

Local Government Levers for Energy Policy in the Existing Single-Family Residential Sector

An examination of available local government policy levers for requiring energy efficiency and/or electrification, and associated energy, greenhouse emissions, and equity tradeoffs, for existing single-family residential buildings

Authors:

Emily Alvarez, StopWaste

Bruce Mast, Ardena Energy

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- Establish metrics to evaluate compliance with existing energy codes.
- Identify and deliver targeted trainings for those involved in energy code enforcement.
- Accelerate energy code compliance throughout the region.

The C&S Program is a locally driven effort of local governments to reduce energy use in buildings through improved design and construction. The program is administered jointly by each of the nine Bay Area counties and the Association of Bay Area Governments (ABAG). Funding for the program is provided through the California Public Utilities Commission (CPUC).

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Executive Summary

The State of California has set increasingly ambitious targets to reduce greenhouse gas (GHG) emissions and slow climate change since Assembly Bill (AB) 32 was passed in 2006. The most recent goal of carbon neutrality by 2045 demonstrates a much different way of thinking than previous percent reductions below business as usual targets. This new goal acknowledges the current climate emergency and will only be achieved through a fundamental rethinking of the sectors and systems that significantly contribute to carbon emissions. One such sector that has yet to undergo a comprehensive change is existing single family residential buildings.

Traditionally, energy policies, codes, and incentives programs concentrated on energy efficiency (more efficient appliances and building envelope upgrades like insulation and air sealing). However, as the State's grid becomes increasingly powered by renewable and carbon free sources, there has been a growing shift in energy policy to transition buildings off of natural gas and to all-electric appliances as a means to achieve deeper GHG savings. In addition to being powered by cleaner sources, many of these electric appliances, such as heat pumps and induction cooking, are also more efficient than their traditional natural gas or electric-resistance counterparts. Chapter 1 of this paper delves into this background in greater detail.

Chapter 2 explores existing energy-related policies leveraged by cities and new concepts being pursued by jurisdictions to regulate carbon and/or energy efficiency and estimates the impact that such policies could have in the East Bay. Ordinance options described include Code Compliance Policies, Energy Assessment and Disclosure Policies, Building Performance Standards, Fossil Fuel Appliance Ban, and Other Policy Options. To examine how such existing levers could address energy efficiency performance and/or electrification in existing single family residential buildings, Chapter 3 introduces measure packages – electrification of hot water heating, electrification of space heating, building envelope upgrades, and a combination – and quantifies their energy and GHG impacts. These above code measures could be layered on to the levers in Chapter 2 in order to more aggressively meet energy efficiency and/or GHG emission reduction targets.

To examine the issues in a more holistic framework, Chapter 4 discusses other impacts and co-benefits of such policy options (equity, indoor air quality, resilience, utility costs) that cities may be concerned with when developing programs or mandates. Chapter 5 introduces some challenges that must be addressed within the existing energy workforce to prepare for the State's increasing focus on electrification and the health benefits of energy efficiency improvements, as workforce readiness is often cited as a reason why it may be difficult to mandate energy efficiency or electrification in existing single family homes.

While many policy options and measure packages are available to cities, as shown in this paper and summarized in Chapter 6, the best pathway for a local government depends on a combination of the housing stock, political support or willingness for such mandates, and what their highest priorities are (i.e. affordability to residents versus GHG reductions). However, by introducing the concepts and policies, local governments may be able to use this paper as a starting point to dive deeper into their specific options, goals, and impacts.

Chapter 1: Introduction

The State of California has set increasingly ambitious targets to reduce greenhouse gas (GHG) emissions and slow climate change since Assembly Bill (AB) 32 was passed in 2006. AB 32 required California to reduce its GHG emissions to 1990 levels by 2020, which translates to a reduction of approximately 15 percent below emissions expected under a “business as usual” scenario. Subsequent goals laid out in Senate Bill (SB) 350 include a 40 percent reduction in emissions by 2030 and 80 percent reduction by 2050. In 2018, Executive Order B-55-18 mandated that the state achieve carbon neutrality by 2045.

It is estimated the State achieved its initial emissions reduction goal outlined in AB 32 in 2016, several years ahead of the 2020 target. However, achieving the deep reductions to meet the 80 percent reduction and carbon neutrality goals will require fundamental changes to the State’s largest sources of emissions, which includes buildings. Given the technological challenges of reducing emissions from industrial and heavy transportation sources, the State’s goals translate into an imperative to achieve 100 percent adoption of all commercially and economically viable mitigation strategies. The implicit emissions goal for residential buildings is thus zero.

In 2017, California emitted 424 million metric tons of CO₂ equivalent (MTCO₂e), of which 6.1 percent were attributed to residential emissions.¹ The nine-county Bay Area produces approximately 86.6 million MTCO₂e annually. Approximately 7.7 percent is from residential fuel usage.² The California Energy Commission (CEC) has found that space heating and water heating end uses contribute 88 percent of residential fossil fuel consumption. Though a smaller proportion of the State’s overall emissions are from buildings, the technologies to increase efficiency and transition to cleaner fuels are already developed and available for residential properties.

Acknowledging the importance of buildings in meeting climate targets, SB 350 also established a goal to double energy efficiency by 2030. Since 1996 the State has run energy efficiency programs, invested in renewable technologies, and funded public interest research using the Public Goods Charge collected on utility bills and overseen by the California Public Utilities Commission (CPUC). While increasingly rigorous energy standards are implemented on a three-year cycle through the California Building Code (CBC) updates, these primarily affect new construction and not existing buildings. Major renovations must adhere to applicable building codes, but many home renovations do not trigger energy improvements or may be completed without a permit. Most existing buildings are upgraded through voluntary efforts and incentivized through rebate programs, such as those overseen by the CPUC. Nationwide, very few cities have any sort of existing building requirements regarding energy, and most that exist mandate disclosure and not performance or improvements. This paper explores energy-related policies currently being leveraged by cities in the existing building sector, and how additional requirements could be layered on that would address mandatory energy efficiency/and or electrification upgrades. It then

¹ California Air Resources Board. “California Greenhouse Gas Emissions for 2000 to 2017.” ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf. 2019.

² Bay Area Air Quality Management District. “Bay Area Emissions Inventory Summary Report: Greenhouse Gases Base Year 2011.”

https://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Emission%20Inventory/BY2011_GHGSummary.ashx?la=en&la=en. January 2015.

attempts to quantify how these actions can contribute to energy efficiency and GHG emission reduction targets.

Focus on Electrification

In addition to increasing energy efficiency, decarbonizing the fuel sources that power California's buildings has huge potential to decrease emissions. While natural gas will never be an emissions-free fuel, electricity can be produced through renewable and carbon-free sources. In 2019, the CEC estimated that California's electric grid was powered by 36 percent renewable sources and 63 percent carbon-free generation sources.³ As Investor Owned Utilities (IOUs) have increasingly clean electrical grids and as more Community Choice Aggregate (CCA) energy providers come online with the goal of providing more renewable energy than the IOUs, emissions from electricity continue to decrease. As such, the State has placed an increasing focus on decarbonization. SB 1477 allocates \$50 million annually through 2023 from utility cap-and-trade auctions to support reducing emissions from buildings and is largely focused on fuel substitution. In August 2019 the CPUC voted unanimously to revise the "three-prong test" which prevented ratepayer-funded programs from funding electrification measures, giving the green light for the Public Goods Charge to be used for fuel substitution measure.

Many cities throughout the State, and over 20 in the Bay Area,⁴ have passed or are considering new construction "reach codes" that require all-electric new construction or higher efficiency standards for mixed-fuel buildings. Some cities, such as Berkeley, have gone as far as passing a ban on new natural gas infrastructure. While these codes only cover new construction, these policies establish a clear preference for electric appliances over natural gas to reduce GHG emissions.

As the focus on and support for electrification grows, what will become of existing energy efficiency programs? Will they work in harmony or will they be competing for funds and attention? Or perhaps phased-out altogether? Will older homes with no insulation, significant air leakage, and new electric heating technologies become the norm? Will cities pursuing existing building reach codes only focus on electrification and leave reducing consumption behind? This paper does not aim to find a solution to all of these questions or propose one policy or strategy over another. However, it intends to identify program and policy options cities can take to tackle consumption and emissions in existing single family residential buildings. It also discusses the potential impacts on GHG emissions and energy consumption for various approaches, other impacts and co-benefits of policy options (equity, indoor air quality, resilience, utility costs), and lastly introduces some challenges that must be addressed within the existing energy efficiency workforce to prepare for the State's increasing focus on electrification and the health benefits of energy efficiency improvements.

³ Carbon-free sources include large hydroelectric and nuclear power.

⁴ 39 jurisdictions as of October 28, 2020. See <http://www.buildingdecarb.org/active-code-efforts.html> for updated results.

Chapter 2: Local Government Policy Levers

Voluntary programs have helped California homeowners make energy efficiency upgrades in their homes for decades. However, a drastic acceleration of existing single family residential upgrades is needed to meet the State’s goal of doubling energy efficiency of existing buildings by 2030. Additionally, the CPUC’s Long Term Energy Strategic Plan includes a goal to reduce energy consumption in existing homes 20 percent by 2015 and 40 percent by 2020. In California, the residential sector is responsible for producing 6.1 percent of total GHG emissions, of which half is attributable to fossil fuels combusted at the point of use. The CEC has found that space heating and water heating end uses contribute 88 percent of residential fossil fuel consumption.

There are approximately 2.9 million housing units in the nine-county Bay Area region. Of those, approximately 2.1 million are single family units (defined as having four or fewer units).⁵ For all housing unit types, approximately 66 percent were constructed before 1979 (residential energy efficiency codes went into place in 1978) and only 12 percent were constructed since 2000.⁶ In order to adequately address residential emissions, the State cannot rely solely on new construction policies.

While there is growing uptake for new construction reach codes, as of summer 2020, no city within the Bay Area has passed a policy requiring mandatory upgrades for existing residential buildings. This approach is essential to meet ambitious GHG emission targets. Some jurisdictions in California and beyond are beginning to explore these options for single family properties. This chapter will outline various policy levers and “trigger points” for electrification and/or energy efficiency upgrades that cities could adopt to address existing single-family buildings.

Ordinance Options

Cities are approaching the challenge of existing residential upgrades in several ways, including energy reach codes that apply to remodels and major renovations, prescriptive upgrade requirements at time of sale, and energy assessment and disclosure policies. However, most cities have relied on disclosure of information and incentive programs to spur voluntary upgrades. While these efforts have increased efficiency throughout the State, they have not yet succeeded in catalyzing clean energy upgrades in existing homes at a pace that supports California’s policy goals. Below is a sampling of policy levers for existing single family residential buildings that have been passed in cities throughout the United States. At this time, most of these options focus on energy efficiency, and not on California’s newer and shifting focus of electrification. Ordinance options described here include Code Compliance Policies, Energy Assessment and Disclosure Policies, Building Performance Standards, Fossil Fuel Appliance Ban, and Other Policy Options. More detailed case studies on specific city policies can be found in Appendix A.

⁵ State of California, Department of Finance, *E-5 Population and Housing Estimates for Cities, Counties and the State — January 1, 2011-2020*. Sacramento, California, May 2020.

⁶ U.S. Census Bureau (2018). *Selected Housing Characteristics, 2014-2018 American Community Survey 5-year estimates*. Retrieved from <https://data.census.gov/cedsci/table?t=Housing%3AHousing%20Units&g=0500000US06001,06013,06041,06055,06075,06081,06085,06095,06097&y=2018&tid=ACSDP5Y2018.DP04&hidePreview=true>

Code Compliance Policies

The Warren-Alquist Act of 1974 established the California Energy Commission and set in motion the development of building energy standards for both new construction and alterations (California Code of Regulations, Title 24, Parts 6 and 11). Primary responsibility for enforcing the energy standards falls to local governments as part of their building permitting and code enforcement duties. Permits are required for many energy efficiency improvements, including hot water heaters; insulation; heating, ventilation, and air conditioning (HVAC) systems; duct replacement; and more.

The central role that local governments can play in code compliance is perhaps best illustrated by the challenges and opportunities of achieving full code compliance for alterations to HVAC systems. Since 2005, the state's Title 24 energy standards have required new and replacement HVAC systems to be installed subject to a building permit issued by a local city or county building department. The standards set minimum equipment efficiencies, govern equipment sizing, and incorporate duct testing and sealing requirements. The standards require Home Energy Rating System (HERS) Raters to perform on-site testing and verification as part of the permit process. The goal of this requirement is to reduce the incidence of installation defects that result in wasted energy.

A 2017 report by DNV-GL on behalf of the CPUC found that code compliance for HVAC change outs was low, with permitted installations accounting for only 8 to 29 percent of total installations.⁷ SB 1414 required the CEC, by January 1, 2019, to approve a plan that would promote code compliance for installation of central air conditioning and heat pumps. The bill authorized the CEC to adopt regulations to increase compliance with permitting and inspection requirements. As of June 2020, that plan and associated regulations remain under development.

Strong and consistent code enforcement would reduce unpermitted equipment change-outs by making the costs of non-compliance commensurate with the costs of compliance. In doing so, it would "level the playing field" for compliant contractors who are otherwise at a business disadvantage relative to their noncompliant competitors. In the current market, the cost disadvantage faced by compliant contractors erodes the value of customer incentives for energy efficiency, which, by law, require proof of code compliance.

The cities of Davis, California, and Minneapolis, Minnesota, offer useful examples of local programs to achieve consistent code compliance. Both programs originated with a focus on ensuring compliance with minimum health and safety requirements. They are structured similarly with program provisions triggered at transfer of title or change in home ownership. At that time, the building owner must submit a completed resale application and applicable fees to the designated City Agency, schedule an inspection, and obtain an inspection report. The report specifies any code compliance issues that must be resolved to obtain a validated certificate. The issues must be resolved either by the seller or by the buyer within 90 days of close of escrow. Minneapolis publishes inspection reports and compliance certificates on its website.

The biggest difference between the two programs is that Minneapolis outsources the inspection to a network of trained and approved third party inspectors, whereas City of Davis Building Inspectors

⁷ DNV GL Energy Insights USA, Inc. *Final Report: 2014-16 HVAC Permit and Code Compliance Market Assessment (Work Order 6) Volume I – Report*. California Public Utilities Commission, CALMAC ID: CPU0172.01, 2017. www.calmac.org

perform resale inspections in-house. As of 2018, City of Davis inspection fees were \$426; typical Minneapolis Truth in Sale of Housing (TISH) inspections cost \$150 to \$250, plus filing fees.⁸

Starting in 2020, the Minneapolis TISH program was extended to include an energy disclosure provision. The Davis Resale Program does not incorporate energy disclosures, but it confirms permitted status of HVAC change outs. In recent years, the Davis Resale program has conducted 500 to 700 inspections per year out of 16,193 eligible housing units (three to four percent annual market penetration). Since 2014, only five percent of resale inspections have found unpermitted HVAC installations. Given the vast difference between the number of unpermitted installations found in Davis and the typical rate of permit noncompliance, one can infer that the program directly or indirectly impacts permitting practices for all HVAC change out events, typically four to nine percent of the installed HVAC equipment stock per year.⁹

A prevailing concern has been that the energy performance of unpermitted HVAC systems would be significantly worse than that of permitted systems. Consistent code enforcement would thus translate into measurable energy savings. However, DNV-GL’s report on code compliance concluded that “the permitted and non-permitted installations in this study had similar rates of compliance with requirements related to their electric and gas energy efficiency. ... Our assessments suggest that the potential energy impacts from improved compliance in installations may not be substantial under current market and enforcement conditions.” The lack of significant increased energy efficiency from projects that complete permits is likely due to the contractors building to-code but avoiding the perceived time lag and cost of permits or a result of not being able to purchase equipment (HVAC or water heaters) in the State that do not meet minimum efficiency standards. Direct energy savings notwithstanding, consistent code enforcement would establish equipment change-outs as a viable market trigger opportunity to enact stronger requirements for energy savings and GHG reductions that either exceed minimum code requirements or require electrification.

