CITY AND COUNTY OF SAN FRANCISCO
BOARD OF SUPERVISORS
BUDGET AND LEGISLATIVE ANALYST
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Policy Analysis Report

To: Supervisor Gordon Mar
From: Budget and Legislative Analyst's Office
Re: Decarbonizing Residential Buildings by Eliminating Natural Gas Usage
Date: April 22, 2021

SUMMARY OF REQUESTED ACTION

Your office requested that the Budget and Legislative Analyst gather information to inform potential policies to reduce or eliminate the use of natural case appliances and to provide financial or other incentives to homeowners for the purchase and use of electric appliances.

For further information about this report, contact Fred Brousseau, Director of Policy Analysis at the Budget and Legislative Analyst's Office.

Executive Summary

- In response to global climate change, the City and County of San Francisco has established a goal of achieving net-zero greenhouse gas emissions by 2050. Furthermore, California state law mandates a 40 percent reduction in greenhouse gas emissions by 2030, as well as a carbon-neutral economy by 2045.
- Natural gas combustion in buildings currently accounts for approximately 38 percent of San Francisco's greenhouse gas emissions according to the San Francisco Department of the Environment. For residential buildings, this is largely due to gas-fueled appliances including water heaters, furnaces, ovens and cooktops, and laundry appliances.
- San Francisco's greenhouse gas emissions could be significantly reduced by replacing residential gas-fueled appliances with those that are electricity-fueled. This could be accomplished by compelling all property owners by legal mandate to replace all gas appliances with electric at their expense. Rebates and low interest loans could be used as tools to make mandated retrofits less financially burdensome to property owners. Partial or full City funding of these costs is another approach that could be used.
- A key barrier to electrical retrofits of San Francisco residences, whichever approach is used, is that they would place a financial burden on property owners and/or the City and County of San Francisco to the extent the City chooses to subsidize or fund such retrofits to reduce greenhouse gas emissions. The primary variables in considering the options for a residential electrification initiative are:

1. Cost,
2. Who would incur the cost, and
3. The speed with which policy makers want a significant reduction in greenhouse gas emissions to occur.

- Estimated costs of electrical appliance retrofitting of residences range from $14,363 per housing unit (both multi-family and single-family units) at the low end up to $19,574 for multi-family units and $34,790 for single family homes at the higher end.
- Applying these cost estimates to an estimated 240,231 housing units that use natural gas for some or all of their appliances in San Francisco (76,470 single family homes and 163,761 multi-family), the Citywide cost to retrofit all residential units currently using natural gas-fueled appliances with those fueled by electricity ranges from $3.5 to $5.9 billion. We note that the City's building stock is not homogenous, and the cost estimates in our report are intended to demonstrate an average range of costs.

  Exhibit A presents the low- and high-cost scenarios for electrifying the estimated 240,231 San Francisco housing units that are presently heated by natural gas.

Exhibit A: Total Low- and High- Cost Scenarios for Replacing Natural Gas-fueled Appliances in San Francisco's Housing Units with Electricity- Fueled Appliances

	Low Cost		High Cost	
	Single family	**Multi-family**	**Single family**	**Multi-family**
Cost/housing unit	$14,363	$14,363	$34,790	$19,574
# Housing Units	76,470	163,761	76,470	163,761
Subtotal	$1.098 Billion	$2.352 Billion	$2.660 Billion	$3.205 Billion
Grand Total: all housing	**$3.450 Billion**		**$5.866 Billion**	

- If one or more of the following approaches to residential appliance electrification were mandated by the Board of Supervisors, the financial burden on property owners and any City funding allocated to an electrical appliance retrofitting endeavor could be reduced. However, while each of these approaches would help reduce San Francisco's greenhouse gas emissions, their impact would take decades to achieve. The approaches are:
  - Requiring electric appliances only for all newly constructed residences' appliances,
  - Requiring electric appliance retrofitting for all residences at the time of sale,
  - Mandating electrical retrofitting of gas-fueled appliances at the time of natural replacement (when the appliances need to be replaced),

- Providing incentives to retrofit appliances by charging property owners a fee for greenhouse gases emitted by their property, similar to a program being implemented by New York City for buildings greater than 25,000 square feet,

- As an example of reducing the costs of mandated retrofitting of all residences at one time, the option above of requiring the replacement of natural gas-fueled appliances with electricity-fueled, but at the time of natural replacement only, could be adopted by the City. This would reduce the costs to just the difference between the cost of new electricity-fueled appliances vs. gas-fueled, or approximately $2,674 to $12,084 for single family homes and $2,674 to $7,073 per multi-family unit, with the difference in costs incurred by the property owner who would have paid for replacement anyway. This would result in total additional costs ranging from approximately $642 million to approximately $2 billion. While less costly, this approach would take decades since appliances such as gas furnaces can last 20-30 years or more before they need replacement.

- In addition to the cost of retrofitting, the unit cost of electricity is currently higher than the unit cost of natural gas, potentially placing an additional cost burden on property owners who retrofit. While electric appliances tend to be more energy efficient than gas appliances, at present the total annual energy cost tends to be greater for electric appliances than for gas appliances due to higher unit costs for electricity compared to natural gas.

- While natural gas prices are currently lower than electricity, an analysis prepared for the California Energy Commission has shown that the relative difference in costs between the two energy sources will lessen in future years and may even reverse the current pattern of electricity costing more than natural gas. The analysis forecasts that natural gas costs could increase by between 127 and 1,339 percent by 2050 whereas electricity costs are forecast to increase by only 20-40 percent.

- Under the low-end estimate for future natural gas prices, a mixed-fuel home would have lower annual energy costs of approximately $170 in 2050 compared to an all-electric home, assuming no changes in appliance energy efficiency. However, under the high-end estimate for future natural gas and electricity prices, a mixed-fuel home would incur approximately $7,100 more in annual energy costs than an all-electric home. Ongoing energy cost savings would be realized after retrofitting once natural gas prices exceed $3 per therm, up from the current $1.209 per therm.

- The extent of the reversal in relative costs between these two energy sources in coming years will be a function of increased electricity consumption in California as a result of greater building electrification and greater use of heat pumps instead of gas-fueled furnaces and water heaters. This will drive up natural gas prices since the

high fixed costs of maintaining the natural gas delivery infrastructure would be paid by a shrinking number of customers.

- To expedite the residential electrification process and produce a greater reduction in greenhouse gas emissions in a shorter time, the City could choose to fund a retrofitting program, at least at its outset. Given the scale of the costs for complete Citywide residential electrification, issuing debt to pay for some or all of the initiative would provide a means of accomplishing the effort quickly without immediate financial burden on property owners, though property owners could be required to share in some portion of the costs over time, possibly on an income-based sliding scale. Some options to consider to help reduce the City's costs if it chooses to fund such an effort could include:

    - **Utility Users Tax** (UUT) The City's current UUT on energy consumption by commercial entities could be expanded to also cover residential utility use. This could generate an estimated $11.5 million per year based on the City's current 7.5 percent rate on commercial energy consumption and the level of residential energy consumption reported by PG&E.

    - **Building Emissions Limits** In 2019, the New York City Council approved limits on building emissions that take effect in 2024, with a range of limits based on type of building use and penalties for buildings that exceed their limit. Building emissions are calculated based on energy use, with different carbon dioxide equivalent estimates based on energy source. San Francisco could consider exploring this program, both as a way to incentivize building retrofits and to generate revenue for decarbonization initiatives.

