updated for a long time - Power density at 0.5 W/ft^2

Inconsistent assumptions between LR, MR and HR

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**

#	Submeasure	Description
1	Prescriptive Pathway	Define standard electric heating, cooling and water heating systems + efficiency measures (if necessary)
2	Performance Pathway	Define standard electric heating, cooling and water heating systems + efficiency measures (if necessary)
3	Update unregulated loads for low-rise	Update assumptions for heat pump dryers, induction cooktops. Identify MF specific changes (e.g. central laundry) to current calculations.
4	Update unregulated loads for high-rise	Update high-rise res assumption for plug loads and MELs to match low-rise

Proposed Code Change Overview

- Provide prescriptive and performance pathway
  - Define standard electric space heating and cooling system
  - Define standard electric water heating systems: individual and central

- **Evaluate two compliance scenarios**
  - **Single all-electric baseline:** Must be cost-effective and achieve equivalent TDV energy as mixed-fuel baseline
  - **Dual baselines:** One all-electric and one mixed fuel. Must achieve equivalent TDV energy

Proposed Code Change Overview

- As necessary, add additional energy efficiency measures
  - Where federal minimum equipment efficiency is lower than typically installed equipment
    - e.g. individual HPWH
  - Avoid unintended EE tradeoffs by setting an artificially lower baseline than current practice
  - Where typical efficient all-electric solution is penalized by TDV difference between electricity and gas

Proposed Code Change Overview: Plug Loads

- Update appliance and plug load modeling rules
  - Update low-rise ACM calculations to account for efficient electric appliances
    - Induction cooktop
    - Heat pump dryer
    - Central laundry
  - Update high-rise ACM calculations to match low-rise ACM calculations
- Market and product research
- Leverage work from companion nonresidential plug load topic
  - Stakeholder meeting on November 12, 2019

Research Approach: Identify All-Electric Baseline

- Identify typical efficient HVAC and DHW practices
  - Program /project data analysis
  - Interview, survey and stakeholder meetings
- Evaluate typical HVAC and DHW system types against gas baseline
  - Energy modeling
  - Cost analysis
  - Greenhouse gas impacts
- Identify gaps between federal minimum and typical practice
  - Market and product research
- Companion HPWH topic to address DHW issues
  - Stakeholder meeting on October 3, 2019

Software Updates

- Current modeling capabilities
  - CBECC-Com and CBECC-Res can model most all-electric HVAC and DHW systems
  - Central HPWH model is currenting under development
- Proposed modeling capabilities/changes
  - Update baseline system type in the CBECC-Res and CBECC-Com
  - Plug load modeling rules
    - Update CBECC-Res plug load modeling rules for induction cooktop, heat pump dryer, and central laundry
    - Modify CBECC-Com to match low-rise

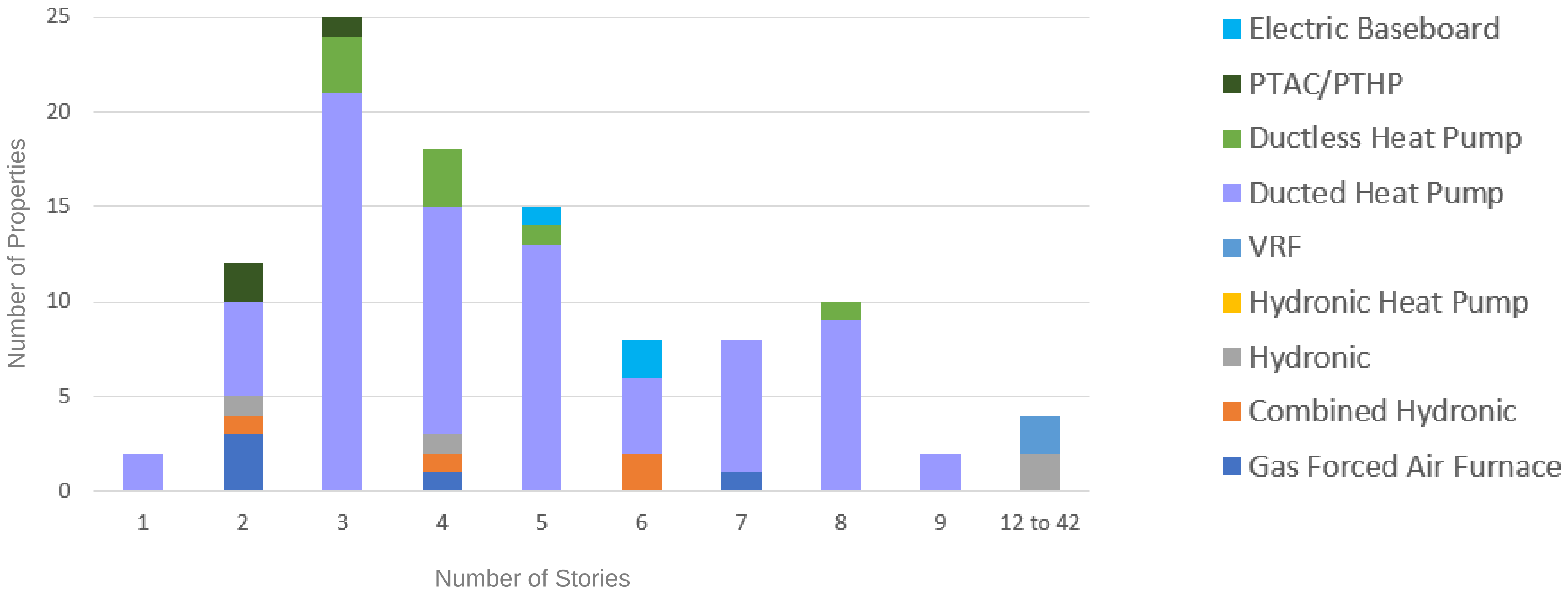
Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis: Goals