Potential Impacts

Table 2-1 below provides rough estimates for what the impact of passing a Permit Disclosure ordinance could be in the Bay Area. Calculations are made using Census data for the number of single-family residences (defined as four or fewer units), annual home sales, and the number of central air conditioning, gas furnace, and gas hot water heating replacements made annually for the Oakland-Fremont-Hayward metropolitan area, which is encompassed by the entirety of Alameda and Contra Costa counties. As shown in Table 2-1, if a policy similar to that of the City of Davis were adopted for these counties, it could lead to 12,100 central AC replacements, 22,300 furnace replacements, and 34,200 hot water heater replacements that are code compliant per year. To replace all hot water heaters in the geographic area based solely on such a policy would take approximately 27 years. Other appliances would be on an even longer cycle since their useful life is longer and annual replacements are fewer. Additionally, as mentioned above, no energy consumption or GHG savings are attributed to such a policy since studies have shown that even work done without permits is largely energy code

⁸ See Carl Nelson and Isaac Smith, *Transforming the Market for Energy Efficiency in Minneapolis: Recommendations for Residential Energy Efficiency Rating and Disclosure*, Center for Energy and the Environment, 2018.

https://www.mncee.org/MNCEE/media/PDFs/Mpls-Residential-EE-Disclosure_White-Paper_20180912.pdf

⁹ 4-9% is the HVAC turn-over rate implied by the US EIA technology forecast of 11-25 year useful lives for residential air central air conditioners. See

<https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/appendix-a.pdf>

compliant. Therefore, to see energy and GHG reductions, such a policy would need to be paired with a requirement to go above code, install a measure in addition to the replacement of an appliance (such as insulation installation or air sealing), or electrifying the end use.

Table 2-1: Annual Impact of Permit Disclosure Policy

Number of annual home inspections ¹	36,400
Inspection costs @ \$400 / inspection ²	\$14,577,774
<i>Improve code compliance from 30% to 95%³</i>	
# Central AC code compliance outcomes	12,100
# Gas furnace code compliance outcomes	22,300
# Gas Domestic Hot Water (DHW) code compliance outcomes	34,200
<i>Code Compliance Environmental Impacts</i>	
Annual kWh savings	0
Annual therm savings	0
Annual GHG reductions	0
Notes:	
1. Estimated by multiplying number of homes sold in the State annually by proportion of 0-4 unit residences in the 9 Bay Area counties	
2. Based on City of Davis ordinance	
3. Based on improvement from standard permit compliance rates to those seen in City of Davis	

Energy Assessment and Disclosure Policies

The American Council for an Energy-Efficient Economy's (ACEEE) Residential Energy Use Disclosure: A Guide for Policymakers offers a succinct summary of the underlying theory of change for energy assessment and disclosure policies:¹⁰

Residential energy rating and disclosure is a promising low cost policy option that can help increase consumer transparency about the costs associated with operating a home, promoting more sound purchasing decisions in a post-mortgage crisis environment. Also, by quantifying building energy use, these policies can inform future policy and program efforts to reduce building energy consumption and track progress toward achieving community-wide climate and/or energy targets.

Energy rating and disclosure policies can involve the participation of a number of players, and those involved in the process can expect the following benefits:

- Homeowners will identify energy- and cost-saving priorities for home energy improvements and receive a better valuation of existing energy efficiency features and improvements in the real estate market.
- Prospective homebuyers will gain more information about the operational costs of owning the houses under their consideration and receive a better valuation of existing energy efficiency features and improvements.

¹⁰ See <https://www.aceee.org/toolkit/2020/02/residential-energy-use-disclosure-guide-policymakers>

- Policymakers will get more access to data on the energy use of the existing building stock, to both inform future policy development and track progress toward meeting local climate and/or energy reduction goals for buildings.
- Realtors will be better informed on documenting and quantifying how energy efficient a home is, allowing them to more confidently market energy efficiency features.
- The cross marketing of utility and disclosure programs can encourage homeowners to leverage energy efficiency programs to make improvements, helping utilities and other program operators to increase participation in energy efficiency programs, which will in turn assist them in achieving program goals.

This theory of change is echoed in the rationale put forward by local governments adopting these policies. For example, Nelson and Smith in their 2018 recommendations to the City of Minneapolis to add energy disclosures to the TISH program, noted “The end goal of an energy disclosure policy is not benchmarking itself but making benchmarking information available and actionable to help people invest wisely in efficiency upgrades.” Similarly, the City of Berkeley’s Building Energy Savings Ordinance (BESO) states “The purpose of this chapter is to reduce energy and water consumption in existing buildings. These efficiency improvements will lower energy and water costs and greenhouse gas emissions citywide and increase comfort, safety, and health for building occupants. The provisions of the ordinance will inform decision makers about energy performance and improvement opportunities.”

In practice, solid empirical evidence of disclosure impacts has proven challenging to obtain but available results suggest the impacts have been modest. Elevate Energy’s early assessment of Chicago’s Energy Cost Disclosure found that “compliance was 13 percent over first 18 months. Compliant homes sold at a higher percentage of their original list price (97.2 percent of list price) than non-compliant homes (95.9 percent of list price); compliant homes were on the market for 69 days compared to 93 days for non-compliant homes.” The assessment was not able to quantify changes in building retrofit activity or energy savings attributable to the policy.¹¹

In a 2016 paper, Dunsky Energy Consulting examined five Home Energy Rating and Disclosure Programs and found audit-to-retrofit conversion rates ranging from 12 percent (Austin, TX) to 37 percent (France).¹² The Austin example illustrates the challenge of relying exclusively on energy disclosures to achieve local energy and climate goals: about five percent of Austin’s homes are bought and sold in a year, of which about half comply with the disclosure requirement. Between 7 to 12 percent go on to pursue a retrofit. The result is that Austin would need 333 years to retrofit its current housing stock if disclosures were the sole driver.

While energy disclosures themselves may not provide a silver bullet, their thoughtful implementation offers a foundation for more impactful regulatory policies. A few best practices emerge from the literature:

¹¹ Deborah Philbrick, Rachel Scheu, and John Blaser , “Moving the Market: Energy Cost Disclosure in Residential Real Estate Listings”, *2016 ACEEE Summer Study on Energy Efficiency in Buildings*

¹² Alex J Hill, et al., “Predicting Home Energy Rating and Disclosure Program Impacts for North American Jurisdictions”, *2016 ACEEE Summer Study on Energy Efficiency in Buildings*

1. Integrating energy disclosures with code compliance requirements (e.g., the Minneapolis model) offers opportunities to achieve multiple policy objectives and reduces incremental costs to participants.
2. Require disclosures as early as possible in the real estate transaction (e.g., time of listing rather than time of sale) to better influence home buyer decision-making.
3. Incorporate stringent enforcement mechanisms to achieve uniform compliance.
4. Consider report content and presentation to communicate meaningful and actionable information.
5. Invest in information systems to reduce participant transaction costs and enable collection of key performance data.
6. Link programs to other initiatives and incentives to drive conversion rates.

The City of Berkeley is considering changes to their BESO that would require upgrades at time of sale, which is expected to be heard at their City Council late 2020/early 2021. The mandatory upgrades would be supported by a transfer tax rebate for specified energy efficiency and/or electrification improvements. Other BESO changes under consideration are switching to a solely emissions or electrification-based assessment and changing the trigger point from time of sale to time of listing.

Potential Impacts

Using the same baseline assumptions as described for Table 2-1 in terms of number of housing units and units sold annually, Table 2-2 below estimates the annual impact for the Oakland-Fremont-Hayward metro area if all jurisdictions were to pass an Energy Assessment and Disclosure policy, such as Minneapolis’ TISH, Berkeley’s BESO, or Austin, Texas’ Energy Conservation Audit and Disclosure (ECAD) ordinance. At the current rate of home sales, it would take 25 years for all homes to go through an assessment, assuming every home is sold during this time period and no home is sold more than once. Therefore, it would likely take much longer for such a policy to actually touch all homes. A study on Austin’s ECAD found that approximately 12 percent of homes that complied with the ECAD went on to make energy upgrades based on their assessment, despite no requirement for upgrades. Assuming that same conversion rate (and a 100 percent compliance rate, which has not been observed in existing policies), there could be 1,410 MTCO_{2e} saved annually. On its own, Oakland, the largest city in Alameda and Contra Costa counties, emits approximately 2.6 million MTCO_{2e} annually according to their 2020 Equitable Climate Action Plan.

Table 2-2: Annual Impact of Energy Assessment and Disclosure Policy

Number of annual energy assessments ¹	36,400
Inspection costs @ \$350 / inspection ²	\$12,755,552
Conversions from assessment to upgrades (assumed at 12% ³)	4,400
<i>Disclosure Environmental Impacts</i>	
Whole house annual electricity savings of 10%	2,187 MWh
Whole house annual gas savings of 10%	183.7 Mtherms
Annual GHG reductions	1,410 MTCO _{2e}
Notes:	
1. Estimated by multiplying number of homes sold in the State annually by proportion of 0-4 unit residences in the 9 Bay Area counties, assumes 100% compliance	
2. Based on BayREN BESO data	
3. Based on City of Austin study on ECAD	

Building Performance Standards

California’s energy and climate goals point to a need to achieve greater energy savings than can be achieved by code compliance alone and to do so faster than a time-of-sale-only strategy would allow. The Boulder SmartRegs program offers a useful example of how a residential energy efficiency ordinance could be structured around a date certain building performance requirement.

SmartRegs requires all licensed rental housing, including both single and multi-family, in the City of Boulder to meet a basic energy efficiency standard. All rental properties in the City of Boulder must earn a HERS score of 120 or lower. The City of Boulder requires that a rental license be approved for a property before it can be used as a rental. A property cannot be advertised as a rental in any manner until the license is issued. Approval depends on the results of required inspections that determine whether a property complies with standards for health and safety, mechanical systems, and energy efficiency. SmartRegs is the energy efficiency component of the inspection and approval process.

Adopted in 2010, the SmartRegs ordinance gave property owners eight years to come into compliance. Voluntary incentives and technical assistance were offered to encourage early compliance. As of December 2017, 100 percent of rentals were inspected, and 86 percent were deemed compliant. Since program inception, 4,603 energy upgrades and 27,951 quick installs have been completed through the City of Boulder’s EnergySmart program. The average cost of upgrades to reach compliance has been less than \$3,000 per residential property. The City of Boulder’s rental properties are expected to save 4.2 million kWh and 940,000 therms annually, leading to \$1.1 million in energy bill savings and 8,300 metric tons of avoided GHG emissions after full compliance (expected by the end of 2018).

Several jurisdictions have piloted innovative building performance standards for the commercial sector that offer potential lessons learned for residential-sector policy development. The Institute for Market Transformation (IMT) has emerged as a leading proponent and subject matter expert on building performance standards. The following synopsis is adapted from several IMT resources:¹³

“Building performance standards (BPS) require direct action by building owners to meet city-mandated performance improvement targets for their property. These targets become stricter over time, driving continuous, long-term improvement in the building stock. BPS is a forward-thinking policy commitment in which a city establishes the long-term, high-performance standard, with interim targets that ratchet up over time. The combination of short- and long-term goals assures that building performance improves consistently over time, and also sends appropriate market signals to discourage investments in long-lived, inefficient, and environmentally damaging technology. Throughout these performance improvement cycles, cities are collecting data and working with the private sector, utilities, and others to create incentives, programs, and technical assistance.”

New York City, Washington DC, the State of Washington, and St. Louis, Missouri have adopted comprehensive commercial-sector building performance standards. They all share the general attributes of setting building-specific performance targets with a date certain for meeting them. New York’s regulation applies to buildings over 25,000 square feet, Washington State and St. Louis target buildings

¹³ See <https://www.imt.org/the-abcs-of-bps-what-you-should-know-about-building-performance-standards/>

over 50,000 square feet, while Washington DC’s regulation will eventually apply to buildings down to 10,000 square feet.

New York City sets performance targets on a GHG emissions per square foot basis. Compliance is demonstrated via annual emissions assessments. The other three jurisdictions set performance targets based on energy use intensity (i.e., energy per square foot) derived from asset ratings. All jurisdictions offer both performance and prescriptive pathways to compliance, and New York City offers an additional option to purchase GHG offsets or renewable energy credits. New York’s penalties are also carbon-based: \$268/MTCO_{2e} for emissions in excess of the cap. The program thus provides a revenue stream to fund additional climate investments, which could include residential upgrades.

Large commercial buildings offer an appropriate starting point for building performance standards because the standards can apply to a relatively low number of buildings and can build on pre-existing benchmarking systems. Washington DC has signaled an intent to extend its requirements down to facilities greater than 10,000 square feet. It remains to be seen whether the model can be further extended to the entire building stock.

While building performance standards have great potential to improve the energy efficiency of buildings and reduce GHGs, they have not yet been applied to existing single family properties outside of the rental setting in Boulder. Benchmarking or labeling with mandatory upgrades by a date-certain have not yet been tried for owner-occupied single family homes. Without adequate lead time and sufficient support (education and financial), such a policy could be detrimental to low- and moderate-income homeowners who cannot afford the upfront costs. Setting a date-certain or annual target, versus time of sale, would impact all properties within a much shorter timeframe, but also requires a new inspection point and follow-up for compliance, which may be time consuming for jurisdictions and challenging to enforce. An innovative model could be to utilize funds from a commercial program, like those collected in New York City, to fund single family residential upgrades for low- and moderate- income homeowners to make energy improvements.

Potential Impacts

The Oakland-Fremont-Hayward metro area has 226,000 single family rental units. As shown in Table 2-3, if those jurisdictions were to pass a rental housing performance standard similar to that of Boulder, it could save about 1,677 MTCO_{2e} annually. While this performs better than a disclosure policy, it is still a small fraction of total GHG emissions for that geographic region. While no cities have adopted such a model as of summer 2020, impacts would be significantly higher if the performance standard was applicable to all single family residential properties and not just those that are rentals, as owner-occupied units are approximately 59 percent of the units within that geography. Greater impacts could also be achieved if upgrades were beyond 10 percent or included electrification, though this would likely increase upfront costs.

Table 2-3: Annual Impact of Rental Performance Standard

Number of annual rental inspections (10% per year)	22,600
Inspection costs @ \$400 / inspection ¹	\$9,040,000
Improve compliance from 63% to 86% ¹	5,200
<i>Rental Performance Environmental Impacts</i>	
Whole house annual electricity savings of 10%	2,599 MWh

Whole house annual gas savings of 10%	218.3 Mtherms
Annual GHG reductions	1,677 MTCO _{2e}
Notes:	
1. Based on Boulder SmartRegs	

Fossil Fuel Appliance Ban

As IMT notes in its study, cities have multiple options with regard to encouraging energy efficiency and electrification in buildings, but none are without challenges. The most obvious solution is to ban fossil fuel equipment, requiring that high efficiency electric alternatives (heat pump water heater, space heating, and dryers and induction stoves) be used when equipment reaches the end of its useful life and is replaced. While untested, there are several approaches a jurisdiction could take to accomplish this, either directly or indirectly.