    - **Rebates** Some utilities, cities, counties, states, and special districts offer rebates of varying amounts to homeowners who convert their gas appliances to electric. Among the more generous rebates we reviewed, the Sacramento Municipal Utility District (SMUD) offers homeowners rebates of up to $13,750 for converting their homes from gas to electric using set-aside ratepayer revenue. The City of San Jose offers grant-funded rebates of up to $6,000 for income-qualified residents and $4,500 for a limited number of other residents depending on available funding. The City and County of San Francisco could enter into discussions with PG&E and/or the California Public Utilities Commission (CPUC) to determine the feasibility of establishing a rate surcharge on San Francisco utility bills to provide funding for rebate programs of similar magnitude as SMUD's.

    - **State Cap-and-Trade funding (AB 1477)** State funding generated from AB 1477, a State law enacted in 2018, provides $50 million statewide in Cap-and-Trade funding per year through two pilot programs that promote

building decarbonization. The City could potentially become involved in the initiatives funded from this source, such as electrification incentives and rebate programs, and use them to enhance the City's residential electrification efforts.

- **BayREN** This utility ratepayer-funded program managed by the Association of Bay Area Governments (ABAG) awards funding to local governments for energy efficiency programs throughout the nine-county Bay Area. The amount of funding that might be available for San Francisco would be small relative to the cost of residential electrification based on funds distributed by this program to date.
- **Low-income weatherization program (LIWP)** This State program provides incentives for energy efficiency measures in low-income households and multi-family housing, with one of its programs specifically assisting with energy efficiency programs for low-income multi-family housing. It may be possible for the City to receive funding from LIWP for one or more building electrification pilot programs for low-income housing.
- **Low amperage appliances** The costs of residential electric appliance retrofitting could be reduced if property owners choose to install low amperage appliances and avoid the need for electric panel upgrading to accommodate new electric appliances. This would limit the appliances that could be installed but, according to at least one electrification consultant, could keep retrofitting costs to $15,000 rather than up to $34,790 for a single- family home.
- **Financing programs for property owners** Programs such as the Property Assessed Clean Energy (PACE) and SMUD's energy efficiency financing programs offer residential property owners a means of financing energy savings programs. Both programs offer reasonable interest rates and, in SMUD's case, several fees and closing costs are not charged. Such programs could be made available if the City chooses to require property owners to contribute to the costs of residential electrification.
- **Prequalifying vendors as a means of lowering residential electrification costs** If the City chooses to fund some or all of a residential electrification program to accelerate the resulting reduction in greenhouse gas emissions, it could pre-qualify contractors and appliance manufacturers as a means of lowering costs. Contractors and electric appliance manufacturers that would benefit from potentially thousands of building retrofits throughout the City should be willing to provide services and products at a negotiated discounted rate in exchange for the high volume of sales that would come

from appearing on a prequalified list. A 10-15 percent discount could reduce total Citywide residential electrification costs by hundreds of millions of dollars.

- **Noticing requirements** In anticipation of potential prohibition of natural gas-fueled appliances or mandated conversions, the Board of Supervisors could consider an ordinance requiring noticing property owners and developers in advance of a mandate being imposed. The notification requirement may discourage property owners from installing or investing in natural gas infrastructure to avoid wasting money, assuming they would eventually have to convert their infrastructure to all-electric.
- **"Pruning" the grid** A potential strategy for reducing natural gas usage is by retiring unneeded gas assets, known as "pruning" the grid. Electrification advocates suggest that instead of performing maintenance on a gas line, PG&E could redirect its planned expenditures on cutting off the line and contributing to electrification of buildings served by the line. Over time, the gas grid would be gradually reduced. PG&E representatives report that they are exploring this strategy, but that there are still unresolved logistical challenges.
- **Building Electrification Working Group** The Board of Supervisors could consider appointing a working group of experts and advocates to further explore these policy options and provide recommendations for building electrification programs.

Project staff: Reuben Holober, Fred Brousseau

Background

In response to global climate change, San Francisco has established a goal of achieving net-zero emissions by 2050. At the 2018 Global Climate Action Summit, Mayor Breed committed to decarbonization goals for buildings in San Francisco, including requiring all new buildings to have net-zero emissions by 2030 and all existing buildings to have net-zero emissions by 2050. Furthermore, California state law mandates a 40 percent reduction in greenhouse gas emissions below 1990 levels by 2030, as well as a carbon-neutral economy by 2045. AB 3232, approved in 2017, directed the California Energy Commission (CEC) to assess how to reduce greenhouse gas emissions from buildings by 40 percent below 1990 levels by 2030. Natural gas combustion in buildings currently accounts for approximately 38 percent of San Francisco's greenhouse gas emissions.[1]

Several California cities, including Berkeley, San Jose, Menlo Park, Palo Alto, Santa Monica, and San Francisco have adopted prohibitions against the use of natural gas infrastructure in new construction, to various extents. While ordinances like these will help prevent emission increases, achieving emission reduction targets will also require a significant percentage of the existing building stock to move from natural gas to renewable electric sources. In January 2020, the California Public Utilities Commission (CPUC) announced that they would examine how to "manage the state's transition away from natural gas-fueled technologies."

Social Cost of Carbon

One way to measure the economic impact of greenhouse gas emissions is the social cost of carbon. This measure attempts to estimate the marginal non-market impacts to the environment and human health for a one-ton increase in carbon dioxide emissions. Various studies have been conducted, with wide ranging estimates of the social cost of carbon. A 2019 meta-analysis study by Pei Wang et al, published in the Journal of Cleaner Production, reviewed 578 estimates from 58 studies and found a range from -$13.36 to $2,386.91 per ton of carbon dioxide, with a mean value of $54.70 per ton. Using a discount rate of 3%, the mean value is $30.78 per ton of carbon dioxide.[2] In February 2021, the Biden Administration increased the Environmental Protection Agency's (EPA) social cost of carbon to $51 per ton, which is similar to the mean value of $54.70 per ton in the Pei Wang study. The EPA's amount may increase again in January 2022 following further analysis.[3]

[1] Source: San Francisco Department of Environment
[2] Discount rates attempt to estimate the relative value today compared with the same value in the future.
[3] Source: Scientific American, "Cost of Carbon Pollution Pegged at $51 a Ton"

While this Budget and Legislative Analyst report is not a cost-benefit analysis and does not estimate the carbon emission reductions associated with various decarbonization options, the social cost of carbon may be a useful framework for analyzing the effectiveness and efficiency of future policy proposals.

Barriers to Residential Electric Appliance Use

Capital Costs

Retrofitting from Gas to Electric Appliances

A key barrier to retrofitting San Francisco residences from natural gas to electric appliances to reduce greenhouse gas emissions is that affected residential property owners would incur substantial costs from disposal of old appliances, purchase of new appliances, labor, and electrical panel upgrades. We have reviewed two sets of estimates of the costs of retrofitting residential units from gas to electric appliances. These two sets of estimates provide a range of costs, with one set higher than the other. In both cases, the estimated costs would represent a substantial cost for many property owners. The studies do not account for the potential need to insulate buildings to improve energy efficiency for heat pump HVAC systems.[4] We also note that there is a wide variety of building types and many factors that impact potential construction costs. The estimates shown below are intended to demonstrate an average range of costs.

