Equitable Electrification Analysis for Existing Buildings in Richmond, CA

Allison Moe, Patrick Gibbs

National Renewable Energy Laboratory (NREL)

August 30, 2023

Notice

This work was authored by the National Renewable Energy Laboratory (NREL), operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the DOE's Communities LEAP (Local Energy Action Program) Pilot.

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

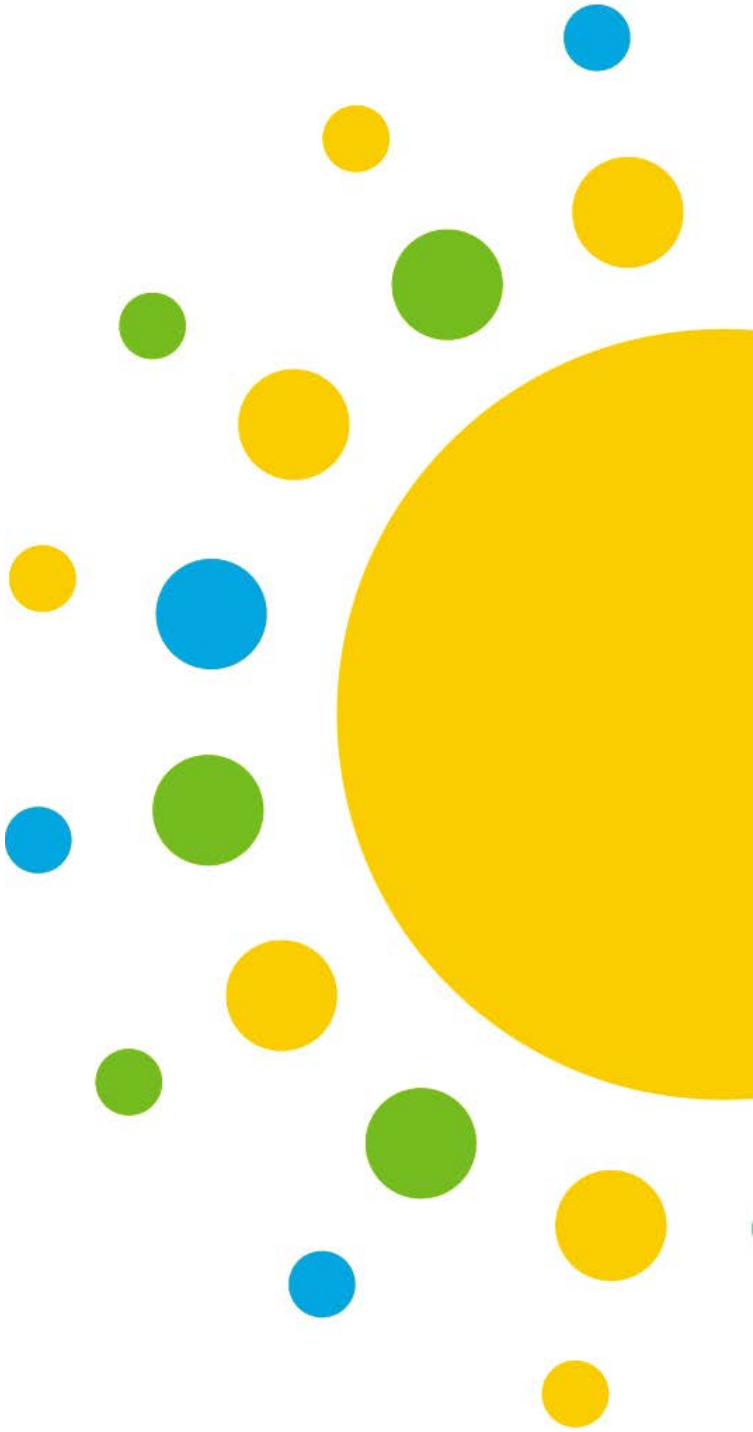
This report is available at no cost from NREL at www.nrel.gov/publications.

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

Agenda

1. Project Overview & Context (~10 minutes)
2. Key Analysis Findings (~40 minutes)
3. Building Electrification Case Studies (~5 minutes)
4. Questions & Discussion (~30 minutes)

Project Overview & Context



Communities LEAP

The Communities LEAP (Local Energy Action Program) Pilot Competitive Technical Assistance Opportunity aims to facilitate sustained community-wide **economic empowerment**, improve **local environmental conditions**, and open the way for other benefits primarily through the U.S. Department of Energy's clean energy deployment work.