The City of Berkeley’s natural gas ban covers all new natural gas infrastructure. However, in existing homes if a gas hot water heater or other appliance burns out it can be replaced with a new gas model if no new infrastructure is needed (such as relocating the appliance). However, a city could take it one step further than Berkeley did and outright ban gas appliances themselves. The switch from gas to electric appliances may have a domino effect on the cost of the project if a home also requires an electrical panel upgrade or re-wiring in addition to the change out of the appliance itself. At time of burnout, a homeowner likely desires to replace the equipment as soon as possible, and if additional work must be completed first, it could mean going without heat, hot water, or a stove for several weeks. Given that permit compliance rates in many cities are very low, it could be very easy for residents to circumvent such requirements, and incidentally further increase permit evasion.

A jurisdiction could also require all new construction to install the electrical infrastructure (breakers, wiring, outlets) for future electrification. While this approach does not have an immediate impact on carbon emissions, it streamlines the electrification process for future residents, as they will not run into the wiring and panel issues that a typical mixed-fuel home might when they want to (or are required to) switch from gas to electric appliances. As it is not considered a reach code, this option does not require review and approval by the CEC. This same approach can be taken for existing buildings, and while it would streamline the eventual replacement of gas appliances, the challenges of the cost and time to install the wiring for the current replacement may still be a barrier. This highlights one of the major challenges that existing homes face compared to new construction- that an existing home likely has occupants who may or may not be able to afford upgrades or wait for emergency replacements to be made.

The DNV-GL study on permit compliance showed insubstantial energy improvements when comparing projects completed with permits to those without. A major factor in these results is that appliances sold in California must meet certain minimum energy efficiency standards. Replacement at time of burnout would be much more effective if gas appliances could no longer be purchased within the State. While individual cities do not have the jurisdiction to control what is sold in stores, the local air district (in the Bay Area – the Bay Area Air Quality Management District or BAAQMD) does have the ability to regulate certain pollutants. AB 398, Cap and Trade, does not allow air districts to regulate carbon dioxide from “capped” sources, but can regulate “non-capped” source of carbon dioxide (including small sources such as back-up generators or individual homes not covered under cap and trade), as well as GHGs from

capped sources, such as methane. However, an Air District may only regulate building emissions sources for which there is an adopted health-based air quality standard, of which there is currently none for GHGs. Therefore a straight carbon regulation is not possible at this time, but they can regulate nitrous oxide (NOx) emissions, which are produced in the burning of fossil fuels such as natural gas. BAAQMD could strengthen its NOx regulations to essentially ban the sale of natural gas appliances within the Bay Area. Contractors and residents could still purchase such appliances outside of BAAQMD’s territory if this is not a statewide requirement.

An alternative to an absolute ban is a financial penalty for the continued use of gas systems. The City of Berkeley introduced a ballot initiative in November 2020 that would increase the utility users tax to create a “Berkeley Climate Action Fund”. The city intended to use the collected fees for electrification or energy efficiency projects in buildings, including single family residences. However, it did not pass, with about 53 percent voting “no.”¹⁴

Potential Impacts

Table 2-4 shows potential impacts of a natural gas ban for single family properties in the Oakland-Fremont-Hayward metro area at time of burnout for furnaces and hot water heaters. To avoid permit evasion decreasing the effectiveness of the policy, it is assumed that an enforcement mechanism has also been put in place, such as the City of Davis’ permit compliance ordinance. Such a policy could reduce GHGs by about 67,000 MTCO_{2e} annually, which is about 1,000 times higher than a disclosure or rental inspection policy. This assumes the same rate of burnout, number of single family housing units, and homes sold as in Table 2-1. If cost-effective building envelope improvements were coupled with electrification, GHG savings could increase to nearly 72,000 MTCO_{2e} annually. However, without some sort of enforcement, energy consumption and GHG savings would be significantly lower.

Table 2-4: Annual Impact of Fossil Fuel Appliance Ban

Number of annual home inspections (10% per year) ¹	34,200
Inspection costs @ \$400 / inspection ²	\$13,693,333
<i>Ban New Fossil Fuel Furnaces & Domestic Hot Water Heating (DHW)</i>	
Annual electricity savings	+96,505 MWh
Annual gas savings of 10%	16,920.5 Mtherms
Annual GHG reductions	67,038 MTCO _{2e}
<i>Ban New Fossil Fuel Furnaces & DHW plus Energy Efficiency³</i>	
Annual electricity savings	+73,113 MWh
Annual gas savings of 10%	16,920.5 Mtherms
Annual GHG reductions	71,717 MTCO _{2e}
Notes:	
1. Estimated by multiplying number of homes sold in the State annually by proportion of 0-4 unit residences in the 9 Bay Area counties	
2. Based on City of Davis ordinance	
3. Includes cost-effective duct and envelope improvements	

¹⁴ Results can be found at: <https://www.acgov.org/rovresults/241/indexA.htm>

Other Policy Options

For more incremental savings, a city could also consider a menu of options for energy efficiency or electrification measures around the time of a major renovation of existing buildings. The City of Piedmont is considering (as of 2020) an existing building reach code that requires projects valued at over \$25,000 to choose one item from a list of measures that include insulation and air sealing, high efficiency lighting, replacement of HVAC or hot water heating with heat pumps, a recommendation from a Home Energy Score or energy audit, and more. This allows for a homeowner who is already heavily investing in a home project to choose which option best fits within their budget and scope of work. A project valued at over \$100,000 would have to choose two measures to complete. Depending on how many homes in a city undergo major renovations within a year, this could have a greater impact than a time of sale metric. However, it may not lead to deep energy retrofits if the low-hanging fruit options are consistently chosen.

One final way for jurisdictions to increase energy efficiency and electrification of existing buildings would be to push utilities or the State to change how impacts of programs are calculated. For example, currently most ratepayer-funded programs are evaluated by a cost-effectiveness metric based on energy efficiency. The Sacramento Municipal Utility District (SMUD) in early 2020 changed from an “energy savings” to a “carbon avoided” metric. According to SMUD, “The change will enable SMUD’s energy efficiency programs to focus investments on those that reduce carbon emissions at the lowest possible cost to customers and clear the way for expanded investments in building electrification alongside traditional efficiency approaches.” SMUD predicts this will double the environmental benefits of their programs.¹⁵ Acknowledging the carbon savings of electrification measures can justify increasing incentives to better match the cost of such improvements. A carbon metric values electrification over energy efficiency and could result in reduced funds for traditional efficiency programs. For example, after the repeal of the three-prong test, BayREN began providing a \$1,000 rebate each for heat pump water and space heaters replacing gas. Rebates for high efficiency gas furnaces decreased from \$850 to \$300. While providing higher rebates for electrification is positive for market uptake of high-efficiency electric equipment, reducing the gas furnace rebate could lead to more homes installing appliances that only meet code-minimum efficiency, without the financial incentive to install high-efficiency gas appliances which exceed code.

¹⁵ “SMUD First in US to Change Efficiency Metric to ‘Avoided Carbon.’” 3 Feb. 2020, www.smud.org/en/Corporate/About-us/News-and-Media/2020/2020/SMUD-first-in-US-to-change-efficiency-metric-to-avoided-carbon.

Chapter 3: Measures for Increased GHG and Energy Savings

Chapter 2 outlined policy levers that cities can utilize in order to require energy efficiency and/or electrification improvements in existing single-family properties. Voluntary upgrades made as a result of disclosure policies, as well as minimal mandatory efficiency upgrades (10 percent) do not make much of a dent in annual GHG emissions for the region. However, a much more significant reduction may be realized with the passage of an aggressive policy like a natural gas appliance ban or replace-on-burnout requirement.

This chapter looks at specific energy efficiency and electrification measures that cities could require as part of one of the policy levers discussed in Chapter 2 or another trigger point (such as replace or upgrade by a date-certain). For example, a city could establish an energy reporting program and, as part of that, could require that any home with a score below a certain level carry out one of the measures discussed below. A city could also require one of these measures as a stand-alone item at time of burnout or major renovation.

The degree of impact on GHGs or energy consumption varies by the measures selected, such as whether a city selects electrification or energy efficient envelope improvements as its main focus, or pursues a hybrid approach. When deciding to pass an energy or electrification ordinance, cities should take into account the impact that each option would have on climate goals and consider how feasible it is to implement the ordinance. This chapter explores the reduction in energy consumption and GHG reduction/avoidance for various measure scenarios and combinations.

Energy Efficiency and Electrification Scenarios

In support of this investigation, two electrification scenarios, one energy efficiency scenario, and one combination of electrification and energy efficiency are analyzed. Further, for the GHG emissions reduction/avoidance calculations, each of these measure packages is analyzed under the lens of a current electricity mix scenario and a 100 percent carbon-free electricity scenario. This reflects the difference in consumption and emissions that are possible in the near-term until the State reaches its goal of 100 percent carbon-free electricity. It also reflects the option available to many Bay Area residents to purchase electricity with the default power mix or subscribe to 100 percent zero carbon electricity through their CCA.

Scenario descriptions are as follows:

1. **Electrify Domestic Hot Water (DHW):** Assume replacement of a 0.59 Energy Factor (EF) gas water heater with a 3.5 Coefficient of Performance (COP) heat pump water heater (HPWH). Baseline water heating load is estimated as 182 therms per year. Conversion zeros out the water heating gas usage and increases electric load by an estimated 899 kWh per year. Effective useful life was modeled as 13 years.
2. **Electrify Space Heating:** Assume replacement of a 0.78 Annual Fuel Utilization Efficiency (AFUE) gas furnace with a 3.2 COP heat pump. Baseline space heating load is estimated as 219 therms per year. Conversion zeros out the gas usage of space heating and increases electric load by an estimated 1,566 kWh. Effective useful life was modeled as 20 years. Consistent with the

observed load curve, which shows minimal summer cooling load in the Bay Area, assume no cooling savings.¹⁶

3. **Building Envelope Energy Efficiency (EE):** Assume a combination of air sealing, duct sealing, and attic insulation¹⁷ to reduce HVAC loads by 50 percent, translating to a 28 percent reduction in whole house gas consumption. Effective useful life was modeled as 20 years. This result is generally consistent with the Home Upgrade Measure Package Energy Savings Calculator, which shows a 26 percent reduction in whole house gas consumption for a 1,600 square foot home with no air conditioning in climate zone 3 attributable to the following measure package:
 - a. Reduce Building Leakage (30%)
 - b. Insulate Ducts (R8)
 - c. Reduce Duct Leakage (10%)
 - d. Insulate Attic (R44)
4. **Electrify DHW + Space Heating + Building Envelope EE:** Modeled the combined impacts of scenarios 1, 2, and 3. This scenario zeros out DHW and space heating gas usage and increases electric load by an estimated 1,658 kWh per year. Building envelope EE measures reduce kWh by 50 percent. To simplify the model, a hybrid effective useful life of 17 years was used, as each technology has a different useful life.

These results are intended primarily to offer useful guidance as to the opportunities and limitations of broad-brush requirements that apply to all residential customers. For that reason, the analysis incorporates multiple simplifying assumptions. The results of this analysis can help a city understand the magnitude of potential policies, but would need to undergo a detailed jurisdiction-specific study in order to get more tailored information on GHG and energy consumption reductions.

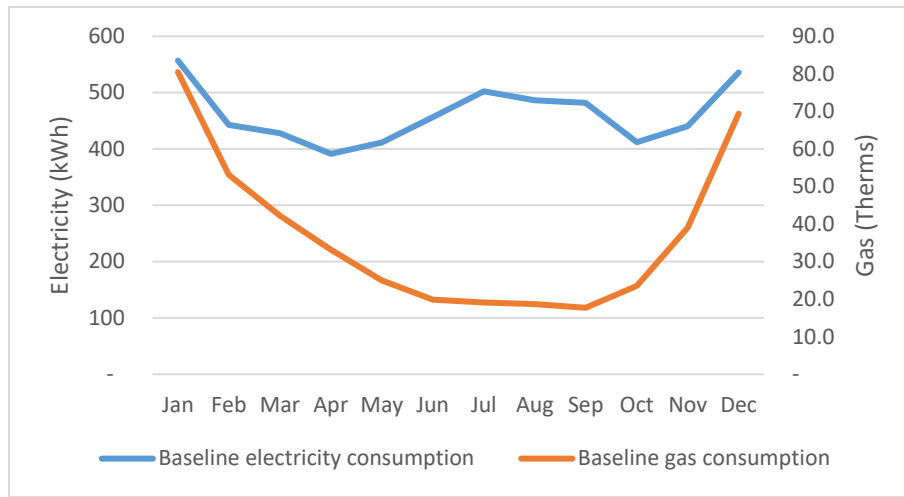
Each scenario is based on how an average Bay Area customer's annual load profile might change, derived from 2017 zip code-level average energy consumption by month, published by PG&E.¹⁸ The resulting load profiles for electricity and gas consumption are shown in Figure 1.

¹⁶ Assumes a heat pump replacing a gas furnace with no existing air conditioning load. As many homes in the Bay Area do not have an existing cooling load, it is probable that a heat pump, which provides both heating and cooling, would increase electricity consumption by adding a new load. However, due to the minimal number of Cooling Degree Days in the Bay Area this increase is not modeled.

¹⁷ These measures are generally considered more cost effective in the Bay Area's mild climate than other envelope improvements such as wall insulation or window replacements.

¹⁸ PG&E data used for assumptions can be found at: https://pge-energydatarequest.com/public_datasets/download?type=gaz&file=PGE_2019_Q4_GasUsageByZip.zip

Figure 1: Annual Electric and Gas Load Profiles for an Average Bay Area PG&E Customer in 2017



Greenhouse Gas Reduction / Avoidance

Estimated GHG reductions for the four modeled scenarios are shown in Tables 3-1 and 3-2 under two electricity carbon emission options. The push for electrification rests upon electricity coming from cleaner sources than natural gas. Additionally, while the electricity mix can continually be sourced from carbon free and renewable resources, the burning of natural gas will never be a zero emission option. Table 3-1 shows savings using PG&E’s 2018 power mix to demonstrate what savings could be until the State reaches its 100 percent carbon-free electricity goals. Many cities within the Bay Area get their power through Community Choice Aggregators (CCAs) which tend to have a cleaner power mix than PG&E, which would mean a smaller difference in savings between the two scenarios. While current electricity is still partially supplied by fossil fuels, the zero-carbon assumption shown in Table 3-2 is consistent with State policy direction and reflects the aggressive investments CCAs are making to decarbonize their electricity supplies.

Both tables show the installation cost for each measure and the Incremental Measure Cost (IMC) or how much more the measure costs compared to the status quo. It then shows GHG reductions and avoided costs for each scenario. To consider the cost effectiveness of various GHG reduction options, the net cost-per-ton of GHGs reduced for both the early replacement scenario and the ROB scenario are calculated. For early replacement, net costs are the full installation costs, plus utility avoided costs, minus lifecycle operating savings. Negative net costs per ton represent the best investment opportunities because they signal that the GHG reductions can be achieved without additional incentives. Estimates are shown per appliance or home, meaning that to see how the models would act on a citywide scale, one would have to multiply by the number of appliances or homes affected (for example by one of the policies listed in Chapter 2).

In Table 3-1, Scenario 4 has the greatest lifecycle GHG reductions, though it also has the highest upfront costs and is not very favorable from a net cost perspective due to the high costs of electrifying space heating. For single measures, Scenario 1: Electrify DHW and Scenario 3: Building Envelope EE show similar GHG reductions and negative net costs, meaning that money is saved per MTCO_{2e} reduced.