Through a review of literature and analyses on the topic, we have identified two credible sets of estimates that provide a range of average costs of converting residential units from natural gas-fueled to electricity-fueled appliances. These estimates range from $19,034 to $34,790 for a single-family house and $18,762 to $19,574 for a multi-family unit, assuming that electrical panel upgrades would be needed in all cases to allow for sufficient electricity to support all appliances in a household. For properties where panel upgrades are not needed, these costs would be lower, as detailed below. Both estimates show that the costs for all electricity-fueled appliances in households compare unfavorably with natural gas-fueled appliances, at least with current pricing differences between the two sources of energy. We also note that the electric HVAC and water heater cost estimates use heat pump appliances. There are other types of electric space and water heaters that may be cheaper to purchase but are less energy efficient than heat pumps.

[4] Investments in building insulation could allow homeowners to install smaller, and less expensive, heat pump HVAC systems.

According to higher cost estimates prepared by Energy and Environmental Economics, Inc. (E3) in a study commissioned by Southern California Edison, Sacramento Municipal Utility District, and the Los Angeles Department of Water and Power, San Francisco property owners can expect to pay approximately $34,790 to retrofit a pre-1978 single-family house with electric appliances. In a multi-family building with four units (the median number of units in multi-family buildings in San Francisco), homeowners would pay approximately $19,574 per unit, assuming that each unit has its own HVAC system, water heater, and dryer. The costs of replacing old gas appliances with new gas appliances would be less, approximately $22,706 for a single-family house and approximately $13,052 per unit for a four-unit building. The breakdown of costs is shown in Exhibit 1 below.

Exhibit 1: Higher Cost Scenario to Retrofit Gas Appliances to Electric and Replace with New Gas Appliances

	Single-Family House, Pre-1978, Electric Retrofit	Single-Family House, Pre-1978, Gas Replacement	Four-Unit Building, Pre-1978, Electric Retrofit (Per Unit)	Four-Unit Building, Pre-1978, Gas Replacement (Per Unit)
Cooktop	$2,295	$1,510	$2,118	$1,510
Dryer	2,944	1,805	2,118	1,805
HVAC[5]	20,633	16,793	8,343	7,276
Water Heater	4,662	2,598	4,251	2,461
Electric Panel Upgrade	4,256	-	2,744	-
Total	**$34,790**	**$22,706**	**$19,574**	**$13,052**
Difference: Gas vs. Electric	**+$12,084**	**-$12,084**	**+$6,522**	**-$6,522**

Source: E3 Report "Residential Building Electrification in California," 2019

A key factor impacting the cost of electrification is electric panel upgrades likely needed to support the appliances. According to E3, the cost of such upgrades is approximately $2,744 per unit in low-density multi-family buildings and approximately $4,256 in single-family houses.

[5] The Gas Replacement HVAC costs of $16,793 (for single-family houses) and $7,276 (for four-unit buildings, per unit) shown in Exhibit 1 are estimated costs of replacing an old gas furnace with a new one. They do not account for installation of air conditioning units. Though not common at present, due to climate change, demand for air conditioning in San Francisco may increase. Heat pump HVAC systems provide the benefit of both heating and air conditioning.

A lower cost scenario for retrofitting households with all electric appliances, shown in Exhibit 2, was presented in a study by Navigant Consulting, Inc. on behalf of the California Building Industry Association. In this scenario, the consultant estimated that retrofit costs would be less than those estimated by E3. For example, the cost to retrofit a single house or multi-family unit that doesn't need an electric panel upgrade is approximately $14,363, according to Navigant, versus between $16,830 and $30,534 in the higher cost scenario prepared by E3. If an electric panel upgrade is needed, the lower cost would be $19,034 for a single-family house, still less than up to $34,970 in the higher cost scenario. However, both the higher and lower cost estimates of retrofitting to all electricity-fueled appliances are higher than replacement with natural gas-fueled appliances.

The lower cost scenario cost for replacement of old gas appliances with new would be $11,689 for both single-family houses and multi-family units compared to between $13,052 and $22,706 in the higher cost scenario. The breakdown of costs for the lower cost scenario is shown in Exhibit 2 below. As with the higher cost scenario presented above, even this lower cost scenario would represent a significant cost to many property owners.

Exhibit 2: Lower Cost Scenario to Retrofit Gas Appliances to Electric and Replace with New Gas Appliances

	Gas Replacement (Single-Family or Multi-Family Unit)	Electric Retrofit, Panel Upgrade Not Needed	Electric Retrofit, Panel Upgrade Needed (Single-Family House)	Electric Retrofit, Panel Upgrade Needed (Multi-Family Unit)
Cooktop	$990	$740	$740	$740
Dryer	593	534	534	534
HVAC	8,586	8,560	8,560	8,560
Water Heater	1,520	4,529	4,529	4,529
Electric Panel Upgrade	-	-	4,671	4,399
Total	**$11,689**	**$14,363**	**$19,034**	**$18,762**

Source: Navigant Report "Impacts of Residential Appliance Electrification," 2018

Energy Costs after Retrofitting

Besides the one-time costs for converting from gas to electric appliances, new ongoing costs would be incurred by property owners that make the change given the current energy pricing structure. At present, natural gas is typically cheaper than electricity on a per-unit basis. However, electric appliances tend to be more

efficient than gas appliances and use fewer units of energy. Furthermore, electric energy costs can be offset through solar panels or other local renewable sources, while natural gas can only be provided through the utility pipelines. However, there is a substantial cost differential between the two energy sources that would have to be overcome to remove this financial disincentive of converting from gas to all electric appliances. There is also a wide range of energy efficiencies in both electric and gas appliances. Investments in building insulation may reduce energy usage and costs, whether for all-electric or mixed-fuel homes. It should be noted that while capital costs to retrofit a building would be paid by the property owner, utility costs may be paid by tenants.

Analyses have been conducted, discussed further below, that show that the costs of natural gas could exceed electricity in the coming decades and that by 2050 there could be a substantial differential between these two sources. If this change occurs as forecast, property owners would benefit from the conversion to electricity-fueled appliances in the future.

Over the past ten years, Pacific Gas and Electric Company (PG&E) rates have increased approximately 1.7% annually for natural gas and 1.4% annually for electricity, after adjusting for inflation. Natural gas rates have fluctuated a bit more during that time period, with a low of $1.09 per therm and a high of $1.32 per therm, while electricity rates have slowly increased from $0.21 per kilowatt hour (kWh) in 2009 to $0.24 per kWh in 2019.[6] However, electricity rates are likely to increase in coming years, as a new state law (Assembly Bill 1054, signed into law in 2019) allows energy utilities to pass the costs of wildfires on to consumers. Average actual PG&E energy costs from 2009 through 2019 are shown in Exhibit 3 below.

[6] One therm equals approximately 29.3 kWh.

Exhibit 3: Average PG&E Energy Costs by Year, 2009 – 2019, Adjusted for Inflation

	Natural Gas Rates		Electricity Rates	
Year	Average per Therm	2019 Dollars	Average per kWh	2019 Dollars
2009	$0.955	$1.13	$0.175	$0.21
2010	1.005	1.18	0.185	0.22
2011	1.050	1.19	0.184	0.21
2012	0.972	1.09	0.186	0.21
2013	0.989	1.09	0.193	0.21
2014	1.144	1.23	0.194	0.21
2015	1.139	1.22	0.204	0.22
2016	1.196	1.27	0.217	0.23
2017	1.259	1.32	0.229	0.24
2018	1.240	1.26	0.231	0.24
2019	1.319	1.32	0.237	0.24
Average Rate		**$1.209**		**$0.222**

Source: PG&E

For comparing the two energy sources, the conversion formula of 1 therm = 29.3 kWh confirms that electricity is more costly. The 29.3 kWh of electricity needed for the same amount of energy as 1 therm of natural gas costs $6.50 using the average prices shown above in Exhibit 5 of $0.222 per kWh of electricity compared to the $1.209 average cost per therm of natural gas. This is the cost differential that would have to be overcome by increased efficiency of electric appliances and/or increased use of renewable sources of electricity. Potentially offsetting those changes in electricity costs and requirements for household appliances are simultaneous improvements in natural gas appliance efficiency.