- Identify typical efficient HVAC and DHW design practices
  - Literature review covering existing studies on decarbonization strategies
  - Analyze data from energy efficiency programs /projects
  - Interview subject matter experts
  - Survey stakeholders
- Identify gaps between federal minimum and typical practice efficiencies
  - Product availability
  - Design practices

Typical HVAC System Types



Source: Consultant Project Data

Market Overview and Analysis: Initial Results – Low-rise

- HVAC system types for low-rise (3 or less stories)
  - Dominant approach: Ductless or ducted split heat pump with outdoor units on roof or ground
  - Packaged terminal heat pump units (PTHP)
  - Electric resistance for only heating designs (combined with above code envelop insulation)
- Market barriers
  - Packaged terminal heat pump units (PTHP)
  - No significant barriers to split heat pump system

Do you have data to support/disprove these findings to date?

Market Overview and Analysis: Initial Results – Mid-rise

- HVAC system types for mid-rise (up to 7 stories)
  - Packaged terminal heat pump units (PTHP)
  - Dominant approach: Ductless or ducted split heat pump with outdoor units on roof or ground
  - Electric resistance for heating-only designs (must be combined with above code insulation)
  - Four-pipe fan coil (FPFC) not commonly used
- Market barriers
  - Packaged terminal heat pump units (PTHP)
  - No significant barriers to split heat pump system