Table 3-1: GHG Reduction/Avoidance of Measures, 2018 PG&E Electricity Mix¹⁹

Annual operations	1: Electrify DHW	2: Electrify Space Heating	3: Building Envelope EE	4: Elec DHW + Space Heating + EE
Installation cost	\$3,689	\$13,423	\$6,080	\$23,192
Incremental Measure Cost (IMC)	\$1,640	\$5,027	\$6,080	\$12,747
Annual GHG reductions, MTCO _{2e}	(0.9)	(1.0)	(0.6)	(2.0)
Lifecycle GHG reductions, MTCO _{2e}	(11.4)	(20.3)	(11.7)	(33.2)
Lifecycle avoided costs	\$(3,405)	\$(5,489)	\$(4,119)	\$(10,180)
Net cost @ early replacement / lifecycle MTCO _{2e}	-\$9	\$471	-\$99	\$319
Net cost @ Replace-on-Burnout (ROB) / lifecycle MTCO _{2e}	-\$188	\$58	-\$99	\$4

Since the electricity mix used in the model for Table 3-1 comes from a significant portion of carbon-free sources, results are similar in Table 3-2. With a cleaner grid, there are no additional carbon savings when combining electrification of DHW and space heating with building envelope efficiency measures. These measures would reduce energy consumption, assuming that energy comes from 100 percent carbon-free sources, no greater emissions reductions are realized. However, the resources and embodied carbon emissions from building more solar, wind, and other zero carbon electricity sources would contribute a large environmental impact that is not measured here. Reducing consumption has the added benefit of fewer infrastructure needs which could help the State achieve its clean energy targets faster. As further discussed in Chapter 4, energy efficiency improvements when paired with electrification provide several co-benefits even when they do not further reduce GHG emissions.

Table 3-2: GHG Reduction/Avoidance of Measures, 100% Carbon-Free Electricity

Annual Operations	1: Electrify DHW	2: Electrify Space Heating	3: Building Envelope EE	4: Elec DHW + Space Heating + EE
Installation cost	\$3,689	\$13,423	\$6,080	\$23,192
Incremental Measure Cost (IMC)	\$1,640	\$5,027	\$6,080	\$12,747
Annual GHG reductions, MTCO _{2e}	(1.0)	(1.2)	(0.6)	(2.2)
Lifecycle GHG reductions, MTCO _{2e}	(12.5)	(23.2)	(11.6)	(35.7)
Lifecycle avoided costs	\$(3,405)	\$(5,489)	\$(4,119)	\$(10,180)
Net cost @ early replacement / lifecycle MTCO _{2e}	-\$8	\$412	-\$100	\$293
Net cost @ ROB / lifecycle MTCO _{2e}	-\$172	\$50	-\$100	\$3

For both electricity mixes, Scenario 2: Electrify Space Heating offers the greatest single-measure GHG benefit though it would cost a significant amount of money per MTCO_{2e} carbon reduced. Energy

¹⁹ 2018 PG&E electricity emissions factor is 0.09344 MTCO_{2e}, as provided at https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/fighting-climate-change/fighting-climate-change.page

efficiency and DHW electrification are close in both scenarios, but in the 100 percent carbon-free electricity option, DHW does outperform energy efficiency in terms of GHG savings. For both electricity options, on a cost-per-ton basis, both DHW electrification and energy efficiency investments look attractive, either as early replacements or at ROB. DHW provides a much higher savings in the ROB scenario versus early replacement.

Space heating electrification is not financially viable for GHG savings as a single-measure, though it is improved in the carbon-free electricity scenario. Electrification of space heating would be increasingly cost effective if paired with rooftop solar or for those homes with an existing cooling load or those who intend to add cooling (which is projected to increase as the Bay Area's temperatures increase due to climate change). Therefore solar customers and residences with space heating and cooling loads may be specifically targeted for electrification more effectively than a broad campaign for all households. This also highlights the need to reduce IMC as the best way to increase its cost-per-ton of GHG savings. However, when combining electrification of space heating with DHW electrification and energy efficiency, a near-zero cost-per-ton is possible.

Bundling Measures

Given the sensitivity of electrification economics to energy prices, combined with concerns about the impacts of new electric loads on the grid, electrification measures should ideally be combined with energy efficiency measures. However, a fully integrated decarbonization project, including electrification of multiple appliances, whole-house energy improvements, and renewable energy generation, would require a substantial financial investment, considerable planning and design, and coordination of multiple trades. This approach is challenging for most customers today.

For DHW, combining with energy efficiency is straightforward because the relevant measures—low-flow showerheads and faucets, pipe insulation, and recirculation pump controls—are generally economical and easy to install and do not have a great impact on what type of appliance should be purchased and installed.

For space conditioning, the combination is more challenging because the energy efficiency project scope, costs, and benefits are all heavily dependent on building geometry and existing conditions unique to each site. The pros and cons of energy efficiency will thus need to be evaluated on a case-by-case basis for each existing home. For maximum effectiveness, the efficiency measures should be installed first and then the new heat pump space heating/cooling sized to the new reduced space conditioning loads.

Building Envelope Energy Efficiency plus DHW Electrification

The biggest risk of adding a heat pump water heater (HPWH) to an inefficient distribution system is that the customer could occasionally run out of hot water. Short of improving distribution system efficiency, this risk can also be mitigated by over-sizing the storage tank and/or setting the tank to a hotter set point (combined with a thermostatic mixing valve and anti-scalding controls). Most HPWHs on the market also come with electric resistance modes to further mitigate this risk. If energy efficiency measures are added at a later date, it is then a straightforward matter to lower the temperature setpoint and disable electric resistance mode. In short, there is no particular harm in decoupling these measures.

Building Envelope Energy Efficiency plus Space Heating Electrification

From a customer bill savings perspective, the impacts of conducting envelope improvements to maximize efficiency before electrification may be mixed. For five case studies analyzed for Ardenna Energy's Peninsula Climate Comfort pilot in San Mateo County, results from two customers showed clear benefits of combining efficiency with heat pump space heating. The expected bill savings exceeded the expected investment and the heat pump size requirement was reduced 40 to 50 percent, offering further savings on installation costs. For two more customers, the operating savings clearly did not justify the added costs. The fifth case offered marginal benefits, depending on the final installation costs. The key determinant for whether or not energy efficiency was cost effective was the home's baseline energy efficiency. Very leaky homes showed benefits for making building envelope upgrades and reasonably well-sealed and insulated homes (even if they were below current code requirements) showed marginal benefits for envelope improvements.

From an energy efficiency perspective, requiring efficiency improvement prior to electrification offers multiple benefits. First, building shell improvements reduce heating and cooling loads, which reduce equipment sizing requirements. Second, right-sized equipment provides higher operating efficiencies. If a heat pump is installed prior to efficiency measures, then it must be sized to the higher load, leaving it oversized if efficiency improvements are added later. Approaching efficiency first reduces energy consumption and allows for right-sizing of equipment for gas or electric end uses. Additional benefits and impacts of combining energy efficiency, aside from operational and GHG reduction, with space heating upgrades are considered in Chapter 4.

Chapter 4: Additional Policy Impacts and Co-Benefits

The State's energy efficiency and carbon goals are certainly critical to crafting policy for existing single family homes. However, looking at houses only through this lens ignores the use of that building for shelter, a basic human right. When exploring policy options, cities must take into account various other co-benefits and impacts on residents and the housing market. For example, is the policy attainable for all residents in terms of accessibility and cost? If not, what incentives or rebates are available to ensure that the benefits of the policy are enjoyed equitably? Does it improve the overall quality of the building and indoor air quality or is it just replacing one fuel source with another? The financial impacts to the utility may also be a consideration in terms of the construction and maintenance of infrastructure which impacts how realistic a particular policy may be to implement. Prioritizing just energy efficiency or just electrification may sacrifice one set of benefits for another. This chapter aims to paint a more holistic picture of the policy options and measures outlined in chapters 2 and 3. While we are facing a climate emergency and reducing GHG emissions must be a priority, considering only GHGs in developing policy could exacerbate inequities already being faced by many in the State.

Equity

While energy efficiency improvements can lower utility bills, low- and moderate-income households may not have the ability to pay for the upfront costs. Low income residents are often considered more energy efficient because they tend to live in smaller units and have more people per unit. A 2020 study from UCLA found that people living in disadvantaged communities use half as much energy, on average, as people in wealthier areas.²⁰ However, at times this perceived "efficiency" is actually a result of living uncomfortably, or even in an unsafe manner, to save energy if they cannot pay utility bills.

A 2016 ACEEE study found that while low-income families paid less overall on utility bills, they paid more per square foot compared to other income levels. In 2011, 5.5 percent of low income customers in California had their utilities disconnected for non-payment. Of those, over half owed less than \$315. These disconnections can lead to residents resorting to unsafe methods for lighting and heating their homes. The ACEEE study also highlights a 2012 report stating that paying utility bills was the number one reason individuals took out a payday loan.²¹ These findings reinforce that "efficiency" can be a necessity of the inability to pay bills while being more likely to live in poorer quality, older homes in need of upgrades. While bringing efficiency and electrification to high-energy users who live in larger, inefficient homes and can afford upgrades is important, there also needs to be an equal or greater effort made to make sure that livable conditions are accessible to all residents. That could mean an increase in energy consumption so that all people can heat their homes or keep the lights on.

While critical to reducing GHG emissions, electrification could over time increase energy insecurity for California's most vulnerable populations unless significant efforts are made to ensure that they are not

²⁰ Fournier, E.D., Cudd, R., Federico, F. and Pincetl, S., 2020. On energy sufficiency and the need for new policies to combat growing inequities in the residential energy sector. *Elem Sci Anth*, 8(1), p.24.

DOI: <http://doi.org/10.1525/elementa.419>

²¹ Drehobl, Ariel, and Lauren Ross. "Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities." *American Council for an Energy Efficient Economy*, www.aceee.org/sites/default/files/publications/researchreports/u1602.pdf.

left behind. PG&E has requested a 15 percent rate increase for gas by 2022 to cover safety upgrades for aging infrastructure. This increase in gas costs could help make the transition to all-electric buildings more affordable. However, as more users leave the natural gas system behind, the cost to maintain that infrastructure is distributed among fewer people, increasing individual costs. Without policy and regulatory interventions, Energy and Environmental Economics (EC3) estimates that at least two million Californians will be left on natural gas. If low- and moderate-income groups are left out of the electrification movement, they will bear the burden of higher gas costs when about 25 percent of Californians are already considered “energy insecure.”²²

Customer Utility Bill Savings

Table 4-1 below analyzes how the scenarios outlined in Chapter 3 perform in terms of bill savings and how much money is needed for upfront costs. This helps a city understand how certain measures perform from an equity perspective. If some measures or packages are economical over their lifetime, focus can be made on helping to cover upfront costs to make them accessible for all residents. Measures or packages that have no bills savings even over their lifetime may be very challenging to approach equitably and would rely on high income residents who can afford the losses in exchange for a more environmentally-friendly option. Customer utility bill savings were calculated assuming an electricity price of \$0.244 and a gas price of \$1.37. These prices represent the current tier 1 prices PG&E charges residential customers on its default rates. Going forward, PG&E intends to migrate customers to a Time of Use (TOU) rate, which offers new opportunities and challenges for utility bill savings.

Customer economics are analyzed via a simple Savings-to-Investment Ratio (SIR), without consideration of future inflation, interest rates, energy price trends, or customer discount rates. SIRs greater than 1.0 represent positive financial outcomes from the customer perspective in the sense that lifecycle savings is projected to exceed the investment cost. The SIR is presented three ways.

- a) Savings is compared to the fully installed cost.
- b) Savings is compared to the IMC. This metric applies only to the electrification measures and reflects a scenario in which the old gas equipment is replaced on burn-out (ROB), or emergency replacement.
- c) Savings is compared to investment after netting out the avoided costs. This scenario would be applicable if the utility or other Program Administrator offered a financial incentive comparable to the avoided cost value.

Scenario 3: Building Envelope EE provides the most utility bill savings. Predictably, for the appliance-replacement scenarios (1 and 2), savings are greater for ROB than they are for early replacement and are even more attractive if a utility or other entity provides a rebate to cover the full IMC. Looking at customer bill savings, all measures are projected to reduce annual customer bills except space heating electrification. Across the board Scenario 2: Electrify Space Heating is shown to provide no savings since the installation costs are very expensive and in the mild Bay Area climate zones there are few heating and cooling degree days when this appliance is running. Space heating could be expected to produce

²² Miller, Carmelita, et al. “Equitable Building Electrification: A Framework for Powering Resilient Communities.” *Greenlining Institute*, greenlining.org/publications/reports/2019/equitable-building-electrification-a-framework-for-powering-resilient-communities/.

positive bill savings for high usage customers, those customers with pre-existing summer cooling loads, or those with rooftop solar (not modeled).

For Scenario 4, adding energy efficiency to the electrification measures improves financial performance somewhat but the efficiency benefits are too weak to overcome the financial drag from space heating. When combining with rooftop solar, space heating electrification becomes more viable, however the upfront costs increase significantly.

Table 4-1: Utility Bill Savings from Measures

Annual Operations	1: Electrify DHW	2: Electrify Space Heating	3: Building Envelope EE	4: Elec DHW + Space Heating + EE
Installation cost	\$3,689	\$13,423	\$6,080	\$23,192
Incremental Measure Cost (IMC)	\$1,640	\$5,027	\$6,080	\$12,747
Annual bill savings	\$30	\$(82)	\$156	\$145
Lifecycle bill savings	\$390	\$(1,634)	\$3,120	\$2,442
<i>Customer Savings-to-Investment Ratio (SIR)</i>				
(a) Base Customer SIR	0.11	-0.12	0.51	0.11
(b) IMC Customer SIR	0.24	-0.33	0.51	0.19
(c) Customer SIR, net of avoided costs	1.37	-0.21	1.59	0.19

It is important to point out here that the economic analysis for electrification measures does not consider the potential expense of upgrading service panels. There is a lack of good data regarding the prevalence of these housing stock conditions and the associated costs of mitigating them. With electric service panels, there appears to be some uncertainty as to what constitutes undersized service. The prevailing wisdom seems to be that homes need 200 Amp service for full electrification; yet there is at least anecdotal evidence that full electrification is possible with just 100 Amp service. There also appears to be some emerging technologies on the horizon that may mitigate the need for service panel upgrades. In sum, this issue requires more research before a coherent public investment plan and policy strategy can be devised.

Indoor Air Quality and Comfort

State and national standards regulate outdoor air quality. Despite spending a majority of time indoors, there are no such regulations for indoor air quality (IAQ). At times, IAQ can significantly exceed outdoor air quality standards, which can negatively affect human health. This indoor pollution can come from a variety of sources- mold, mildew, and dust from inside; dirty air infiltrating from outdoors (from traffic, industrial emissions, or wildfire smoke); or combustion of natural gas indoors.

Removal of natural gas combustion appliances can help to improve air quality, as they release carbon monoxide, nitrogen oxides, particulate matter, and formaldehyde indoors. While replacing natural gas furnaces, hot water heaters, and dryers will reduce the possibility of gas leaks or incomplete combustion of methane circulating in a home, the most polluting gas appliance in a residence is also the one that tends to elicit the strongest emotional connection: gas stoves. A 2020 UCLA study on the effect of residential appliances on air quality found that in 90 percent of modeled scenarios IAQ did not meet

State or national air quality standards when using a gas stove and oven simultaneously for one hour.²³ There has also shown to be a correlation between using gas stoves and a higher prevalence of childhood asthma.²⁴ From a safety standpoint, when energy insecure customers have their electricity turned off or are trying to reduce energy consumption, it can lead to hazardous practices for heating or lighting a home. One such approach is using gas stoves for heating, which can potentially lead to carbon monoxide poisoning.