The Energy Solutions Center, a non-profit organization comprised of energy utilities and equipment manufacturers that promotes natural gas, provides a calculator with estimates of annual energy use by various home appliances. It is noted that the organization is sponsored by natural gas companies and may have a bias in favor of their sponsors. For example, a building electrification advocate reports that the calculator underestimates the efficiency of heat pump water heaters and electric dryers.[7] However, the calculator was the only one found that shows space heating,

[7] Source: Climate Emergency Coalition; "ENERGY STAR Market & Industry Scoping Report, Residential Clothes Dryers, November 2011." ENERGY STAR is program run jointly by the U.S. Environmental Protection Agency and U.S. Department of Energy.

water heating, clothes drying, and cooking energy use estimates, with many climate profiles throughout the United States and several energy efficiency options for the types of space heating and water heating equipment.

Retrofitting from Gas to Electric Appliances

In the Energy Solutions Center projections, it is assumed that existing low efficiency gas appliances are replaced with higher efficiency electric appliances. For example, their projections assume an average furnace (AFUE 80%)[8] is replaced with a standard efficiency heat pump HVAC (8.7 HSPF)[9], and a standard tank water heater (EF=0.59)[10] is replaced with a heat pump water heater (EF=2.0). It should be noted that we were unable to find a heat pump water heater on the market with an EF below 2.3, and most have an EF above 3.0, but the calculator only allowed for a heat pump water heater with an EF of 2.0. The single-family houses used for their projections are 2,000 square feet, with four occupants, running 5.44 dryer loads per week, while the multi-family units are 1,000 square feet, with two occupants, running 2.72 dryer loads per week.[11] Using average PG&E energy rates of $1.209 per therm and $0.222 per kWh, estimated annual energy costs are shown in Exhibit 4 below.

[8] Annual fuel utilization efficiency (AFUE) is a thermal efficiency measure of furnaces and boilers. An AFUE of 80% means that 80% of energy in the fuel is converted to space heating by the furnace.

[9] Heating seasonal performance factor (HSPF) is a measure of heat pump efficiency. HSPF is the ratio of heat output (measured in British Thermal Units, or BTUs) throughout the heating season relative to electricity used (measured in watt-hours).

[10] Energy factor (EF) is a measure of appliance efficiency. For water heaters, EF is the ratio of water heat output to energy input. An EF greater than 1.0 means that more heat energy is produced than is being consumed from fuel.

[11] The Energy Solutions Center uses a default of eight dryer loads per week for a four-occupant household. However, we have revised this input to 5.44 loads per week, or 2.72 loads per week for a two-person household, based on the U.S. Department of Energy updated estimates. (Source: "ENERGY STAR Market & Industry Scoping Report, Residential Clothes Dryers, November 2011."

Exhibit 4: Estimated Annual Energy Costs, Replacement of Gas Appliances with Electric in Existing Residences

	Single-Family House		Multi-Family Unit	
Usage Type	**Natural Gas (Therms/Year)**	**Electricity (kWh/Year)**	**Natural Gas (Therms/Year)**	**Electricity (kWh/Year)**
Space Heating	260.0	2,069	170.8	1,359
Water Heating	207.6	1,795	140.9	1,218
Clothes Dryer	25.3	658	12.7	329
Cooking	50.0	792	37.5	594
Total	**542.9**	**5,314**	**361.9**	**3,500**
Energy Rate	$1.209/Therm	$0.222/kWh	$1.209/Therm	$0.222/kWh
Total Cost	**$656.37**	**$1,179.71**	**$437.54**	**$777.00**
Cost Difference	**-$523.34**	**+$523.34**	**-$339.46**	**+339.46**

Source: Energy Solutions Center
https://www.energydepot.com/ResidentialEnergyCalculator/

Single-family homeowners would pay approximately $523.34 annually in additional energy costs at present by converting to all electric appliances, while owners or tenants of multi-family units would pay approximately $339.46 annually in additional energy costs per unit given current pricing differentials between natural gas and electricity. Property owners could reduce this increased amount if upgrading to higher efficiency appliances, such as a high efficiency heat pump (10 HSPF), or could pay more if using lower efficiency electric appliances, such as a standard electric water heater (EF=0.90).

Future Energy Costs

According to a separate study by E3 conducted on behalf of the California Energy Commission, the consultant concluded that natural gas rates are likely to increase significantly due to increased building electrification and may exceed electricity rates in future years. As demand for natural gas is reduced, rate payers who still use natural gas would have to pay a greater share of fixed costs for the utility. Investments in renewable gas by utilities, such as biomethane and hydrogen blend, will also add to the cost.

E3 examined four different scenarios:

1) Current Policy Reference (in which statewide emission reduction goals are not met by 2050),

2) No Building Electrification (which meets emission reduction goals by 2050 through renewable gas and transportation electrification but no change in building energy use),

3) Slower Building Electrification (where heat pumps comprise 20% of sales by 2030 and 68% by 2050), and

4) 4) High Building Electrification (where heat pumps comprise 50% of sales by 2030 and 68% of sales by 2050).

In these scenarios, the cost of natural gas increases from $3 to $19 per therm by 2050, adjusted to 2018 dollars, as shown in Exhibit 5 below.[12] These amounts represent increases of between 127 to 1,339 percent from the $1.32 per therm average cost in 2019 reported by PG&E and presented in Exhibit 3 above. E3 projects that electricity rates will increase approximately 20-40 percent by 2050 depending on the impact of wildfire-related costs, but significantly less than natural gas cost increases in any case.

Exhibit 5: Projected Alternative Scenarios of Natural Gas Rates by 2050

Scenario	2050 Natural Gas Rates, Per Therm (2018 Dollars)
Current Policy Reference	$3.00
No Building Electrification	$5.50
Slower Building Electrification	$5.70
High Building Electrification	$19.00

Source: Gridworks, presenting estimates by E3, "California's Gas System in Transition," presented at June 6, 2019 California Energy Commission Workshop

According to the study, even in the "No Building Electrification" scenario, in which emissions reductions are met through renewable gas and transportation electrification but no change in building energy use, residents would pay lower energy bills in 2050 in all-electric homes than in mixed-fuel homes assuming natural gas rates increase from $1.32 per therm in 2019 to $5.50. If natural gas rates do rise as projected in the study, it may incentivize property owners to retrofit their homes to all-electric and would provide ongoing savings to those that have converted their appliances as long as the price differential remains in effect.

Applying the energy usage estimates from the Energy Solutions Center to the projected natural gas costs in Exhibit 5, we attempted to estimate household energy costs in 2050, assuming no changes in energy efficiency to appliances. Using E3's low-end estimate of $3.00 per therm in 2050, we estimate that single family homes with natural gas appliances would pay approximately $170.12 less per year than single family homes with all-electric appliances. However, using E3's high-end

[12] According to Gridworks, these rate projections were made by E3 on behalf of PG&E. This work is separate from the report conducted for the California Energy Commission, but it is an extension of that work.

estimate of $19.00 per therm, we estimate that homes with natural gas appliances would pay approximately $7,101.88 more each year. Further, as soon as natural gas prices reach $3.40 per therm, natural gas would become more costly relative to electricity on a unit of energy basis. Considering that electric appliances have become more efficient over time and will likely continue to do so in the future, we would expect annual energy usage for all-electric homes to be less than the estimate shown in Exhibit 6 below, reducing total electricity costs compared to natural gas in the future.