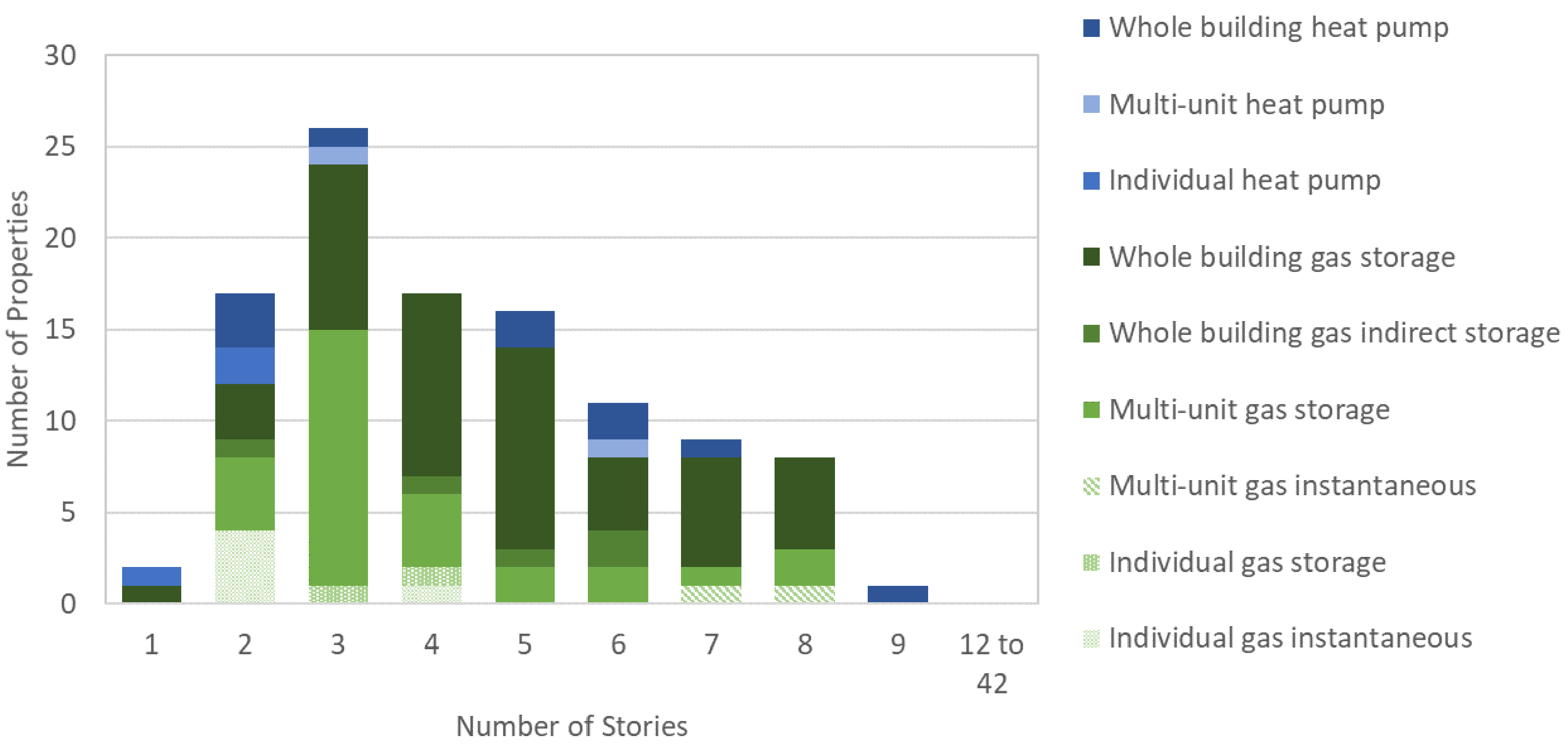
Do you have data to support/disprove these findings to date?

Market Overview and Analysis: Initial Results – High-rise

- HVAC system types for high-rise (8+ stories)
  - Ducted heat pump (up to 9 stories)
  - Central hydronic systems with gas boiler (9+ stories)
  - Variable refrigerant flow (VRF) systems (9+ stories)
- Market barriers
  - PTHPs are generally low efficiency
  - Split heat pumps: Challenge to locate outdoor units
  - VRF systems: High cost, California HFC phasedown
  - Ground source heat pumps are too expensive to be widely applicable
  - Central air to water heat pump boilers: Limited product and lack of performance data

Do you have data to support/disprove these findings to date?

Typical DHW System Design



Source: Consultant project data

Market Overview and Analysis: Initial Results - DHW

- Market trends: DHW design
  - Gas storage systems dominant in low-rise, mid-rise and high-rise
  - Shared (multi-unit) gas water heaters are increasing share in low-rise
  - Heat Pump Water Heating systems increasing share – both individual and whole building
- Market barriers
  - Central HPWH is still new to the industry
    - Requires sophisticated engineering compared to gas heaters
    - High maintenance requirement
  - HPWH systems require more coordination among designers and trades
    - Space for storage tank
    - Access to ambient air for compressor to operate

Do you have data to support/disprove these findings to date?

Market Overview and Analysis: Heat Pump Dryer and Induction Cooktop

- Current market: Heat pump dryer and induction cooktop
  - Low market penetration
- Market barriers
  - Consumer acceptance and familiarity to heat pump dryer and induction cooktop
    - Potential increased first and operational costs
    - Different cooking behavior and cookware for induction cooktops
    - Concern around adequate capacity/performance for heat pump dryers
  - Limited product availability
  - Lack of knowledge of product
  - Lack of performance data

Do you have data to support/disprove these findings to date?