Upgrading building envelopes, through insulation, air sealing, duct sealing, and proper ventilation, can improve IAQ while also improving the quality and comfort of housing. As shown in Table 4-1, building envelope improvements can lower energy bills as the air that is being conditioned is not leaking out of the house. Lower income residents are more likely to live in lower quality homes in need of basic upgrades, such as windows, insulation, or fixing leaks. This sector of the population is also more likely to live in areas exposed to pollution, such as near industrial uses or highways, which makes improving the building envelope even more important for improving IAQ. Electrifying a home without envelope improvements will not address air infiltration and leakage and may have limited effects on occupant comfort since the home will still not hold hot or cold conditioned air effectively and could be drafty.

Resilience

Energy efficiency upgrades and electrification help to increase the resilience of single family residential buildings. As discussed in the IAQ section, building envelope upgrades and air sealing can reduce outside air infiltration, which is especially important during wildfire smoke events. Updating mechanical equipment can provide better IAQ during wildfires as new HVAC systems are compatible with higher performance filters. Older homes that have not been upgraded can have IAQ with particulate levels of 70 to 80 percent of what is outdoors. Installing high-performance filtration systems can reduce particulate levels to 50 percent and coupling that with airtight homes can reduce indoor exposure to outside particulates to less than five percent.²⁵

As California's summers become hotter and winters become drier, wildfire season is extending. Traditionally in the fall, a second wildfire season is developing in the summer, overlapping with hotter temperatures. As many homes in the Bay Area do not have mechanical cooling loads, they rely on opening windows for cooling and ventilation when it is hot outside. If windows cannot be opened due to smoke events, this not only decreases the comfort indoors, but can cause hazardous heat conditions, especially for vulnerable populations such as seniors. Reducing air leaks and insulating the home can lower indoor temperatures during extreme heat events. As the climate becomes hotter, the demand for air conditioning rises. High-efficient heat pump space conditioning, which provide both heating and cooling capabilities, can provide relief during extreme heat events and is less taxing to both the grid and the environment than older, inefficient window air conditioning units or central air conditioning systems.

²³ Zhu, Dr. Yifang, et al., *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California*. UCLA. April 2020.

²⁴ Knibbs, L. et al. *Damp housing, gas stoves, and the burden of childhood asthma in Australia*. Medical Journal of Australia. 2018 (7): 299-302.

²⁵ Sully, Jessica. "Improving Indoor Air Quality during Wildfires." *U.S. Department of Energy Science News*, 28 Oct. 2019, www.eurekaalert.org/features/doe/2019-10/dbnl-iaa102819.php.

Reducing energy consumption through energy efficiency upgrades (including switching to more efficient heat pump technologies) can help prevent blackouts. Blackouts often occur when the electric grid is overloaded, such as when it is very hot out and many residents are using their air conditioners at the same time. At times, the California Independent System Operator (CAISO) can proactively turn off power in various areas where they predict the grid to be overloaded, known as rolling blackouts. While heat pumps and induction stoves are more efficient than their gas counterparts and therefore reduce energy consumption just by switching, water efficiency and building envelope improvements can further help with grid resilience by maximizing load reductions. Envelope improvements can also help with load shifting, or pre-heating and pre-cooling spaces during off-peak hours.

Different than a blackout from an overloaded power grid, utilities throughout the State have begun to institute Public Safety Power Shutoff (PSPS) events where electricity is proactively turned off in certain weather conditions that are conducive to wildfire (i.e. high temperatures, extreme dryness, and/or high winds). A tighter building envelope, as stated above, will help keep indoor temperatures more comfortable if power is intentionally shut off or if there is a blackout. However, as the PSPS events are enacted to reduce wildfire risk, reducing consumption does not help with prevention. There are concerns that electrifying homes would be worse for resilience during PSPS events or blackouts, leaving a resident completely without power. While some, especially older, gas appliances can function during a blackout, many modern gas appliances require electricity to work. Coupling electrification with solar plus storage with the ability to “island” from the grid would maximize resilience during power outages. Improving efficiency would increase the battery life, especially important when smoky conditions may reduce the efficacy of solar panels. While some rely on diesel generators during power outages, these can drastically increase air pollution and may be a fire hazard if there is dry vegetation and prime wildfire conditions.

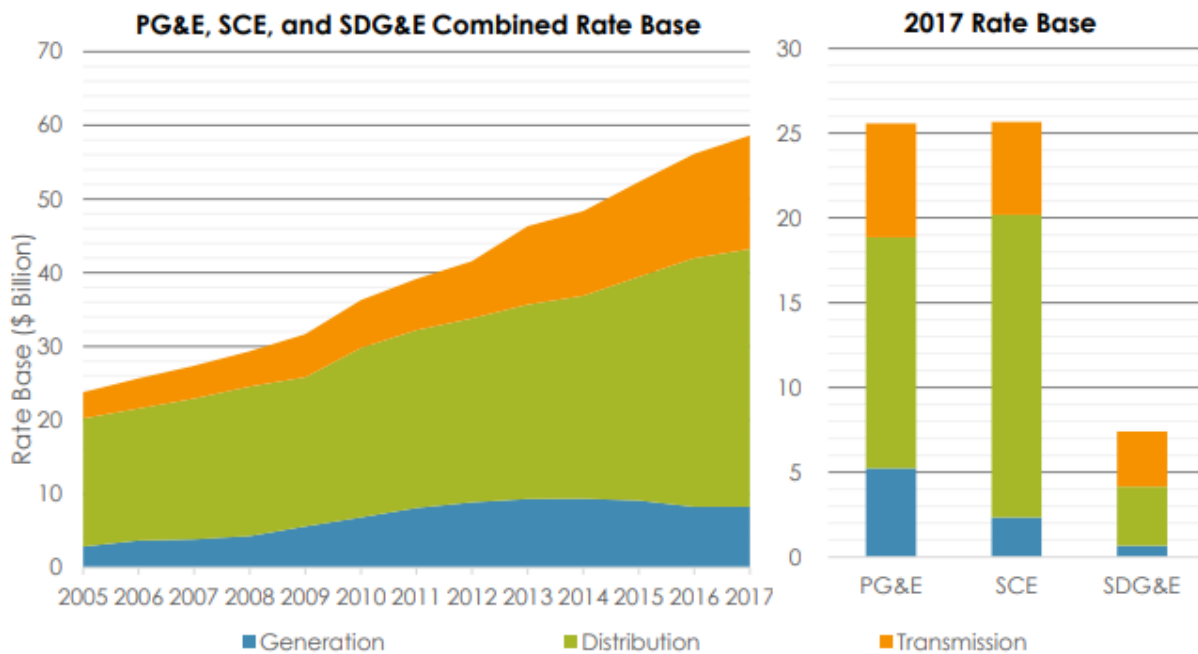
In 2010, an improperly installed PG&E gas pipeline in San Bruno, California exploded killing eight people and destroying dozens of homes. In 2018 excessive pressure in Columbia Gas of Massachusetts natural gas pipelines caused several explosions and fires that led to 30,000 evacuations and one person killed. In addition to these infrastructure failures, large earthquakes can also cause gas pipeline explosions and fires. This is more likely for older pipelines as newer ones are built to updated seismic standards. While these extreme events are rare, it highlights that natural gas pipelines can cause devastation if not properly installed and maintained.

Despite decreasing usage of natural gas through efficiency and electrification, the cost to maintain natural gas infrastructure is increasing. As stated in the “Equity” section above, PG&E has requested a rate increase to help cover the costs of maintenance. Removing natural gas use from homes can help reduce risks from fire and explosion. Additionally, replacing gas stoves with induction ranges can reduce fire risk since there is no open flame or hot surface. However, if electrification is accomplished in a piecemeal fashion, it decreases the resilience benefits for two reasons. One, there is still a need for a natural gas connection to a home and two, the natural gas infrastructure must still be maintained. Even if an entire home is electrified, if the surrounding neighbors connected to the same pipeline do not, the infrastructure cannot be removed. Strategic, large-scale electrification is the most effective way to be able to “trim the gas tree” and decommission and/or remove gas pipelines that can reduce maintenance costs and increase resilience.

Avoided Utility Costs

Avoiding future utility costs for generation, transmission, and distribution represents the standard rationale that has underpinned California energy efficiency policy for several decades. Most households in the Bay Area receive electricity through CCAs or a municipal utility, with gas service by PG&E.²⁶ When crafting policy for existing single family residential homes, the impact on the grid and associated infrastructure needs may be a consideration. While a local governments could pass a policy and/or reach code without considering utility costs, such upstream impacts could influence affordability, such as utility bill savings estimated in Table 4-2. The installation and maintenance costs of infrastructure are responsible for a significant portion of a utility’s rate base. For electricity, CCA customers may not pay for the IOU’s generation costs as they directly pay for generation, but they still pay for transmission and distribution costs since CCAs do not own or operate separate infrastructure than the IOUs. Figure 2 below shows the trends in the electricity utility rate base in 2017, with distribution being the largest factor.

Figure 2: Trends Electric Utility Rate Base



Source: California Public Utilities Commission, 2018, California Electric and Gas Utility Cost Report: Public Utilities Code Section 913 Annual Report to the Governor and Legislature.²⁷

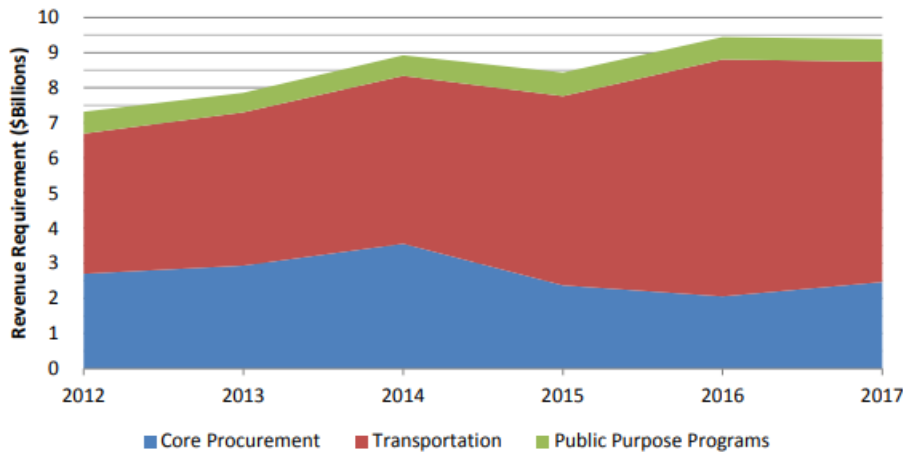
As CCAs and most municipal utilities do not provide natural gas service, the Bay Area largely relies on PG&E. Figure 3 below shows that transportation of natural gas is the largest source of revenue needed. Costs for gas infrastructure have been increasing in recent years, though did decrease slightly between 2016 and 2017. However, as previously mentioned, PG&E has requested a natural gas rate increase through 2022 to cover infrastructure costs and safety improvements.

²⁶ Households served by a CCA have the choice to “opt-out” and receive both gas and electricity through PG&E.

²⁷ Report may be found at

www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/About_Us/Organization/Divisions/Office_of_Governmental_Affairs/Legislation/2018/California%20Electric%20And%20Gas%20Utility%20Cost%20Report.pdf

Figure 3: Trends in Gas Utility Revenue Requirement Components



Source: California Public Utilities Commission, 2018, California Electric and Gas Utility Cost Report: Public Utilities Code Section 913 Annual Report to the Governor and Legislature.

Utility costs and energy consumption were estimated for the four scenarios outlined in Chapter 3 to better understand how various local government policies could affect these costs, and therefore possibly utility bill costs down the line. The model used PG&E avoided costs for gas and electric service in climate zone 3, as represented in the CPUC 2020 avoided cost calculators.²⁸ Avoided costs show considerable variation across seasons, and electric avoided costs show additional variation by time of day. The calculated average avoided cost is estimated as \$1.86 per therm and \$0.08516 per kWh.

The electrification measures are the primary contributors to gas avoided costs. Energy efficiency avoids gas costs as a stand-alone measure since a tighter building envelope reduces the need for space heating (assumed to be gas in a baseline scenario). That value transitions to the electric side when efficiency is paired with end use electrification. Electrification measures add electric utility costs because they add load. No measures show avoided cost savings in excess of the full installed costs.

Table 4-2: Avoided Utility Costs and Energy Consumption Changes

Annual Operations	1: Electrify DHW	2: Electrify Space Heating	3: Building Envelope EE	4: Elec DHW + Space Heating + EE
Installation cost	\$3,689	\$13,423	\$6,080	\$23,192
Incremental Measure Cost (IMC)	\$1,640	\$5,027	\$6,080	\$12,747
Annual change in kWh	899	1,566	(24)	1,658
Annual change in therms	(182)	(219)	(110)	(401)
Gas avoided costs (lifecycle)	\$(4,400)	\$(8,156)	\$(4,078)	\$(12,556)
Electric avoided costs (lifecycle)	\$995	\$2,667	\$(41)	\$2,375
Total avoided costs (lifecycle)	\$(3,405)	\$(5,489)	\$(4,119)	\$(10,180)

²⁸ Calculators can be found at: <https://www.cpuc.ca.gov/General.aspx?id=5267>. Avoided cost parameters were derived from the 2020 electric and gas avoided cost calculators, version 1c. The electric value was calculated as the simple average of Hourly Average Levelized Value of Electricity across 8,760 hourly periods. The gas value was calculated as the average across 12 months.

Actual avoided costs will depend on the geographic distribution of upgrades. As Environmental Defense Fund and others have pointed out, a scattershot approach to building electrification does little to mitigate the need for continued gas infrastructure investments, whereas a targeted approach could allow certain high-cost gas distribution branches to be decommissioned rather than replaced. This investment approach would require 100 percent electrification of the customers served by the targeted line, whereas this analysis only considers space heating and hot water (not cooking, clothes drying, or other gas end-uses such as fireplaces).

Chapter 5: Workforce Development

Mandatory upgrades for existing buildings are often cited as a challenge for many reasons, including permit evasion, timeline for upgrading the entirety of the building stock, and ability for the workforce to meet increased demand (especially in regards to newer technology such as electrification). A city may wish to pass an existing single family residential policy, but have concerns over whether or not it is implementable with the number of professionals who can perform the work or the availability of equipment. While many energy efficiency improvements are routine to install, electrification and health-specific upgrades may be less common. To better understand where the Bay Area workforce currently stands in relation to these kinds of upgrades, we surveyed the pool of BayREN Home+ contractors and Home Energy Score (HES) Assessors. While there are contractors and energy professionals outside of the BayREN programs who could perform such work, the Home+ contractors and HES Assessors are assumed to be leaders in energy efficiency due to their involvement in BayREN. It may be inferred that if BayREN participating contractors are uncomfortable with electrification and health-specific measures, that others outside of the programs would also be. This chapter outlines the results of the survey of the BayREN workforce, including their current approach to recommendations, barriers to new technologies, and how BayREN can help fill any gaps.