Exhibit 6: Energy Cost Estimates in 2050, Single Family House

	All-Electric	Natural Gas (Low-Cost Estimate)	Natural Gas (High-Cost Estimate)
Energy Usage[13]	5,314 kWh	454.5 Therms	454.5 Therms
Energy Rate	$0.289/kWh[14]	$3.00/Therm	$19.00/Therm
Cost	$1,533.62	$1,363.50	$8,635.50
Difference (Compared to Electric)	N/A	-$170.12	+$7,101.88

Source: BLA calculations based on Energy Solutions Center usage and efficiency estimates and utility cost estimates attributed to E3 by Gridworks.

PG&E Power Shutoffs

Another potential barrier to conversion to all electric appliances is that in October 2019, PG&E began issuing Public Safety Power Shutoffs to prevent against wildfires. The shutoffs occurred during dry and windy conditions when faulty power lines could potentially start catastrophic fires. Between PG&E, Southern California Edison, and San Diego Gas & Electric, over 3 million Californians lost power in the fall of 2019. PG&E has stated that the shutoffs could continue for another 10 years as it works to improve its dated system.

The possibility of continued power shutoffs could deter residential property owners from converting from natural gas to all-electric. With natural gas stoves, residents would still be able to cook in the event of a shutoff. Without solar panels or other on-site generation, all electric buildings are dependent on a reliable power grid. While most natural gas appliances, such as space heaters, water heaters, and

[13] The natural gas usage amounts shown are for newer natural gas appliances, such as a high-efficiency furnace (AFUE 92%) and tankless water heaters (EF=0.8).

[14] The electricity rate of $0.289/kWh shown in Exhibit 10 assumes a 30 percent increase in electricity rates in 2050, using constant dollars. This is an average of the 20 to 40 percent electricity rate increase range projected by E3.

dryers, still require an electric component to function, future power shutoffs may remain a deterrent to building electrification.

One potential solution to the power shutoffs is the purchase of PG&E power assets by the San Francisco Public Utilities Commission (SFPUC). In September 2019, Mayor London Breed proposed purchasing PG&E's power assets for $2.5 billion, using power revenue bonds. SFPUC is currently analyzing the proposal. The conditions of the power assets are unknown, and it is also unknown if SFPUC would be able to prevent shutoffs if it purchased the assets. Increased proliferation of solar panels on buildings would also reduce reliance on the electric grid.

Estimates of Citywide Residential Electrification Costs through Appliance Conversion

Housing Data

According to the 2017 American Community Survey, there are approximately 124,140 single family housing units and 265,846 multi-family housing units in San Francisco, and approximately 61.6% of all housing units are heated by natural gas. If this percentage were equally applied to single family and multi-family housing, we estimate that there are approximately 76,470 single family units and 163,761 multi-family units in the city heated by natural gas.[15]

Exhibit 7 presents a summary of a high- and low-cost scenario for retrofitting all existing single family and multi-family housing in San Francisco from gas to all electric appliances based on the low- and high-cost scenarios presented above in this report and as developed by Navigant Consulting and E3 Consulting, respectively.

[15] The housing data does not distinguish between multi-family buildings that use central space and water heating and units that are individually metered. The housing data also does not specify if other household appliances are gas or electric powered.

Exhibit 7: Low- and High- Cost Scenarios for Retrofitting all San Francisco Housing Units

	Low Cost		High Cost	
	Single family	**Multi-family**	**Single family**	**Multi-family**
Cost/unit	$14,363	$14,363	$34,790	$19,574
# Units	76,470	163,761	76,470	163,761
Subtotal	$1.098 Billion	$2.352 Billion	$2.660 Billion	$3.205 Billion
Grand Total: all housing	**$3.450 Billion**		**$5.866 Billion**	
Difference between Low- and High-Cost	-$2.416 Billion		+$2.416 Billion	

Sources: Low cost per unit based on projections prepared by Navigant Consulting; high cost per unit based on projections prepared by E3 Consulting. Number of housing units and heating sources from 2017 American Community Survey, U.S. Census Bureau.

High-Cost Scenario

According to the E3 study, the cost to retrofit a pre-1978 building from gas to all-electric is approximately $34,790 for a single-family house and approximately $19,574 per unit for a four-unit building. Assuming that there are 76,470 single-family houses and 163,761 multi-family units heated by natural gas,[16] the total cost to retrofit every unit applying the average unit costs derived by E3 would be approximately $2.660 billion for all single-family houses and approximately $3.205 billion for all multi-family units, for a total cost of $5.866 billion.

Low-Cost Scenario

According to the Navigant study, the cost to retrofit a building from gas to all-electric, assuming that an electric panel upgrade is not needed, is approximately $14,363 for both single-family houses and multi-family units. Assuming that there are 240,231 total units heated by natural gas, the total cost to retrofit every unit is approximately $3.450 billion. If electric panel upgrades were required, the cost would be approximately $19,034 for single family houses and $18,762 for multi-family units. The total cost would be approximately $1.456 billion for all single-family houses and approximately $3.072 billion for all multi-family units, for a higher total cost than presented in Exhibit 7 of $4.528 billion.

[16] Since the American Community Survey housing data does not specify if other appliances are powered by gas or electricity, and because space heating is the appliance with the largest natural gas usage, this report uses the number of gas-heated units as a proxy for the number of units that use gas-powered space heaters, water heaters, driers, and stoves/ovens.

Other Costs

At this time, it is unclear if the power grid in San Francisco would not be able to handle widespread electrification of residential appliances. According to the E3 study, California statewide summer peak loads would be slightly reduced in 2050, as air conditioning systems would be replaced by more efficient heat pumps. Winter peak loads would increase, as gas heating systems are replaced by electric, but would remain below summer peak loads. However, the study did not evaluate distribution impacts of building electrification at the local level.

PG&E representatives interviewed for this report stated that the utility upgrades the power grid as needed and is not concerned that grid capacity would be impacted by building electrification. Vehicle electrification, with associated charging stations, is likely to have a much greater impact to grid loads than building electrification, according to these PG&E representatives

For some buildings, sidewalk transformers would have to be installed to handle the increased loads demanded by electrification. In larger buildings, sidewalk transformers would be necessary and an incremental cost when compared to the full cost of electrification. In smaller buildings, residential property owners may choose to install low amperage appliances to attempt to avoid the added cost of transformers. The City Department of the Environment reports that sidewalk transformer needs and costs are difficult to model at this time.

Cost Mitigation Strategies

Retrofit appliances at time of natural replacement

While the Citywide costs in both the high-cost and low-cost scenarios presented above are high, there is a natural cost borne by property owners who have to replace their gas appliances when the equipment reaches the end of their useful lives. Over a 30-year timeframe, it is likely that most residential property owners would have to replace their gas furnace, water heater, oven, and drier at least once. In that sense, the incremental costs of retrofitting gas appliances with electric within a shorter time window than what residential property owners would follow through the natural appliance replacement cycle can be considered the actual costs of a retrofitting program. However, the reduction in greenhouse gas emissions would be prolonged under this approach compared to a program mandating retrofits within a shorter time period.