The National Renewable Energy Laboratory (NREL) is the primary technical assistance program coordinator and provider for the Communities LEAP pilot.

Project Overview

Since June 2022, NREL has provided technical assistance in the form of research and analysis to support the City of Richmond in identifying strategies to equitably transition its existing buildings* to clean electricity.

This presentation summarizes the findings from that research and analysis. The full report is published and available here.

*NREL's analysis addressed a majority of residential, commercial, and some light industrial buildings.

Project Overview

Approaches to transition existing building stock to clean electricity include:

1. Building Electrification: The adoption of technologies that use electricity in place of natural gas or other fossil fuels. Key examples include space heating, water heating, appliances, and other equipment.
2. Building Envelope Improvements: Installing measures like insulation and air sealing that will reduce the energy needed for space heating and cooling.

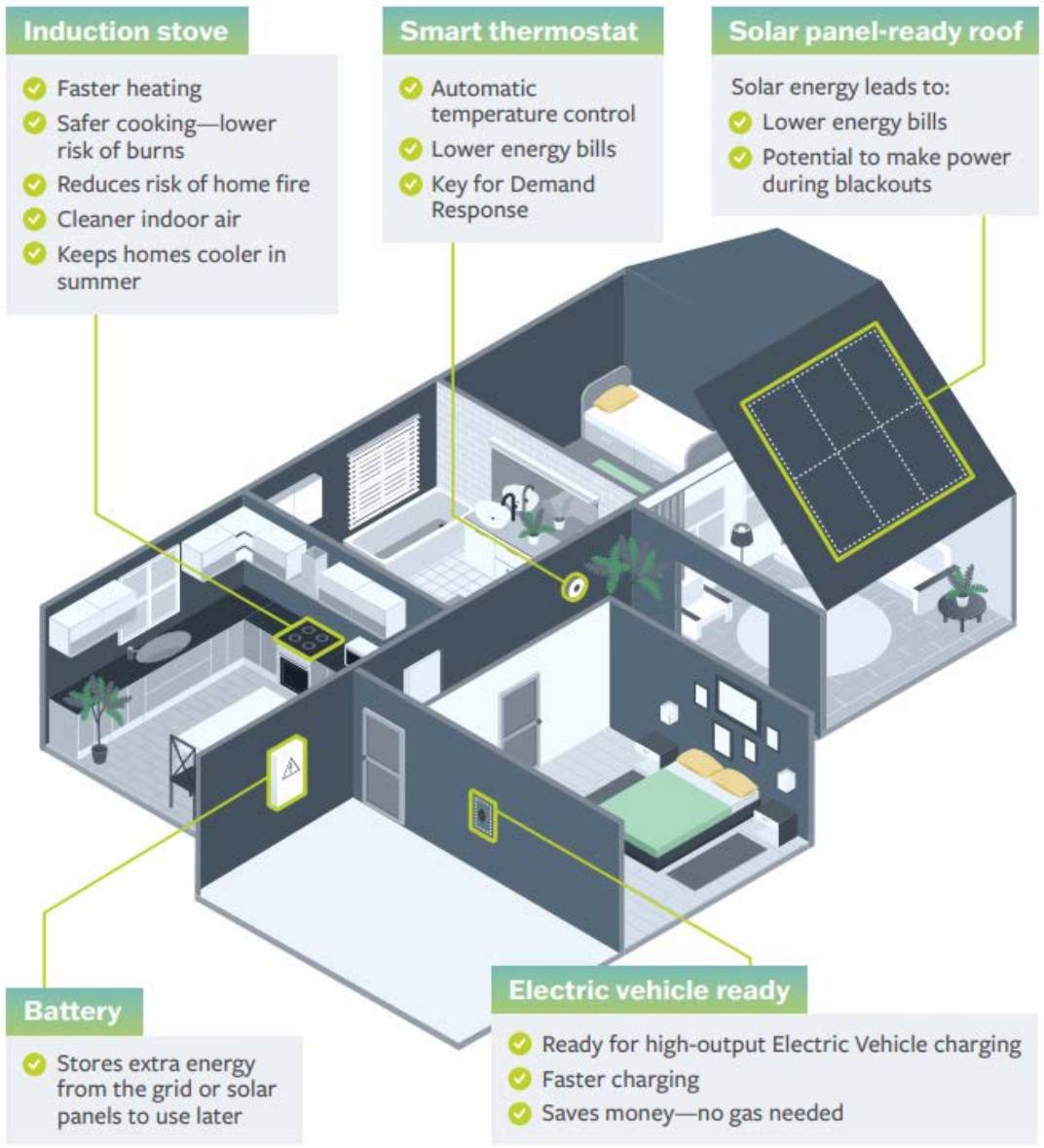


Illustration from City of Richmond [Zero Net Carbon Ready Homes brochure]

Homes will also come with:

Heat Pump Water Heater (Electric)

- 3–4x more efficient than gas water heaters
- Lower energy bills
- Lower fire risk

Space Heating (Electric)

- Cleaner indoor air
- Lower fire risk

High Efficiency Dryer & Washer

- Lower energy bills
- Lower fire risk

Insulation

- Increased comfort
- Lower energy bills

Energy-Efficient Windows

- Quieter, increased comfort
- Lower energy bills

Project Overview

NREL analyzed how building envelope and electrification upgrades to existing residential and commercial buildings in Richmond might impact the following four areas:

1. Environmental Health (Basis and focus of analysis)
   - Energy consumption
   - Greenhouse gas (GHG) emissions
2. Costs (Residential buildings only)
   - Utility bills
   - Return on investment
3. Jobs & Employment
   - New jobs in construction and energy efficiency trades
   - Upskilling existing workers for new technologies and processes
   - Wages associated with jobs
4. Individual Health
   - Indoor air quality for residents and workers

NREL's analysis includes a review of potential equity implications for the above impact areas.

Data Background

Analysis was built on energy consumption data modeled using the ResStock™ and ComStock™ tools.

Building stock characteristics database

+

Physics-based computer modeling

+

High-performance computing