Survey Methodology and Results

The BayREN survey was distributed to all participating Home+ contractors and HES Assessors. The BayREN Home+ program is a single family rebate program. A single household is eligible for up to \$5,000 in rebates over a five-year period for upgrades such as insulation, air sealing, duct sealing, or space and water heating upgrades. To be eligible for rebates, homeowners must utilize one of the participating contractors who are enrolled in the program, have gone through energy efficiency training, and met other requirements.²⁹ HES Assessors participate through the BayREN Green Labeling program, which focuses on increasing energy transparency in the single family residential marketplace. BayREN, through StopWaste, is a U.S. Department of Energy (DOE) HES partner and is able to administer scores throughout the Bay Area. Assessors must pass a DOE online training and exam, hold a valid license as defined by the DOE, complete mentoring and a participation agreement with BayREN, and meet DOE quality control standards for conducting scores. The HES is a simple 1 to 10 score, with 10 being the most efficient, based on the energy assets of a home (windows, insulation, space and water heating equipment, etc.). With the score, the Assessor provides a customized report that recommends upgrades to improve the home's efficiency and score.³⁰

The survey was distributed in April 2020 and was open for approximately one month. To encourage participation, ten respondents were selected at random to receive a \$50 gift card. The first set of questions covered affiliation with BayREN, size and age of company, services provided, and whether or not the respondent currently provides electrification recommendations in their work. From there, respondents were directed to a different set of questions depending on their answers. After

²⁹ More information on the Home+ program and requirements for contractor enrollment can be found at www.BayRENResidential.org

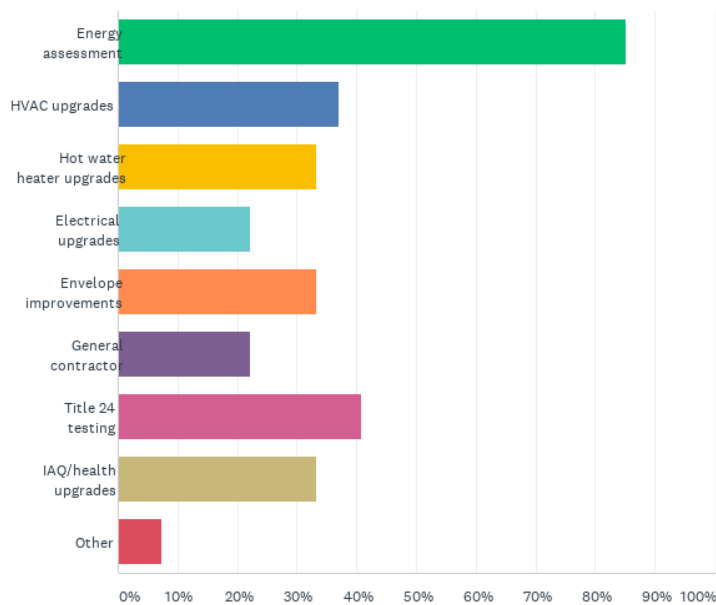
³⁰ More information on the Green Labeling program and requirements for Assessor participation can be found at www.BayREN.org/green-labeling

electrification questions, a set of questions on healthy home upgrades was asked. Survey questions can be found in Appendix C.

Makeup of Respondents

A total of 27 survey responses were collected. Nineteen were Assessors (out of approximately 40 active Assessors) and 11 were Home+ contractors (out of approximately 60 active contractors). Several respondents participate in both programs. The majority of respondents (88 percent) have been involved within BayREN programs for more than one year, with 44 percent participating for over five years. Many are small to medium business with two to 10 employees (44 percent). Twenty-two percent of respondents are self-employed. The chart of Q4 responses below shows the distribution of energy efficiency services provided by respondents.

Q4 Which of the following energy efficiency upgrades do you provide? Select all that apply.



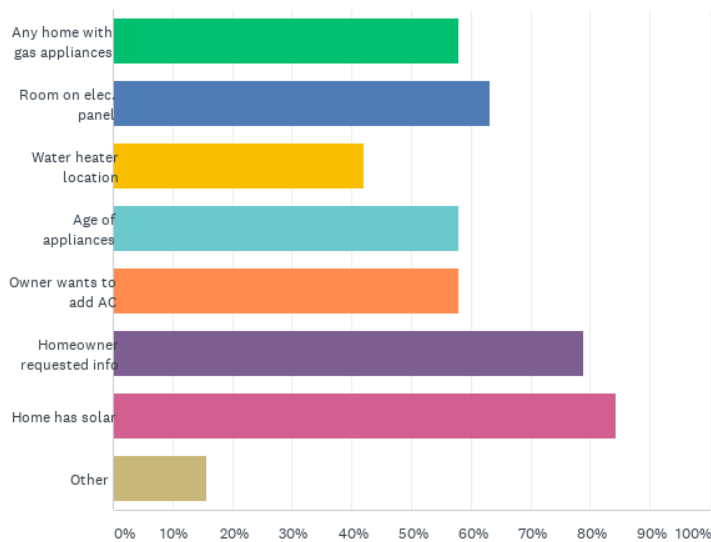
Electrification Responses

Current Electrification Recommendations

Of the 27, most respondents provide at least one type of electrification recommendation to customers (could select more than one). Most common are heat pump space heating and heat pump water heating (HWPH) replacements (52 percent each). Twenty-six percent provide recommendations for induction cooktop upgrades and 22 percent recommend heat pump dryers. Only six respondents, or 22 percent, said that they do not provide any type of electrification recommendations. Several respondents stated that they just perform testing and make no recommendations of any type, electrification or otherwise. From these responses, it does appear that at least the BayREN workforce is prepared for the transition to increase electrification. Again, it is assumed that the BayREN workforce is more advanced than typical contractors in the field of energy efficiency, so outside of BayREN, contractors may be less likely to have already incorporated electrification into their practices.

For those who make electrification recommendations, 42 percent always provide such recommendations, 32 percent only provide them when a home is determined to be a “good fit”, and 16 percent only when the homeowner asks. The results of Q7 below show how these building professionals determine if a home is a “good fit” for electrification. The number one response (84 percent) was a home that has solar and 79 percent if the homeowner requests information on electrification. Fifty-eight of respondents who already provide electrification recommendations feel that any home with natural gas appliances is a good fit.

Q7 How do you determine if a home is a good fit for electrification? Select all that apply.

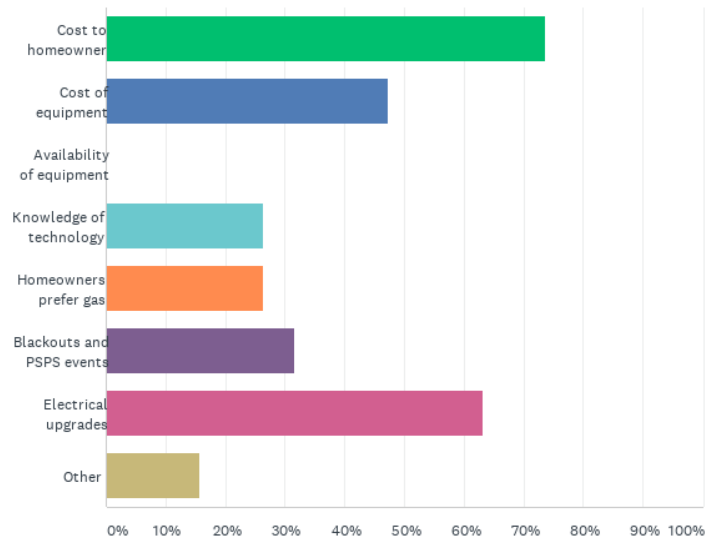


Barriers to Electrification Recommendations

The next set of questions addresses perceived barriers to electrification and why surveyed contractors and Assessors do not currently make electrification recommendations. Q8 results shown below demonstrate that the number one perceived barrier is the cost to the homeowner (74 percent), followed by potential electrical upgrades (i.e. electrical panel or removing knob and tube wiring). Despite often being cited anecdotally, no one responded that availability of equipment was a barrier.

The six who do not currently make electrification recommendation were asked why. The number one reason given was being unfamiliar with the requirements and technology (50 percent). Two were hesitant since the installations may involve bringing in another trade (i.e. if you are a plumber you may also need to involve an electrician). Contrary to the response to Q8 (which was available to all respondents), two of those who do not currently make electrification recommendations said that availability of equipment is a barrier. This means that it could be more of a perceived barrier than an actual one. Alternatively, it could mean that there are greater challenges than availability since Q8 only asked for their top three answers. Only one felt that natural gas appliances are superior to electric and none selected that homeowners were not interested in fuel-switching.

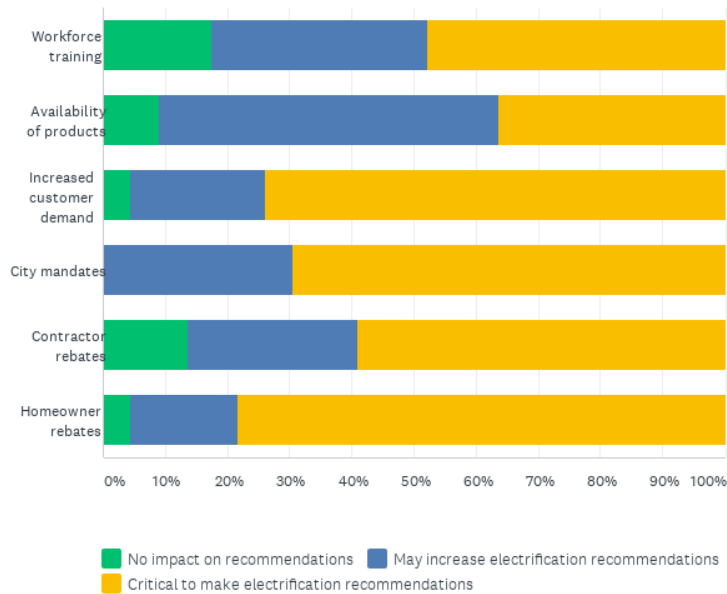
Q8 What do you think are the top 3 most significant barriers to electrification?



Support Needed to Increase Electrification Recommendations

All respondents were provided with options for what would impact their ability and desire to make electrification recommendations. While most of the options were selected as “critical”, the most impactful were voted to be homeowner rebates, increased customer demand for electrification, and city mandates. A summary of Q10 responses are provided below.

Q10 Would the following impact your ability/desire to make electrification recommendations?



In an open-ended question as to how BayREN can better support the transition to electrification, 16 answered. Most responses mentioned education to homeowners about the benefits of electrification and marketing programs and rebates for gas change-outs. Several respondents said that the cost-effectiveness needs to be improved for these new measures, including increasing rebates.

Healthy Homes Responses

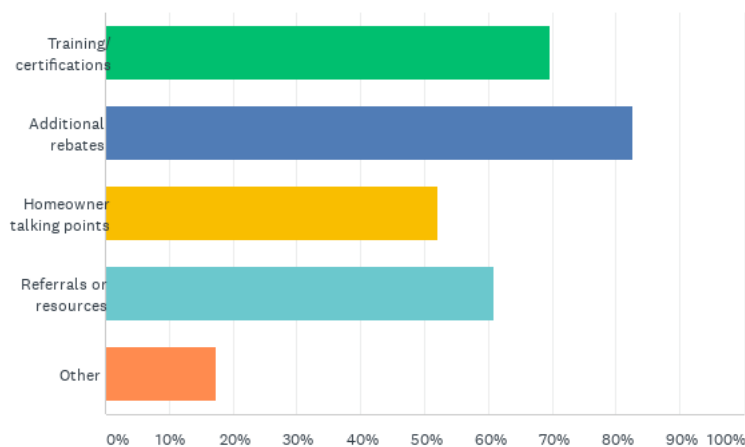
Healthy Homes Recommendations and Barriers

Twenty-three respondents answered whether or not they currently incorporate healthy homes recommendations into their work. Seventy percent responded that they always talk about the health benefits of energy efficiency. Only 9 percent (two respondents) said that they do not provide health recommendations because it is typically outside of their scope of work. When asked how often they see homes with severe health and safety issues (e.g. mold, pests, broken windows), 61 percent said they see these conditions in fewer than 25 percent of homes. Only one said they see these conditions in more than 75 percent of homes. Since BayREN Home+ is a rebate program, contractors and Assessors are more likely to do work in moderate- to high-income households which may be generally newer or in better condition. When respondents encounter these conditions, 57 percent said that they refer the work to other contractors/trades and do not make the health and safety upgrades themselves. Thirty-nine percent incorporate the work into their scope.

Support Needed to Increase Healthy Homes Recommendations

When asked how BayREN could support contractors and Assessors in making healthy homes recommendations, the number one response (83 percent) was additional rebates for health-related upgrades. Many also said that training and referral resources for homeowners with severe health and safety issues would also be helpful. Under “other” one respondent felt that educating homeowners on IAQ benefits of energy efficiency was important. A summary of Q15 results is shown below.

Q15 Would any of the following support mechanisms from BayREN help your business make recommendations related to healthy homes?



Chapter 6: Key Themes and Recommendations

California will need to more comprehensively address existing single family homes in order to meet aggressive GHG emissions goals. Thus far, existing building policy has primarily focused on the disclosure of energy information and upgrades have relied on a combination of this information and incentive programs. Depending on voluntary measures alone is not sufficient to make needed carbon reductions, as they are very slow to reach the entire building stock. As the State's grid becomes increasingly powered by renewable and carbon free sources, there has been a shift in energy policy to transition buildings off of natural gas and to all-electric appliances as a means to achieve deeper GHG savings.

An effective policy includes several key pieces. First is “when” the policy or mandate is triggered. Examples of this are provided in Chapter 2, which outlines policy levers local governments have used to address existing single family residential building energy use. The next critical piece is “what” is actually required. In some cases this could be energy disclosures (such as Berkeley's BESO) or a more aggressive requirement that a home receive a Home Energy Score and make one or more of the recommended improvements to increase the score. Examples of measures that could be required in the “what” of a policy are provided in Chapter 3. A jurisdiction should also consider “why” a certain policy or set of measures is required. Will it reduce GHG emissions? Does it increase the quality of housing or improve the health or comfort of residents? Will it save people money on their utility bills or decrease energy burdens? These important policy impacts, such as equity and resilience, are discussed in Chapter 4.

One last consideration is “how” a policy is going to be implemented or enforced. For example if a policy is enacted to install a heat pump water heater at time of burnout, a mechanism to prevent permit evasion may be necessary to see meaningful GHG and energy reductions. Also, “how” will the workforce and market respond to new mandates, including those that may require different technologies than the status quo? Chapter 5 presents the results of a survey of the BayREN workforce on several aspects of workforce readiness.

This paper is general in its nature, aiming to introduce the available policy levers and broadly estimate their potential impacts. Which policy and package of measures is best depends on the size and makeup of the jurisdiction, as well as what their goals may be, carbon and otherwise. While more detailed work would be needed to delve deeper into many of these topics or to more precisely estimate impacts for specific jurisdictions, several themes clearly emerge in relation to how cities should approach energy efficiency and electrification:

Policy Development

- **Existing levers exist for local governments to mandate energy efficiency and/or electrification upgrades.** While cities throughout the country have developed policies aimed at energy in the single family residential sector, most rely on disclosure and incentives to spur voluntary upgrades and none address electrification. However, it is possible that cities utilize these levers, such as pulling a building permit or disclosure at time of sale, to layer on energy efficiency and/or electrification measures.