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Central heat pump water heating
  - Lack of performance data and design guides for central system
  - Footprint required for central heat pump systems is larger than that for gas boilers
  - Central heat pump water heaters cannot be modeled in CBECC
    - Poses compliance challenges for high-rise buildings that tend to use central systems
    - Energy Commission working on CBECC updates to address this issue
  - Solar thermal requirements - prescriptive requirement for solar thermal system does not work well with heat pump technology

Technical Considerations

- Space cooling/heating for low-rise and mid-rise
  - Split/packaged duct and ductless heat pump system
- Technical Barriers
  - No technical feasibility challenges

Do you agree with this description? What else should we know?

Poll

What is the appropriate baseline electric HVAC system for high-rise multifamily buildings?

- Central system, decentralized or individual?
- Variable Refrigerant Flow
- Packaged Terminal Heat Pumps
- Split Heat Pump
- Hydronic System with Heat Pump Boiler
- Other? Please type your response in the Chat

Technical Barriers and Potential Solutions

- Packaged Terminal Heat Pump: low efficiency
- Variable Refrigerant Flow
  - Refrigerant pipe length limitation
  - Refrigerant leakage risk (ASHRAE 15)
  - California HFC phasedown
- Split heat pump
  - Location for outdoor units (use roof as condensing farm)
- Central air to water heat pump boiler
  - Hot water temperature lower than traditional gas boiler
  - Operational constraints such as high minimum flowrate

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Energy cost savings

Modeling Approach

Electric Baseline Package

- **Systems**: Typical efficient all-electric system type with federal minimum efficiency equipment
- **Others:** Prescriptive requirements + <u>energy efficiency measures</u>

TDV =

Typical Efficient Mixed Fuel Design

- **Systems**: Typical efficient mixed fuel system design practice
- **Others:** Prescriptive requirements

Set electric baseline so that typical efficient and cost-competitive electric systems achieve same compliance margin as typical efficient mixed fuel system.

Methodology for Energy Impacts Analysis

- Based on 2019 CBECC-Res and CBECC-Com prototype energy models, using new multifamily prototypes developed for 2022 CASE analysis
- Modeling and results will be climate-zone specific
- Will not be presenting results of energy and cost-effectiveness analysis during this meeting

Incremental Cost Information

- How we plan to collect costs of base case technology and proposed technology
  - Interviews with manufacturers, distributors or contractors
  - Real world project cost data from contractors and consultants
  - Internet and distributor surveys for measure costs
  - RS Means or other cost-estimating publications or software
- What components of costs did we leave out?
  - Design and other ‘soft’ costs are not part of the measure cost-effectiveness, though they do form part of the technical and market feasibility analysis for the measures

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Designers will have options to demonstrate compliance
- Designers need to consider impacts on electrical and plumbing design
- Coordination between trades
  - e.g. Architects for space for HPWHs and provide access to ambient air. Structural engineers, if central HPWH and storage tank are on the roof.

2. Permit Application Phase

- No significant impact for plans examiners or local jurisdictions, except to use revised compliance forms and review new details related to electrical equipment specifications

Compliance Verification Process

3. Construction phase

- Builders and contractors need to consider measure impacts on electrical and plumbing installation
- Coordination between trades

4. Inspection Phase

- All electric design will introduce changes in electrical and plumbing designs. Inspectors will need new knowledge and skills.
  - e.g. Installation practices for central HPWH