NOTE: All figures in this presentation are from NREL's ResStock or ComStock data unless otherwise noted.

ResStock version used: September 2022, with the 2018 Actual Meteorological Year weather file
ComStock version used: March 2023, with the 2018 Actual Meteorological Year weather file

Report pages 18, 74, 76

Building Types Modeled

Building Sector	Building Types Included in this Analysis	Building Types Excluded from This Analysis
Residential Buildings (38,499 housing units, 55 million square feet)	• Single family attached and detached • Small multifamily buildings (2-4 units) • Large multifamily (5+ units)	• Mobile homes • Assisted care facilities or other congregate housing
Commercial Buildings (13,351 buildings, 29 million square feet)	• Private education • Food service • Healthcare • Lodging • Mercantile • Office • Warehouse and storage	• Laboratory facilities • Grocery stores • Entertainment venues • Recreation centers • Religious buildings • Vehicle repair shops • All industrial buildings except warehouse and storage • Public education buildings • Non-city government-owned buildings

NREL's analysis models included approximately:

- 98% of residential buildings
- 65% of commercial and institutional buildings/85% of commercial and institutional building floor area
- 16% of industrial buildings/39% of industrial building floor area

Report pages 73-77

Building Upgrades Modeled

Upgrade Type	Residential Building Upgrades Modeled	Commercial Building Upgrades Modeled
Building Envelope	• Wall insulation • Attic insulation • Foundation wall and rim joist insulation • General air sealing • Duct sealing	• Wall insulation • Attic/Roof insulation
Lower-Efficiency Electrification	• Lower-efficiency* air source heat pump and electric resistance backup for space heating • Lower-efficiency* heat pump water heater • Electric resistance dryer • Electric range and oven	N/A
Higher-Efficiency Electrification	• Higher-efficiency air source heat pump and electric resistance backup for space heating • Higher-efficiency heat pump water heater • Ventless heat pump dryer • Induction range and electric oven	• For buildings with boilers: replacement with higher-efficiency air source heat pump boilers • For buildings with gas-fired or electric resistance rooftop units: replacement with higher-efficiency heat pump rooftop units
Building Envelope + Higher-Efficiency Electrification	See Above	N/A

*The term “lower-efficiency electrification” is used to describe the assumed/modeled efficiency levels for these scenarios relative to the “higher-efficiency electrification” scenarios.