- **An equitable approach to both energy efficiency and electrification must be taken.** Incentives that do not bring home improvements within reach for low- and moderate-income residences will further exacerbate inequities and energy insecurity. The basic need for all residents to safely and affordably heat and light their homes is paramount. Relying on early adopters to bring electrification costs down will leave vulnerable residents behind paying for gas infrastructure and shouldering the cost of maintenance.
- **There is still an important place for energy efficiency in this new world of electrification.** Energy efficiency helps to reduce loads, right-size equipment, and improve indoor air quality, as well as the comfort and quality of the home. It can also help reduce energy bills, which is critical for low- and moderate-income customers. While not all homes are easy to electrify at this time due to financial barriers or physical characteristics of the home, most should be able to make at least minor efficiency improvements. Both paths produce measurable energy savings, GHG emissions reductions, and may realize some utility bill savings.
- **Electrification is the most effective way to reduce GHGs.** The world is facing a climate emergency and relying on minor energy efficiency improvements through voluntary action will not be sufficient to meet the State’s ambitious GHG reduction and carbon neutrality goals. Achieving deep carbon reductions will require a fundamental change in systems, including how buildings are constructed and their fuel sources. Electrification coupled with a clean grid is the most effective option for reducing GHG emissions.
- **Enforcement is key to policy effectiveness.** Unfortunately permit evasion is a large problem throughout California. Passing policies that make construction projects longer or more costly could have the unintended consequence of increased evasion if enforcement is not factored into the equation. Therefore any mandatory policies that go beyond the building code must have an enforcement mechanism in place.
- **Each city’s approach and impacts will be different, though regional consistency is helpful for residents, the workforce, and incentive programs.** Each city’s regulatory pathway to achieving building energy efficiency and climate action goals will hinge on the city’s goals, the composition of its building stock, and its relationships with key stakeholders. At the same time, having regulations and incentives that differ from jurisdiction to jurisdiction creates a complicated patchwork that can be difficult for contractors and residents to navigate effectively. Providing some consistency across the region can therefore help with compliance and uptake.

Measures and Technology

- **Heat pump space heating must come down in cost to be widely scalable.** While all electrification measures could benefit from removing barriers and reducing upfront costs, currently heat pump water heaters are more cost effective than heat pump space heaters. Therefore water heating may be the best place to start for cities wishing to require or incentivize electrification. Customers with both a heating and a cooling load, those who wish to add air conditioning, or those who have solar may be viable targets for heat pump space heating. Focusing on preparing households for electrification, such as pre-wiring or increasing panel sizes, will help remove barriers when a resident wants to or is required to make the switch.

- **Piecemeal electrification is more palatable from a cost standpoint, but sacrifices certain co-benefits.** Electrifying single end uses at a time can be more financially viable for homeowners, but leaving gas appliances within a home does not reap the full benefits of resiliency, IAQ improvements, or being able to cap the gas line, reducing the need and cost to maintain natural gas infrastructure.
- **Building professionals are, or can get, on board with electrification and health initiatives.** Surveys of BayREN contractors and Assessors show that many are already incorporating these recommendations into their work. Others feel that they could make the transition with additional rebates, owner education, or market development to bring the costs down for electric equipment.

Appendix A: Policy Case Studies

Code Compliance Policies

City of Davis Resale Program

Summary: The Resale Program was implemented in 1976 to maintain the quality of housing stock in Davis and to ensure that residential units meet minimum building codes and health, fire, and life-safety regulations.

No later than fifteen working days prior to close of escrow transfer of title or change in ownership or end of any inspection period stipulated by the agreement of sale of any unit, the owner, or his/her authorized representative shall submit a completed resale application and applicable fees to the Building Division Office. An inspection date and time will be scheduled upon receipt of the completed application and applicable fees. A written report is issued within five working days of completed inspection and/or all necessary information has been received.

The Resale Report shall remain valid until either the report is validated or 18 months from the inspection date. If there is a sale within those 18 months, one of two things must happen prior to close of sale. Either the seller completes all work necessary and obtains the validated Certificate, or the buyer agrees to complete the Report and obtain the validated Certificate within 90 days of close of escrow. Prior to close of sale, the seller must provide the buyer with a copy of both the Report and this brochure. Prior to close of sale or no later than five working days after the close, a copy of Page 1 of the Report that has been signed by the buyer must be submitted to the Building Division office. If there is no sale within those 18 months, one of two things must happen. Either the seller chooses to not complete all Report items and the Report will automatically be voided (Seller must reapply for another inspection prior to any future sale) or the seller completes the process and obtains the validated Resale Certificate. The validated Resale Certificate is valid for 18 months from last resale inspection date or until the property is altered without a permit for which a permit is required.

- **Goals:** Ensure that residential units meet minimum building codes and health, fire, and life-safety regulations
- **Metrics:** Prescriptive checklist of code compliance items
- **Applicable to:** Residential properties, hotels, and motels
- **Trigger event:** Transfer of title or change in home ownership
- **Time to compliance:** Prior to close of sale
- **Compliance pathways:**
 - Building owner to submit a completed resale application and applicable fees to the Building Division Office, schedule an inspection, and obtain a Resale Report. Then complete all work necessary and obtain the validated Certificate prior to close of sale.
 - Properties with four or more residential units are subject to the Resale Self-Certification process.
- **Effective Date:** 1976

- **Results:** 500-700 resale inspections per year out of 16,193 eligible housing units (3.1-4.3 percent annual market penetration); since 2014, only 5 percent of resale inspections have found unpermitted HVAC installations.
- **Sources:**
 - <https://www.cityofdavis.org/city-hall/community-development-and-sustainability/building/resale-program>
 - <https://efiling.energy.ca.gov/GetDocument.aspx?tn=224431&DocumentContentId=54708>

City of Minneapolis Truth in Sale of Housing (TISH)

Summary: Minneapolis, Saint Paul, and nine smaller cities in the Twin Cities metro area require homes to be inspected by a licensed evaluator before they are offered for sale. Saint Paul's program is a disclosure-only evaluation, whereas Minneapolis and most other cities have a list of items that would need repair if deemed unsafe. Approximately 5,000 homes per year are sold in Minneapolis, with seller-paid home inspections required prior to the home going on the market. The resulting TISH report is available to all prospective homebuyers.

- **Goals:** Ensure that residential units meet minimum building codes and health, fire, and life-safety regulations
- **Metrics:** Prescriptive checklist of code compliance items
- **Applicable to:** Time of sale disclosure affects one- and two- unit properties that are available for sale in the City of Minneapolis. Not applicable to:
 - Any newly constructed dwelling when title is transferred to the first owner.
 - The sale or transfer of title of any dwelling to a public body
 - The sale or transfer of title of any dwelling for the purpose of demolition
 - The sale or conveyance of any dwelling by sheriff or other public or court officer in the performance of their official duties
- **Trigger event:** Time of sale
- **Time to compliance:** Disclosure report must be provided to prospective buyers at least three days before the end of the “option period,” or the period in which a potential buyer can cancel their contract to purchase the house.
- **Compliance pathways:** TISH reports are valid for two years or one sale
- **Penalties:** Noncompliance is a misdemeanor enforceable by mandamus, injunction, or other appropriate remedy
- **Sources:**
 - <http://www.minneapolismn.gov/ccs/WCMSP-207401>
 - http://www.minneapolismn.gov/ccs/ccs_sequencetxt
 - <http://structuretech1.com/truth-in-housing-evaluations/>
 - https://library.municode.com/mn/minneapolis/codes/code_of_ordinances?nodid=CO_OR_TIT12HO_CH248TRSAHO

Building Energy Benchmarking, Labeling, and Disclosure Policies

Berkeley Energy Saving Ordinance (BESO) Time of Sale

Summary: BESO requires building owners and homeowners to complete and publicly report comprehensive energy assessments to uncover energy saving opportunities. The assessments are conducted by registered energy assessors who provide tailored recommendations on how to save

energy and link building owners to incentive programs for energy efficiency upgrades. Energy efficiency improvements are voluntary and encouraged. While the BESO applies to all existing buildings, the information below is specific to single family residential, since that is the focus of this paper.

- **Goals:** The purpose of this ordinance is to reduce energy and water consumption in existing buildings. These efficiency improvements will lower energy and water costs and GHG emissions citywide and increase comfort, safety, and health for building occupants. The provisions of the ordinance will inform decision makers about energy performance and improvement opportunities. This ordinance is a key implementation action of the City’s Climate Action Plan.
- **Metrics:** Home Energy Scores
- **Applicable to:** All single family homes that are offered for sale
- **Trigger event:** Prior to sale
- **Time to compliance:** Assessments may be deferred to buyer for up to 12 months, at time of sale
- **Compliance pathways:**
 - Submit Energy Assessment
 - Deferral for New or Planned Construction - Time of Sale reporting requirements may be deferred for up to ten years for new construction, and up to 24 months for a planned "extensive renovation" or demolition. A project qualifies as an "extensive renovation" if it includes replacement of all energy-related equipment and at least half of the building envelope.
 - Apply for Exemption, based on one of the following:
 - High performance buildings with high scores or upgrades;
 - Buildings with low energy use as demonstrated by utility bill reporting;
 - Financial hardship including owners participating in energy assistance and/or property tax assistance programs; and
 - Time of sale, to allow buyers to accept responsibility for conducting assessment within 12 months of purchase
- **Effective Date:** December 1, 2015
- **Penalties:** Fines of \$100 for each violation and additional fine up to \$25 per day for each day that the violation continues, up to a maximum of \$1,000 per violation
- **Sources:**
 - <https://www.cityofberkeley.info/BESO/>

Minneapolis Truth in Sale of Housing (TISH) Energy Disclosure Report

Summary: On February 15th, 2019, the Minneapolis City Council approved three policies to enhance residential energy awareness: multi-family benchmarking, time of rent energy disclosure, and time of sale energy disclosure.

Time of sale energy disclosure report will be incorporated into the Truth in Sale of Housing (TISH) process. No upgrades are required. The energy disclosure report will include an energy asset rating that is grounded in cost effective improvements specific to the Minneapolis housing stock. Time-of-Rent Energy Disclosure requires rental property owners to disclose energy use at time of rent.

- **Goals:** Time of sale energy disclosure reports provide homeowners and prospective buyers with the general energy performance of a home

- **Metrics:** Energy score of 0-100 based on attic insulation, wall insulation, windows, and heating system
- **Applicable to:** Time of sale disclosure affects 1 -2 unit properties that are available for sale in the City of Minneapolis. Not applicable to
 - Any newly constructed dwelling when title is transferred to the first owner.
 - The sale or transfer of title of any dwelling to a public body
 - The sale or transfer of title of any dwelling for the purpose of demolition
 - The sale or conveyance of any dwelling by sheriff or other public or court officer in the performance of their official duties
- **Trigger event:** Time of sale, which already triggers a Truth in Sale of Housing (TISH) requirement
- **Time to compliance:** Disclosure report must be provided to prospective buyers at least three days before the end of the “option period,” or the period in which a potential buyer can cancel their contract to purchase the house (i.e., close of escrow)
- **Compliance pathways:** TISH reports are valid for two years or one sale
- **Effective Date:** Time of sale energy disclosure requirement effective as of January 15, 2020
- **Penalties:** Noncompliance is a misdemeanor enforceable by mandamus, injunction, or other appropriate remedy
- **Sources:**
 - <http://www.minneapolismn.gov/sustainability/buildings-energy/index.htm>
 - <https://lims.minneapolismn.gov/File/2018-01331>
 - https://www.mncee.org/MNCEE/media/PDFs/Mpls-Residential-EE-Disclosure_White-Paper_20180912.pdf

Chicago Energy Cost Disclosure

Summary: In July 2013, the City of Chicago became the first municipality in the country to disclose residential energy costs (gas and electric) when a home was listed for sale via a multiple listing service (MLS). The achievement was the result of a unique partnership between Midwest Real Estate Data (MRED), the MLS serving Chicago; City of Chicago Office of the Mayor; and Elevate Energy. When a home is listed for sale in Chicago, Realtors can access an energy cost disclosure report for a property in near real-time, which they in turn are required to provide to home purchasers pursuant to City of Chicago ordinance.

The Chicago Municipal Code requires that a building or dwelling unit owner must provide a disclosure to prospective tenants whether they will be responsible directly to the utility company for paying the cost of gas or electric heat for that building or unit. The property owner / landlord must also provide in writing the annual cost of heating based on the previous 12 months.

In addition, at the time any residential dwelling unit or building is offered for sale, the owners / agents must provide information as to the gas or electric cost for heating that unit or building for the previous 12 months. The owner or agent must also inform the prospective purchaser whether the dwelling unit or building was occupied during the previous 12 months, and if so, for what portion of the time.

- **Goals:** Consumer protection
- **Metrics:** Compliance rates
- **Applicable to:** All residential units in which occupant pays utility bills
- **Trigger event:** Time of lease and time of sale

- **Time to compliance:** Prior to lease or sale
- **Compliance pathways:** Disclose prior 12 months of electricity and gas costs
- **Effective Date:** July 2013
- **Penalties:** \$500 fine
- **Results:** compliance was 13 percent over first 18 months. Compliant homes sold at a higher percentage of their original list price (97.2 percent of list price) than non-compliant homes (95.9 percent of list price); compliant homes were on the market for 69 days compared to 93 days for non-compliant homes
- **Sources:**
 - https://www.chicago.gov/city/en/depts/bacp/supp_info/energy_disclosureapplication.html
 - [http://library.amlegal.com/nxt/gateway.dll/Illinois/chicago_il/municipalcodeofchicago?f=templates\\$fn=default.htm\\$3.0\\$vid=amlegal:chicago_il](http://library.amlegal.com/nxt/gateway.dll/Illinois/chicago_il/municipalcodeofchicago?f=templates$fn=default.htm$3.0$vid=amlegal:chicago_il)
 - <https://www.elevateenergy.org/chicago-energy-cost-disclosure-homes/>
 - <https://www.elevateenergy.org/wp/wp-content/uploads/Moving-the-Market -Energy-Cost-Disclosure-in-Residential-Real-Estate-Listings.pdf>

City of Austin Energy Conservation Audit and Disclosure (ECAD) Ordinance

Summary: The ECAD ordinance requires energy audits and disclosures for all homes and buildings which are served by Austin Energy and located within Austin city limits. ECAD promotes energy efficiency by identifying potential energy savings in homes, businesses, and multifamily properties.

- **Goals:** Contribute to City’s Climate Action Plan goals, including (a) Attain energy efficiency savings equal to at least 1,200 MW annually through energy efficiency and demand response initiatives; and (b) Achieve 100 percent carbon-free electricity generation by 2035.
- **Metrics:** Compliance rates, conversion rate from audits to retrofits
- **Applicable to:** All residential units more than 10 years old with the City of Austin city limits and served by Austin Energy
- **Trigger event:** Time of sale
- **Time to compliance:** Prior to sale
- **Compliance pathways:**
 - Seller must obtain an energy audit by a qualified ECAD energy professional and disclose the results to potential buyers.
 - Alternatively, buyer can agree in writing to participate in an Austin Energy Free Weatherization Program or an equivalent Austin Electric Utility program, not later than six months after the time of sale
 - Sellers may apply for a variance from ECAD reporting requirements if the buyer plans to make major changes to a property, including demolition or major remodeling
 - ECAD does not require any improvements
- **Effective Date:** May 2, 2011
- **Penalties:** \$500 fine
- **Other Provisions:**
 - Does not apply to properties sold through foreclosure, eminent domain, probate court, inter-family transfers, divorce settlements

- Does not apply to mobile homes, homes less than 10 years old, or homes that have had qualifying energy improvements within the last 10 years through Austin Energy’s Home Performance with Energy Star or Weatherization Programs
- **Results:** The city does not actively enforce the ordinance, except by complaint. Compliance is estimated at about 52 percent for homes, and 80 percent for multifamily residences. It is estimated the ordinance could affect about 3,000 homes annually going forward. Austin Energy tracked the actual rates of homeowners that completed the recommended upgrades in the first year at 12 percent and for the second year at 7 percent.
- **Sources:**
 - <https://austinenergy.com/ae/energy-efficiency/ecad-ordinance/energy-conservation-audit-and-disclosure-ordinance>

Building Performance Standards

Boulder SmartRegs

Summary: SmartRegs requires all licensed rental housing in the City of Boulder to meet a basic energy efficiency standard. The City of Boulder requires that a rental license be approved for a property before it can be used as a rental. A property cannot be advertised as a rental in any manner until the license is issued. Approval depends on the results of required inspections that determine whether a property complies with standards for health/safety, mechanical systems, and energy efficiency. SmartRegs is the energy efficiency component of the inspection and approval process.