According to the E3 study higher cost scenario, shown above in Exhibit 1, when replacing existing gas appliances, it costs approximately $12,084 more to install new electric appliances (with an electric panel upgrade) than to install new gas appliances in a single-family house and approximately $6,522 more in a multi-family

unit. Using these estimates, the additional cost for replacing all gas appliances with electric is approximately $924 million for all single-family houses and approximately $1.068 billion for all multi-family units, for a total of approximately $1.992 billion, excluding the costs that would be incurred by residential property owners anyway when they replace their appliances in the regular cycle of appliance replacement.

According to the Navigant study, which estimated lower costs overall for retrofitting gas appliances with electric, when replacing existing gas appliances, and an electric panel upgrade is not needed, it costs approximately $2,674 more to install new electric appliances than to install new gas appliances in either a single-family house or multi-family unit. If electric panel upgrades are needed, it costs approximately $7,345 in a single-family house and approximately $7,073 more in a multi-family unit. These cost details are presented above in Exhibit 2. Using these estimates, the additional cost for replacing all gas appliances with electric, if panel upgrades are not needed, compared to new gas appliances is approximately $642 million. If panel upgrades are needed, the additional cost is approximately $562 million for all single-family houses and approximately $1.158 billion for all multi-family units, for a total of approximately $1.72 billion. These costs exclude the costs that would be incurred by residential property owners anyway when they replace their appliances in the regular cycle of appliance replacement.

Low Amperage Appliances

Property owners could potentially avoid the need for electric panel upgrades by installing low amperage appliances. According to a California electrification consultant interviewed for this report, panels as low as 30 amps could power all-electric homes. However, the appliances that would work with these panels are fairly limited, such as two-burner stoves instead of four-burner stoves. Smart panel systems can help to reduce loads during peak use to allow for appliance functionality. According to the consultant, the cost of a full retrofit on a 30-amp panel is approximately $15,000, or significantly less than the average amounts estimated for higher cost scenario retrofits presented above in Exhibit 1.

Job Creation

A 2019 report by the UCLA Luskin Center for Innovation estimated the effects of building electrification in California. The report estimated that electrification of California's residential building stock of approximately 12.2 million to 13 million units with natural gas would require approximately 22,900-35,700 construction workers per year for the period of 2020-2045. Using San Francisco's estimated 240,231 natural gas heated housing units and ratios of approximately 0.0018-0.0032 jobs created per retrofitted unit inferred from the UCLA study, we estimate that electrification of San Francisco's residential housing stock would create

approximately 423-774 construction jobs per year for the 25-year period from 2020-2045 (assuming the San Francisco retrofits were spread over the same time period as assumed for the state in the study). A building electrification advocate reports that few contractors currently do electrification work, especially among Disadvantaged Business Enterprise contractors.[17] This implies that significant investments in job training may be required to support the workforce needed to achieve widespread building decarbonization. These estimates do not include any net new jobs that might be created for increased manufacturing of electricity-fueled appliances, or impacts to jobs in the energy sector as consumer demand transitions from natural gas to electricity.

Alternative Approaches for Residential Electrification Retrofitting

There are various approaches that could be used to achieve residential electrification in San Francisco. Key variables in considering the options are: cost, who would incur the cost, and the speed with which policy makers want the program to be accomplished.

Mandatory Conversion to Electric Appliances upon Replacement

One option to achieve residential electrification while avoiding public costs for the retrofitting process is mandating appliance conversion from gas to electric at the point an appliance fails and needs replacement, as described above in the Cost Mitigation Strategies section as it would also lower the cost for each housing unit to just the incremental cost of the retrofit. This could be done by prohibiting by law the further installation of natural gas appliances in San Francisco and requiring replacement appliances to be all-electric As discussed above, the average added cost per housing unit would range from approximately $2,674 to $12,084, depending on whether an electric panel upgrade is needed, if the unit is single-family or multi-family, and other factors.

Various online sources show different lifespans for gas furnaces. According to Consumer Reports, furnaces last an average of 15-20 years. Other sources state that the average lifespan is 15-30 years. Using these estimates, if a law mandating furnace conversion at the point of replacement were imposed, we would anticipate that most gas furnaces would be converted to electric within a 20-30 year timeframe.

Several online sources, including Home Depot, Lowe's, and Home Advisor, state that the average lifespan for gas water heaters is 8-12 years. Based on these

[17] Source: Emerald Cities Collaborative

assumptions, if a law mandating electric conversion at point of replacement were imposed, we would anticipate that most gas water heaters would be converted to electric within a 10-12 year timeframe.

As mentioned above, while this conversion schedule would ensure that most home appliances are converted within two to three decades at no public cost, it would place an additional burden on property owners and would delay the desired reduction in greenhouse gas emissions that would result from residential electrification. Most homes in San Francisco would require electric panel conversions to support electric appliances. With current prices, the residents would also pay more in energy costs, as electricity typically costs more than gas, as discussed above. A public subsidy, rebates, or loans could be provided to partially offset these costs, especially for low-income residents.

Conversion at Point of Residential Sales

Another option to achieve residential electrification would be to require conversion by ordinance at the point of sale of residential units. The City of Bellingham, Washington has considered requiring conversion of gas heating to electric at the point of sale of all residences. This would be a logical time for mandating a conversion, as home sellers would likely be able to pass through some or all of the cost to the buyer, though it would also mean a slow-paced process of achieving electrification of all residential buildings.

According to the San Francisco Assessor's 2019 annual report, 5,854 single family homes were sold in San Francisco in 2018. However, this number includes sales of condominiums, which are typically considered multi-family housing. Assuming the correct number is approximately 4,000, this would represent an annual single-family housing turnover rate of 3.22%. Assuming that approximately 61.6% of these single-family houses have natural gas heating, then approximately 2,464 houses would be sold in the first year and converted to electric heating. Over a ten-year period, 21,358 houses would be converted, with 55,112 natural gas systems remaining until they are all converted to electric.[18]

Public funding for some or all residential electrification retrofitting

The City could choose to fund all or a portion of the costs of a residential electrification program in the interest of expediting conversion and reducing the

[18] This calculation assumes that some homes will be sold multiple times, so each year there will be about 3.22% fewer units that turn over the first time

City's greenhouse gas emissions more quickly. To fully cover the total cost of residential electrification at one time, estimated to be between $4.5 and $5.9 billion as discussed above, a major commitment from the City would be necessary through a mechanism such as issuing bonds. As mentioned above, the SFPUC is currently studying the feasibility of acquiring PG&E's power assets. If the SFPUC were to acquire the power assets, it would be able to issue revenue bonds that could be used for building decarbonization projects. If the City were to cover only some of the total cost, to spread out the initiative over time (possibly with multiple bond issuances), or to combine funding mechanisms with rebates, incentives, and some property owner contribution, no one party would bear the full costs of the initiative.

Other than issuing bonds to cover the entirety or some portion of the costs of residential electrification retrofitting, some funding and other mechanisms to consider for a publicly funded or subsidized residential electrification retrofit program are now presented.

Possible Electrification Funding Sources and Cost Reduction Strategies

Utility Users Tax

San Francisco imposes a 7.5% Utility Users Tax (UUT) on commercial properties. The tax is assessed on telephone services, cellular telephone services, electricity, natural gas, steam, and water. Residential properties are not subject to a UUT tax.

