Existing Single Family Building Upgrades Cost-Effectiveness Study

Building Energy Efficiency Standards: January 1, 2023

Complete Report

Introduction

This report documents cost-effective measure upgrades in existing single-family buildings that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023. It evaluates efficiency measures such as adding insulation, replacing windows, and duct upgrades, fuel substitution measures that upgrade space heating and water heating to heat pumps, and solar photovoltaics (PV). These prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh), and source energy savings, GHG emissions reductions, and LSC (long-term systemwide cost) impacts.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Long-term Systemwide Cost (LSC) is the California Energy Commission's LCC methodology for the 2025 Title 24, Part 6 (Title 24) code cycle (previously referred to as Time Dependent Valuation (TDV)), which is intended to capture the long-term projected cost of energy including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution

Note on Reporting Results

The extensive analysis for this type of report led to an overwhelming number of scenarios including different base cases, house vintages, replacement options, and climate zones. In this Summary and in the full study, the Statewide Reach Codes Team produced graphical representations of ***select key cases*** indicating high level measure cost effectiveness from either an On-Bill perspective, an LSC perspective, both metrics, or neither. In this Summary, the results illustrated are for four specific ***envelope and duct measures*** for the pre-1978 vintage prototype (see Figures 1-4), and for five ***heat pump space heater measures*** for the 1992-2010 vintage (see Figures 5-9).

The full dataset of all results is available here. Results alongside policy options can also be explored using the Cost-Effectiveness Explorer.

impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24 code development.

> **Prototypes:**
> For this analysis, the prototype was a single-story, three-bedroom detached home with attached two-car garage (1,665 square feet). Three vintages were analyzed (pre-1978, 1978-1991, 1992-2010).
>
> **Climate Zones:** All 16

Study Results

The following summarizes key results from the study:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs, these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages.

2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in the 1978-1991 vintage (see Figures 1-4). Duct upgrades may be able to be coupled with other measures to reduce the cost.

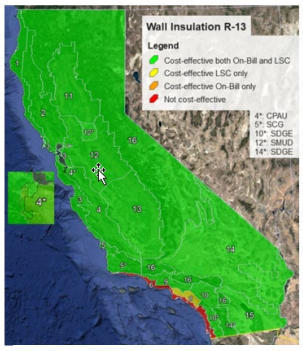

Figure 1. R-13 wall insulation

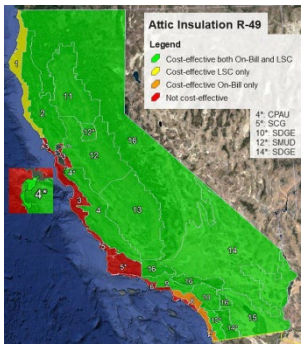

Figure 2. R-49 attic insulation

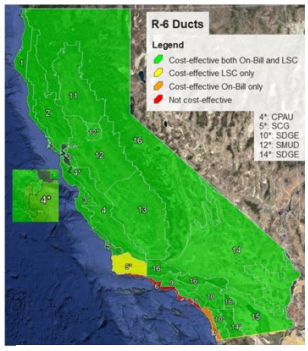

Figure 3. New R-6 ducts

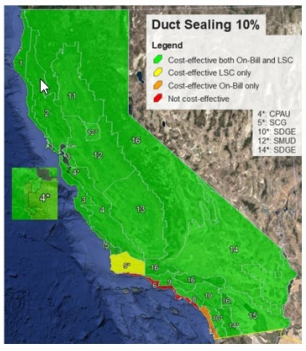

Figure 4. 10% duct leakage

3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The Dual Fuel Heat Pump (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.

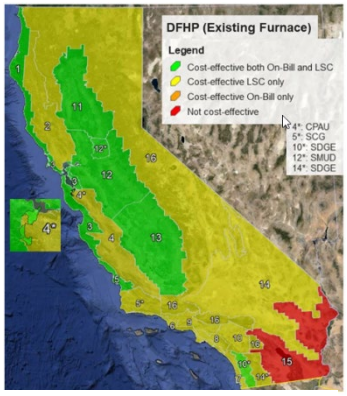

Figure 5. Dual fuel HP with existing furnace as backup

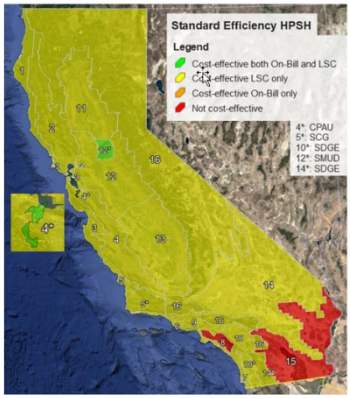

Figure 6. Standard efficiency ducted central HP replacement

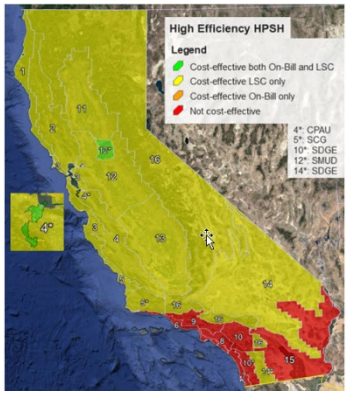

Figure 7. High efficiency ducted central HP replacement

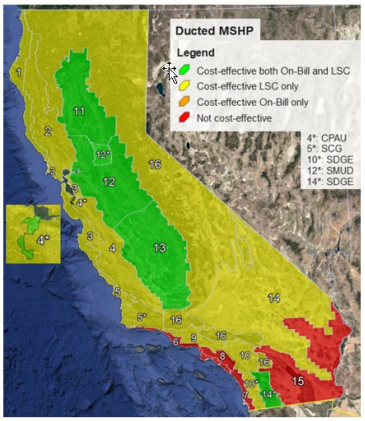

Figure 8. Ducted mini-split HP replacement

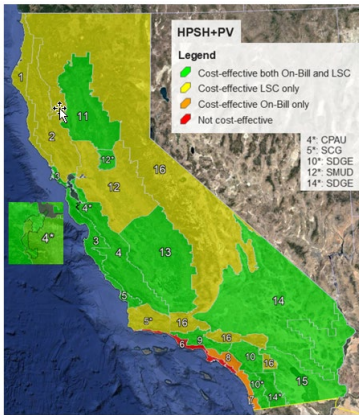

Figure 9. Standard efficiency ducted central HP + PV

4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective.

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5. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The

reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.

6. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3, 5, and 6.

Recommendations

Some of the various approaches available for jurisdictions who are interested in reach codes for existing buildings excerpted from the full report are listed below along with key considerations. The report contains the complete discussion.

1. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type or ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing when ducts are in an unconditioned space.

2. Equipment Replacement: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the additional considerations outlined in the report. Equipment replacement ordinances must consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn't have been required as part of the proposed scope of work in absence of the reach code. In addition, an equipment replacement policy must include considerations for residents with income or resource constraints.

3. "Flexible Path", minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The maximum target value shown in the Cost-effectiveness Explorer is based on a combination of cost-effective, non-preempted measures.

4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of that additional demand, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.

Other Considerations

Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Review the full report for select recommended strategies. For a discussion of specific health and safety considerations related to remodeling older vintage residences, review the complete report.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the CEC. This study provides valuable context for jurisdictions pursuing other ordinance paths, such as a health and safety approach, to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results, helping residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

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Get in touch with the Reach Code Team

Visit LocalEnergyCodes.com to access our resources and sign up for newsletters

Contact info@localenergycodes.com for no-charge assistance from expert Reach Code advisors

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