Market Actors

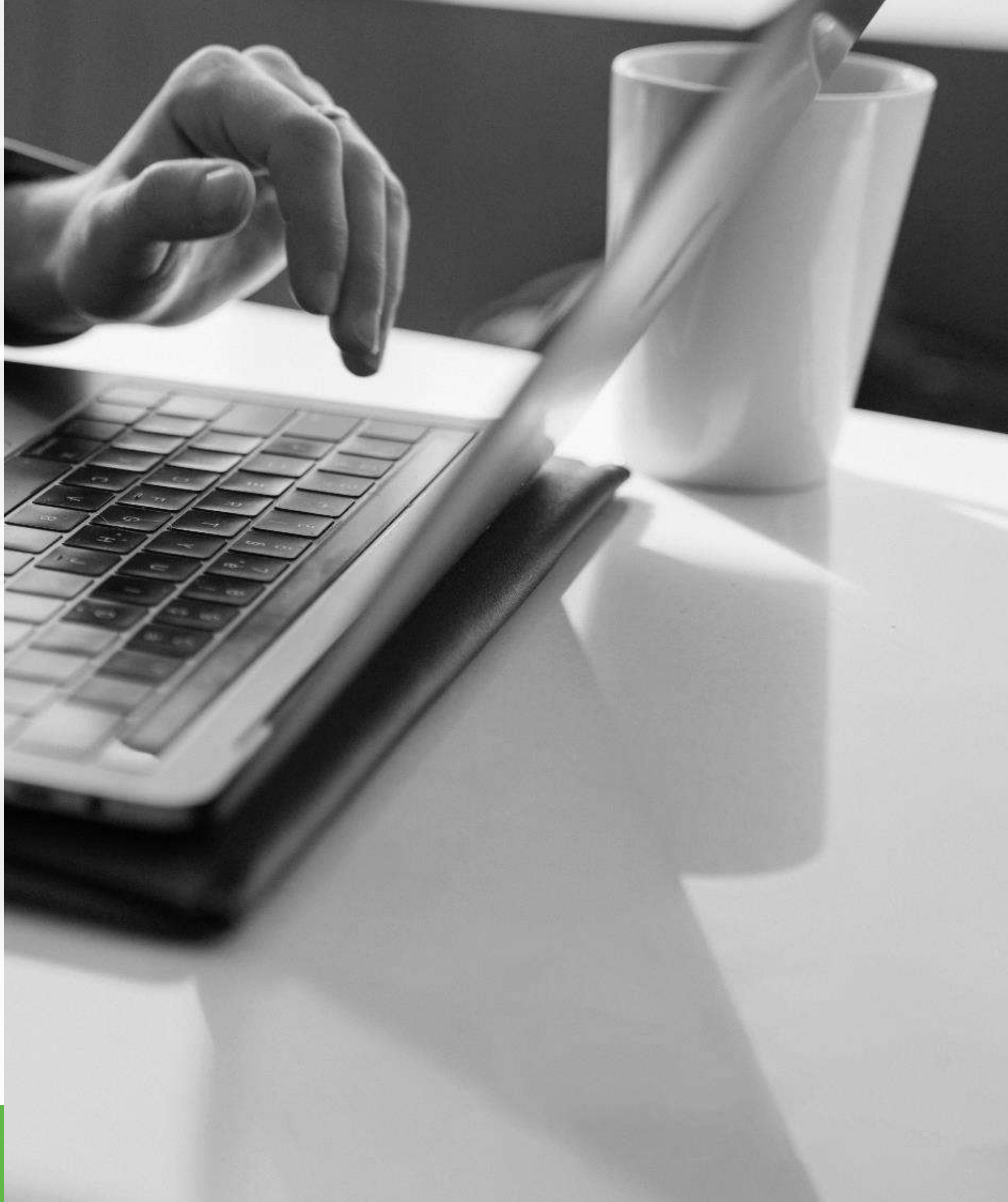
Market actors involved in implementing this measure include:

- Building Owners
- Architects
- Designers
  - Electrical
  - Mechanical
  - Plumbing
  - Structural
- Energy Consultants
- Builders
- Installers
- Plans Examiners
- Building Inspectors
- HERS Raters
- Manufacturers

- Statewide CASE Team conducting surveys and interviews with designers, energy consultants, developers, and manufacturers

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



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- Split Heat Pump
- Hydronic System with Heat Pump Boiler
- Other? Please type your response in the Chat

Poll

What is the appropriate baseline for an electric DHW system for multifamily buildings?

- Whole Building HPWH with storage tanks and recirculation loops
- Individual HPWH
- Multi-unit HPWH with storage tanks BUT without recirculation loops
- Other? Please type your response in the Chat

Discussion

- **What are your current strategies for achieving code compliance with all-electric multifamily buildings?**
- **What is the prevalence of common laundry facilities?**
- **Is this accounted in your analysis?**

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Questions?

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Please complete the closing polls below

Upcoming Meetings

Meeting Topic	Building Type	Date
Lighting Part 2: Indoor Lighting	NR	Thursday, September 12, 2019
Covered Processes Part 1: Controlled Environment Horticulture	NR	Thursday, September 19, 2019
Multifamily & Nonresidential Water Heating	MF/NR	Thursday, October 3, 2019
Single Family HVAC	SF	Thursday, October 10, 2019
Nonresidential HVAC Part 1: Data Centers, Boilers, & Controls	NR	Tuesday, October 15, 2019
Nonresidential Envelope	NR	Thursday, October 24, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Tuesday, November 5, 2019
Nonresidential HVAC Part 2: Air Distribution, & Controls	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019