A residential UUT on natural gas consumption would be one way to generate revenue for potential decarbonization measures, as well as an incentive for homeowners to decarbonize. According to the California Energy Commission, residential natural gas consumption in San Francisco in 2018 was 131.7 million therms. Using the commercial UUT rate of 7.5%, and an average retail cost of $1.21 per therm, the average tax per therm would be $0.09075. If this rate were applied to residential customers, the annual tax revenue would be approximately $11.95 million. However, natural gas consumption in San Francisco has declined. If it continues to decline, either through decarbonization or improved efficiency, UUT revenues based on natural gas consumption would decline. A residential UUT on natural gas consumption would also likely be regressive, impacting low-income households the hardest.

Using the low-cost scenario of $14,363 per retrofit, revenue from a residential UUT on natural gas use could retrofit approximately 832 units per year. Using the high-cost scenario of $34,790 per retrofit (for single-family houses), this revenue could retrofit approximately 344 housing units per year out of the estimated total of 240,231 housing units in San Francisco.

Commercial UUT Shift

Another tool that could be considered to encourage commercial property owners to convert gas appliances to electric, the Board of Supervisors could consider increasing the commercial UUT on natural gas while reducing the UUT on electricity. While this would not produce increased revenue to be used to pay for a portion of the costs of residential electrification, it could provide a small incentive to make greater use of electricity in lieu of natural gas.

According to the California Energy Commission, the commercial electricity consumption in San Francisco in 2018 was 4.18 billion kWh and the commercial natural gas consumption was 96.3 million therms. Using UUT rates of 7.5%, our estimate of revenue generated under the current structure is shown in Exhibit 8 below.

Exhibit 8: 2018 Commercial Utility User Tax Revenue Estimates, City and County of San Francisco

Energy Type	Total Consumption	Cost per Unit	Total Sales	UUT Rate	Total Revenue
Natural Gas	96,300,000 therms	$1.210	$116,523,000	7.5%	$8,739,225
Electricity	4,180,000,000 kWh	0.222	927,960,000	7.5%	69,597,000
Total					**$78,336,225**
**Natural gas units in therms, electricity units in kWh*					

Source: BLA calculations using PG&E energy rates and California Energy Commission consumption data

The Board of Supervisors could consider increasing the UUT on natural gas while reducing the UUT on electricity to keep the adjustment revenue neutral. However, since the electric UUT revenue is much greater than the gas UUT revenue, a large increase in the gas UUT rate would be paired with a minor decrease in the electric UUT rate from 7.5 to 7.1 percent. Exhibit 9 below shows a scenario where the gas UUT rate is increased to 11%, which would match the City of Los Angeles for the highest UUT rate in California.

Exhibit 9: UUT Revenue Estimates with increased Natural Gas UUT Rate to 11%, City and County of San Francisco

Energy Type	Total Consumption	Cost per Unit	Total Sales	UUT Rate	Total Revenue
Natural Gas	96,300,000	$1.210	$116,523,000	11.0%	$12,817,530
Electricity	4,180,000,000	0.222	927,960,000	7.1%	65,518,695
Total					**$78,336,225**
**Natural gas units in therms, electricity units in kWh*					

Source: BLA calculations using PG&E energy rates and California Energy Commission consumption data

In the scenario presented in Exhibit 9, a 3.5 percentage point increase in the natural gas UUT rate to 11% would be paired with a 0.4 point decrease in the electric UUT rate, to 7.1 percent, to keep the adjustments revenue neutral while increasing the possible incentive for consuming electricity rather than natural gas. Exhibit 10 below shows a scenario where the gas UUT rate is doubled to 15% while the UUT on electricity is lowered from 7.5 to 6.6 percent.

Exhibit 10: UUT Revenue Estimates, 15% Natural Gas UUT Rate, City and County of San Francisco

Energy Type	Total Consumption	Cost per Unit	Total Sales	UUT Rate	Total Revenue
Natural Gas	96,300,000	$1.210	$116,523,000	15.0%	$17,478,450
Electricity	4,180,000,000	0.222	927,960,000	6.6%	60,857,775
Total					**$78,336,225**
**Natural gas units in therms, electricity units in kWh*					

Source: BLA calculations using PG&E energy rates and California Energy Commission consumption data

In this scenario, a 7.5 point increase in the natural gas UUT rate to 15% would be paired with a 0.9 point decrease in the electric UUT rate, to 6.6 percent, to keep the adjustment revenue neutral. In both scenarios, the rate adjustment would be more of a disincentive to natural gas use than an incentive towards electricity use.

Building Emission Limits

In April 2019, the New York City Council approved the Climate Mobilization Act, which included emissions limits for buildings over 25,000 square feet. The law takes effect in 2024, with limits set based on type of building use, ranging from 4.26 to 23.81 kg of carbon dioxide equivalent per square foot per year. In 2030, the limits are reduced to a range of 1.10 to 11.93 kg of carbon dioxide equivalent per square foot per year. Emission limits for the periods of 2035 to 2039 and 2040 to 2044 will be published by the end of 2022. Building emissions are calculated based on energy use, with different carbon dioxide equivalent estimates based on energy source. The penalty for emissions above the limit is $286 per metric ton of carbon dioxide equivalent per year. San Francisco could consider exploring this program, both as a way to incentivize building retrofits and to generate revenue for decarbonization initiatives.

Potential State funding

California Senate Bill 1477, signed by then-Governor Jerry Brown in 2018, provides $50 million per year statewide through two programs for four years in state Cap-

and-Trade funding for pilot programs that promote building decarbonization.[19] The first program, the Building Initiative for Low Emissions Development (BUILD) program, provides up to $20 million per year in incentives for new all-electric construction projects. The second program, the Technology and Equipment for Clean Heating (TECH) program, provides $30 million per year to promote purchases of low-emission space and water heating equipment in new and existing buildings. While the TECH program will be implemented at the state level, it may be possible for the City to coordinate with the selected third-party implementer to become involved in the program and use some of this funding to lower residential electrification costs.

Bay Area Regional Energy Network (BayREN)

The Bay Area Regional Energy Network (BayREN), managed by the Association of Bay Area Governments (ABAG), provides funding for energy efficiency programs throughout the nine-county Bay Area funded by utility ratepayer funds through the CPUC. From 2013 through 2018, BayREN provided over $40 million in incentives and upgraded the energy efficiency of 39,000 housing units throughout the Bay Area. Programs are available for both single-family and multi-family housing units. Some of this funding could potentially be used for residential electrification in San Francisco although given the current funding level of the program, it would likely only be a modest amount available for San Francisco's program. As of the writing of this report, BayREN also offers homeowners up to $5,000 in rebates for electric appliances and energy efficiency improvements.

Low-Income Weatherization Program

The California Low-Income Weatherization Program (LIWP) provides incentives for energy efficiency measures in low-income households and multi-family housing. The LIWP's Multi-Family Energy Efficiency and Renewables program assists with energy efficiency programs specifically in low-income multi-family housing. Approximately $63.9 million has been allocated to the Multi-Family Energy Efficiency and Renewables program for the period of 2014-2022. The program is administered by the California Department of Community Services and

[19] The California Cap-and-Trade program sets limits on approximately 450 entities, such as power plants, industrial plants, and fuel distributors that are responsible for approximately 85% of California's total greenhouse gas emissions. The State auctions credits that major polluters can purchase to offset their emissions. From November 2012 through December 2018, the State generated approximately $9.5 billion for the Greenhouse Gas Reduction Fund, which is appropriated by the State Legislature to agencies implementing emission reduction programs and projects.

Development. It may be possible for the City to receive funding from LIWP for a building electrification pilot program for low-income housing.