- **Goals:** All rental properties in City of Boulder earn a HERS score of 120 or lower. City has achieved 96.2 percent compliance.
- **Metrics:** HERS index
- **Applicable to:** All rental housing units within the City of Boulder, with limited exceptions applicable to buildings achieving equivalent energy efficiency performance, historic buildings, affordable housing, and buildings where energy efficiency upgrades are technically impractical.
- **Trigger event:** Rental license application
- **Time to compliance:** Rental owners had eight years to comply with SmartRegs with the deadline on December 31, 2018
- **Compliance pathways:**
 - **Performance Path** requires a Home Energy Rating System (HERS) score of 120 or lower.
 - **Prescriptive Path** involves a checklist designed as an alternative to the SmartRegs performance path. Each unit must achieve 100 checklist points or more in addition to two mandatory points in the water conservation category.
- **Effective Date:** Adopted by Boulder City Council on September 21, 2010
- **Penalties:** Units no longer eligible to rent
- **Results:** As of December 2017, 100 percent of rentals were inspected, and 86 percent were deemed compliant. Since program inception, 4,603 energy upgrades and 27,951 quick installs have been completed through the City of Boulder’s EnergySmart program. The average cost of upgrades to reach compliance is less than \$3,000 per residential property. City of Boulder’s rental properties are expected to save 4,200,000 kWh and 940,000 therms annually, leading to \$1,100,000 in energy bill savings and 8,300 metric tons of avoided carbon emissions after full compliance by the end of 2018.

- **Sources:**

- <https://bouldercolorado.gov/plan-develop/smartregs>
- <https://www-static.bouldercolorado.gov/docs/PDS/forms/rental-license-smartregs-handbook.pdf>
- http://rmi.org/wp-content/uploads/2018/05/Better-Rentals-Better-City_Final3.pdf
- See also Rocky Mountain Institute's Efficiency Standards for Rentals Action Guide: <https://rmi.org/rental-toolkit/prepare/identify-local-context/>

Appendix B: Documentation of Data Sources and Analysis Methods for GHG and Consumption/Efficiency Savings

Data Sources and Input Assumptions

- **Energy consumption data.** 2017 monthly average gas and electric consumption by zip code was accessed via the [PG&E Energy Data Request Program](#). Data was obtained for all zip codes in the nine-county San Francisco Bay Area. A customer-weighted average was calculated to represent a typical customer annual load profile, as illustrated in Figure 1.
- **Energy Efficiency Installation costs.** Installation costs for building shell energy efficiency improvements were set at \$6,080, based on unpublished analysis by a former Home Upgrade Program contractor (Bruce Severance, personal communication). Note that these costs are higher than the IOU workpaper value of \$3,262.
- **Electrification Installation costs.** Installation costs for gas furnaces, gas domestic hot water (DHW), heat pumps, and heat pump water heaters (HPWH) were adapted from Excel documentation for pre-1978 single-family homes published by E3 in support of its 2019 white paper *Residential Building Electrification in California*. Cost estimates do not include service panel upgrades. Installation cost values used were as follows:
 - Gas furnace: \$8,396
 - Gas DHW: \$2,049
 - Electric heat pump: \$13,423
 - Electric HPWH: \$3,689
- **Avoided Utility Costs.** Avoided cost parameters were derived from the [2020 electric and gas avoided cost calculators, version 1c](#). PG&E avoided costs for gas and electric service in climate zone 3 were used as inputs. The electric value was calculated as the simple average of Hourly Average Levelized Value of Electricity across 8,760 hourly periods. The gas value was calculated as the average across 12 months. The calculated average avoided cost is estimated as \$1.86 per Therm and \$0.08516 per kWh.
- **kWh price:** \$0.24, [PG&E E1 baseline usage price](#)
- **Therm price:** \$1.37, [PG&E G1 baseline usage price](#)
- **Electricity emissions factor:** 0.093439952 Mt CO₂e / MWh, from [PG&E 2019 Corporate Responsibility Report](#). Results were also modeled with a value of zero, representing 100 percent emissions-free electricity.
- **Gas emissions factor:** 0.0053 Mt CO₂e / Therm
- **Gas DHW baseline efficiency:** 0.59 EF, National standard until 2015, when standard was increased to 0.62
- **Gas furnace baseline efficiency:** 0.78 AFUE, National standard until 2006, when standard was increased to 0.8
- **Heat Pump space heating efficiency:** 3.2 COP, consistent with E3 Pathways model
- **Heat Pump Water Heater efficiency:** 3.5 COP, Conservative lower bound for HPWH efficiencies for multiple manufacturers and models, consistent with E3 Residential Electrification report
- **Hot water share of gas baseline consumption:** 0.82, from CEC IEPR report p. 18

- **Effective useful life (EUL):** All measures modeled with EULs of 20 years except DHW, which was modeled as 13 years.

Analysis Methods

As a first step in the quantitative analysis, baseline gas consumption was disaggregated into space heating, water heating, and other loads. Monthly gas consumption for the three lowest months—June, July, and August—was treated as the baseload. The three month average for those months was 18.5 Therms. All gas consumption exceeding this baseload in the other months was considered space heating. The baseload was further disaggregated by applying the “hot water share of gas baseline consumption” percentage (82 percent). The remaining 18 percent of baseload was classified as “Other”. On an annualized basis, water heating accounted for 182 Therms, space heating for 219 Therms, and Other for 40 Therms, for a total of 441 annual Therms.

- **Annual change in Therms**
 - **Electrify Domestic Hot Water (DHW):** zero out the DHW portion of the gas consumption profile
 - **Electrify Space Heating:** zero out the space heating portion of the gas consumption profile
 - **Building Envelope Energy Efficiency (EE):** reduce the space heating portion of the gas consumption profile by 50 percent
 - **Electrify DHW + Space Heating + EE:** sum the results from the three single-measure scenarios described above.
- **Annual change in kWh**
 - **Electrify Domestic Hot Water (DHW):** Convert gas DHW load to electric HPWH load and add it to the baseline electricity consumption. Load conversion formula is
 - $HPWH \text{ (kWh)} = (\text{Gas DHW (Therms)} * \text{Gas DHW baseline efficiency} * 29.3 \text{ kWh / Therm}) / \text{HPWH efficiency}$
 - **Electrify Space Heating:** Convert gas space heating load to electric heat pump load and add it to the baseline electricity consumption. Load conversion formula is
 - $HP \text{ (kWh)} = (\text{Gas Furnace (Therms)} * \text{Gas furnace baseline efficiency} * 29.3 \text{ kWh / Therm}) / \text{Heat pump space heating efficiency}$
 - **Building Envelope EE:** No impact in the absence of summer cooling loads
 - **Electrify DHW + Space Heating + EE:** sum the results from the three single-measure scenarios described above.
- **Gas avoided costs (lifecycle):** Product of annual gas savings, EUL, and Gas Avoided Utility Cost
- **Electric avoided costs (lifecycle):** Product of annual electricity savings (negative value for increased load), EUL, and Electric Avoided Utility Cost
- **Incremental Measure Cost (IMC):** For heat pumps, the incremental cost relative to the cost of installing a furnace; for HPWH, the incremental cost relative to the cost of installing a gas DHW; for EE and PV, incremental cost equals full installation cost (i.e., baseline costs are zero)
- **Annual GHG reductions, MTCO_{2e}:** Sum of annual change in kWh and Therms, each multiplied by its respective emissions factor
- **Lifecycle GHG reductions, MTCO_{2e}:** Annual GHG reductions multiplied by the EUL
- **Customer Savings-to-Investment Ratio (SIR)**

- **Customer SIR (IMC):** Lifecycle utility bill savings (i.e., annual savings x EUL), divided by full installation cost
- **Customer SIR, net of avoided costs:** Lifecycle utility bill savings divided by the difference between full installation cost and total utility avoided costs
- **Net cost @ early replacement / lifecycle MTCO_{2e}:** Installed costs minus avoided costs and minus lifetime operating savings, divided by lifecycle GHG reductions
- **Net cost @ Replace-on-Burnout (ROB) / lifecycle MTCO_{2e}:** Incremental measure cost minus avoided costs and minus lifetime operating savings, divided by lifecycle GHG reductions

Appendix C: Contractor and Assessor Survey Questions

Introduction

BayREN is working on a paper on how the Home+ and Home Energy Score programs can support the State's goals of doubling energy efficiency in existing buildings by 2030. In addition to appliance upgrades and building envelope measures, BayREN aims to help the State achieve its goals through electrification/decarbonization of buildings and making the connection between energy improvements and health. These efforts cannot be successful without the Contractors and Assessors.

To better understand the current workflows and identify additional support BayREN can provide during this transition, please respond to this short survey. Survey respondents who provide their email addresses will be entered into a lottery to win one of 10 Amazon gift cards worth \$50 each. If you have any questions, please contact ealvarez@stopwaste.org. Thank you!

* 1. What is your affiliation with BayREN?

- Home+ Contractor
- Home Energy Score Assessor
- Other (please specify)

* 2. How long have you been involved in BayREN programs?

- Less than 1 year
- 1-5 years
- Greater than 5 years

* 3. How many employees does your company have?

- 1 (self-employed)
- 2-10
- 11-50
- More than 50

* 4. Which of the following energy efficiency upgrades do you provides? Select all that apply.

- | | |
|--|--|
| <input type="checkbox"/> Energy audits/assessments | <input type="checkbox"/> Envelope improvements (e.g. insulation, air sealing, windows) |
| <input type="checkbox"/> HVAC upgrades | <input type="checkbox"/> General contractor |
| <input type="checkbox"/> Hot water heater upgrades | <input type="checkbox"/> Title 24 testing |
| <input type="checkbox"/> Electrical upgrades | <input type="checkbox"/> Indoor air quality/healthy home improvements |
| <input type="checkbox"/> Other (please specify) | |

* 5. Are you currently providing customers with any of the following options for switching gas appliances to electric options?

- | | |
|---|---|
| <input type="checkbox"/> Gas furnace to heat pump space heating | <input type="checkbox"/> Gas dryer to heat pump dryer |
| <input type="checkbox"/> Gas hot water heater to heat pump water heater | <input type="checkbox"/> No, I do not provide any electrification recommendations |
| <input type="checkbox"/> Gas stove to induction stove/cooktop | |
| <input type="checkbox"/> Other (please specify) | |

Electrification Recommendations

Please answer the following questions about when and how you make recommendations for electrification.

* 6. Do you always provide electrification recommendations?

- I provide electrification recommendations to every customer
- Only when the home is a good fit for electrification
- Only when the homeowner requests electrification options
- Other (please specify)

* 7. How do you determine if a home is a good fit for electrification? Select all that apply.

- | | |
|---|--|
| <input type="checkbox"/> Any home that has natural gas appliances is a good fit | <input type="checkbox"/> Homeowner would like to add air conditioning |
| <input type="checkbox"/> Home has room on existing electrical panel | <input type="checkbox"/> Homeowner has requested information or is interested in electrification |
| <input type="checkbox"/> Examine location of hot water heater | <input type="checkbox"/> Home has solar |
| <input type="checkbox"/> Age of appliances | |
| <input type="checkbox"/> Other (please specify) | |

* 8. What do you think are the top 3 most significant barriers to electrification?

- | | |
|---|--|
| <input type="checkbox"/> Cost to homeowner | <input type="checkbox"/> Homeowner preferences for natural gas |
| <input type="checkbox"/> Cost of equipment | <input type="checkbox"/> Blackouts and power safety shut off events |
| <input type="checkbox"/> Availability of equipment | <input type="checkbox"/> Electrical upgrades (i.e. service panel, outdated wiring) |
| <input type="checkbox"/> Knowledge of technology and installation | |
| <input type="checkbox"/> Other (please specify) | |

Barriers to Electrification Recommendations

Please answer the following questions on barriers to making electrification recommendations or your motivations for choosing not to make such recommendations.

* 9. Why do you not currently make electrification recommendations? Select all that apply.

- | | |
|---|---|
| <input type="checkbox"/> I am unfamiliar with the technology and requirements | <input type="checkbox"/> Electric/heat pump equipment is not readily available |
| <input type="checkbox"/> I believe natural gas appliances are superior to electric/heat pump versions | <input type="checkbox"/> It requires me to bring another tradesperson onto the job site (i.e. electrician or plumber) |
| <input type="checkbox"/> Customers do not want to switch fuel sources | <input type="checkbox"/> Concerns over blackouts and power safety shutoff events |
| <input type="checkbox"/> Electrification options are expensive | |
| <input type="checkbox"/> Other (please specify) | |

BayREN Electrification Support

Please let us know how BayREN can help overcome barriers and assist you in making electrification recommendations.

* 10. Would the following impact your ability/desire to make electrification recommendations?

	No impact on recommendations	May increase electrification recommendations	Critical to make electrification recommendations
Workforce training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Better availability of technology/products	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increased demand from customers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
City mandates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contractor rebates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Homeowner rebates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. Is there anything else BayREN can do to support your business to make electrification recommendations?

Healthy Homes Recommendations

BayREN programs also have a goal to improve indoor air quality of homes. This can lead to positive health outcomes, such as reduced instances of severe asthma attacks. Please answer the following questions regarding your familiarity and current work in regards to healthy homes.

* 12. Does your company incorporate recommendations related to healthy homes into your work?

- Yes, I always talk about health impacts
- Yes, but only if I am asked by a customer
- Yes, but only if there are obvious health issues in the home
- Other (please specify)
- No, because it is not typically part of the scope of my work
- No, because I do not feel like I have sufficient information or qualifications to make such recommendations

* 13. Approximately in what percent of projects do you see homes with severe health and safety-related issues (e.g. mold/moisture, pests, building envelope issues such as broken windows)?

- Less than 25%
- 25-50%
- 50-75%
- 75-100%
- Other (please specify)

* 14. What is your approach if you encounter severe health and safety issues?

- Incorporate remediation/correction of issues into the scope of energy upgrade job (improvements are made by your company)
- Refer out to other contractors/trades who can make the necessary upgrades (improvements are made by another company)
- I continue with the energy efficiency upgrades and do not address other issues
- I do not take the job or will not make improvements until other issues are addressed first
- Other (please specify)

* 15. Would any of the following support mechanisms from BayREN help your business make recommendations related to healthy homes?

- Training and/or health certifications
- Additional rebates for health-related upgrades
- Talking points for homeowners on health benefits of energy upgrades
- Referrals or resources for homeowners who have serious health and safety-related home issues (i.e. public health departments, specialty contractors)
- Other (please specify)

Additional Comments and Submit

Thank you for taking this survey. This will help BayREN better understand the state of our industry and how we can better support our workforce.

16. Is there anything else you would like BayREN to know about your business' approach to making energy upgrade recommendations or how BayREN can provide more support?

*** 17. Would you be willing to answer additional questions related to this survey with a BayREN staff member?**

Yes

No

If yes, please provide your name, company name, and the best phone number to contact you.

18. Please provide your email address if you wish to be entered into the lottery to win one of 10 Amazon gift cards worth \$50 each.