Financing programs for property owners

If some or all of the costs of a San Francisco residential electrification program is to be covered by property owners, the Property Assessed Clean Energy (PACE) program allows them to finance energy efficiency upgrades at market rates, with repayment through the property tax assessment process. San Francisco currently has two approved PACE financing partners: California First and Hero. Electric heat pump HVAC and water heater units are both eligible for financing through the PACE program.

The Sacramento Municipal Utility District (SMUD) also offers energy efficiency financing programs that are competitive with PACE. As of the writing of this report, SMUD offered 6.99% fixed rate 15-year term loans, while PACE's interest rates started at 7.75%. SMUD does not assess several fees and closing costs that are assessed by PACE. SMUD's funding source for their program is ratepayer revenue.

Prequalifying vendors as a means of lowering residential electrification costs

If the City undertakes policies that accelerate residential building electrification and elects to incur some or all of the costs of such an effort, it could pursue prequalification of contractors and appliance manufacturers as a means of lowering costs. Contractors and electric appliance manufacturers selected for this work would benefit from potentially thousands of building retrofits throughout the City. They should be willing to provide services and products at a negotiated discounted rate in exchange for the high volume of sales that would come from appearing on a prequalified list. A 10-15 percent discount could reduce total Citywide residential electrification costs by hundreds of millions of dollars.

Noticing requirements

In anticipation of potential prohibition of natural gas or mandated conversions, the Board of Supervisors could consider an ordinance requiring noticing property owners and developers in advance of a mandate being imposed. The notification requirement may discourage property owners from installing or investing in natural gas infrastructure, to avoid wasting money, assuming they would eventually have to convert their infrastructure to all-electric.

Rebate programs

Some utilities, cities, counties, states, and special districts offer rebates of varying amounts to homeowners who convert their gas appliances to electric. Sacramento Municipal Utility District (SMUD) offers one of the most robust home electrification

programs. Homeowners may receive rebates up to $13,750 for converting their homes from gas to electric, including $4,500 to replace a gas furnace with an electric heat pump HVAC, and $3,000 to replace a gas water heater with an electric heat pump water heater. Rebates up to $5,000 are provided for new homes. The source of funding for this program is ratepayer revenue.

While the City and County of San Francisco does not have ratepayer revenue available since the City's residential customers are mostly served by the investor-owned Pacific Gas & Electric company (PG&E), the Board of Supervisors could consider entering into discussions with PG&E and/or representatives of the California Public Utilities Commission (CPUC) about such a program and the possibility of a rate surcharge, if necessary, to provide a funding source for residential electrification. However, funding may be available through SFPUC's CleanPowerSF Community Choice Aggregation (CCA) program.[20] Other CCA programs, including those in Alameda, San Mateo, and Sonoma Counties, provide electric appliance rebates to various extents.

San Francisco could develop a rebate program similar to SMUD's. According to the 2017 American Community Survey, there are approximately 240,231 housing units in San Francisco that are heated through a utility gas system. Using SMUD's $13,750 rebate amount, and assuming a 0.1 percent annual take up rate (240 housing units per year), a rebate program would cost approximately $3,300,000 per year.[21] Under a similar budget, the City would be able to provide more rebates if the rebate amount were reduced. For example, rebates under Marin County's standard program total $3,000 per year. With a $3,300,000 budget for rebates, 1,100 rebates could be provided assuming $3,000 per year per property owner.

Another option would be to dedicate the estimated $11,950,000 revenue from a potential residential UUT on natural gas to rebate programs. Using SMUD's $13,750 rebate amount, the City would be able to provide approximately 869 rebates per year with this new revenue source. Using Marin County's $3,000 rebate amount, the City could provide approximately 3,983 rebates per year.

Other examples of relevant rebate programs include:

[20] Community Choice Aggregation (CCA) programs enable local governments to purchase and/or develop power on behalf of the local community.

[21] The 0.1 percent annual take up rate is a BLA assumption intended to show the number of grants that could be provided within a given budget, rather than an attempt to estimate the demand for grants if they were made available.

- The County of Marin offers rebates ranging from $250-$1,000 per gas appliance replaced, with rebates of $250-$4,500 for income-qualified households. The funding source for this program is a Bay Area Air Quality Management District (BAAQMD) grant. The standard rebates are $1,000 for a heat pump water heater, $1,000 for a central heat pump space heater, $800 for a mini-split heat pump space heater, $500 for an induction cooking range (cooktop and oven), $250 for an induction cooktop (excluding the oven), and $500 for an electrical panel upgrade.
- Marin County's income-qualified rebates are $2,000 for a heat pump water heater, $4,500 for a central heat pump space heater, $3,000 for a mini-split heat pump space heater, $500 for an induction cooking range (cooktop and oven), $250 for an induction cooktop (excluding the oven), and $1,200 for an electrical panel upgrade.
- The City of San Jose offers rebates for replacing gas water heaters with electric heat pump water heaters. The funding source for this program is also a BAAQMD grant. Rebates are up to $3,500 for income-qualified residents and $2,000 for other residents, with an additional rebate up to $2,500 for an electrical panel upgrade. Rebates were available through September 2020 at the time this report was prepared.
- The City of Palo Alto offers rebates up to $1,500 for residents who install electric heat pump water heaters. The units must have an energy factor (EF) of 2.8 or higher. The funding source for this program is ratepayer revenue from the City's municipal utility.
- The State of Maine offers residents rebates up to $500 for the first indoor heat pump space heating unit, $250 for the second unit, and up to $750 for electric heat pump water heaters.
- The State of Vermont provides instant rebates up to $500 on heat pump space heating units and up to $600 for electric heat pump water heaters.

California Public Utilities Commission (CPUC) regulations now make it easier for utilities to fund energy efficiency measures. Between 1992 and August 2019, the CPUC had relied on a "three-prong test" that required energy efficiency measures implemented by regulated utilities to meet three goals: reduce energy use, benefit the environment, and be cost-effective. Programs that replaced natural gas appliances with electric appliances would fail the test, as electricity typically costs more than gas. Therefore, the only programs that were allowed were programs that replaced appliances with more efficient versions using the same fuel source. In August 2019, the CPUC determined that a fuel substitution measure would no

longer have to pass the cost-effectiveness test, allowing utilities to more easily fund energy efficiency measures. At this time, PG&E only offers a $300 rebate for heat pump storage water heaters. This change in CPUC regulations could open up the potential for additional funding of energy efficiency measures by PG&E. The Board of Supervisors could consider entering into dialogue between the City and PG&E about additional measures that the utility could initiate to boost residential electrification.

"Pruning" the grid

A potential strategy for reducing natural gas usage is by retiring unneeded gas assets, known as "pruning" the grid. Electrification advocates suggest that instead of performing maintenance on a gas line, PG&E could spend the project budget on cutting off the line and contributing to electrification of buildings served by the line. Over time, the gas grid would be gradually reduced. PG&E representatives interviewed reported that the company is exploring this strategy, but that there are logistical challenges. PG&E currently does not have a guiding policy on grid pruning and thus would consider asset retirement on a case by case basis. Gas lines would have to remain functional unless 100% of customers served by the line agree to convert to all-electric appliances. For this reason, it may be more feasible in rural or suburban areas such as cul-de-sacs where the gas lines dead end and only serve a small number of customers. PG&E also reports that savings from grid retirement would not necessarily be used for funding building electrification. Savings may be used to fund other gas infrastructure projects to prevent future rate increases, as referenced in the E3 study above.

Building Electrification Working Group

The Board of Supervisors could consider appointing a working group to further explore these policy options and provide recommendations for building electrification programs.