Report page 78

Richmond, CA LEAP Project Overview

Project Limitations:

- ✓Analysis is based on *modeled* energy consumption patterns not actual/real-time utility data
- ✓Analysis does not include all building types
- ✓Analysis does not include every possible building upgrade or combination of upgrades
- ✓Cost analysis and job estimates use high level average project costs from local contractors and estimated utility rates
- ✓Analysis does not provide recommendations

Local Policy Context

This project provides technical assistance within the policy context of several existing city efforts:

- ✓ 2012 Richmond General Plan
- ✓ 2014 Health in All Policies
- ✓ 2016 Climate Action Plan
- ✓ 2018 Richmond Advanced Energy Community Report
- ✓ 2021 Richmond natural gas ban for new developments
- ✓ 2022-23 Green Blue New Deal
- ✓ Transparent Richmond

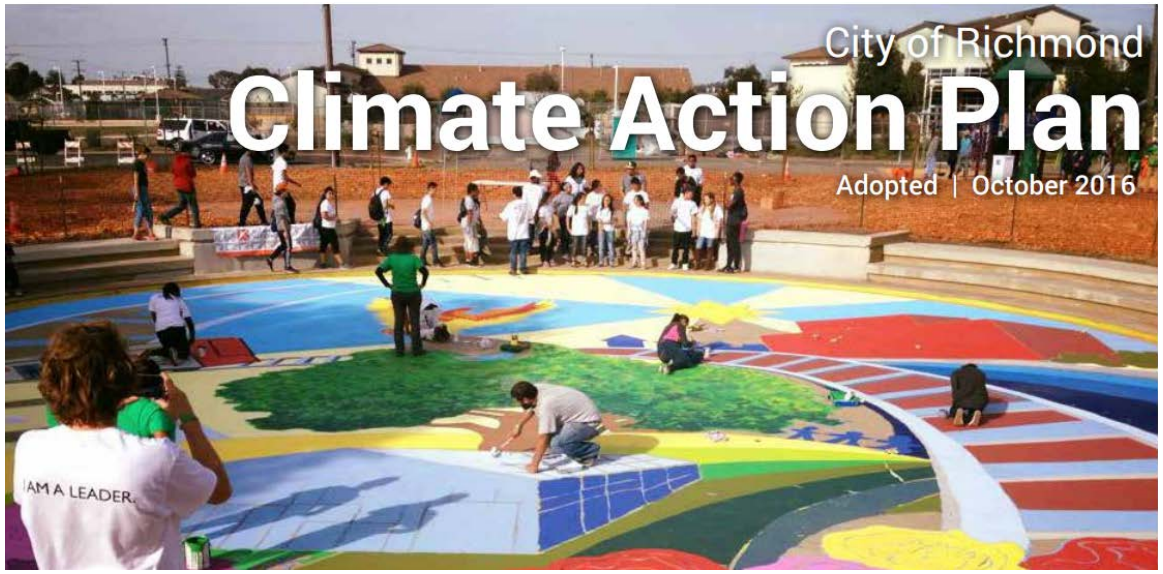


Photo from City of Richmond Climate Action Plan, 2016

State and Regional Policy Context

- ✓ In 2015, the California Energy Commission passed SB 350 with the goals of increasing renewable electricity procurement to 50% by 2030, and doubling statewide energy efficiency savings for both natural gas and electricity by 2030.

- ✓ In 2022, the California Energy Commission adopted its 2022 Energy Code that encourages the use of electric heat pumps for space and water heating for new and renovated buildings.

- ✓ In 2022, the California Air Resources Board voted to ban the sale of all natural gas-fired space and water-heating appliances by 2030.

- ✓ In March 2023, the Bay Area Air Quality Management District voted on rules that would eliminate nitrogen oxide (NOx) emissions from all new space and water heaters starting in 2027. The rules apply to both residential and commercial buildings. Electric appliances are currently the only options that meet this requirement.

Federal Policy Context

2021 Infrastructure Investment and Jobs Act (IIJA)

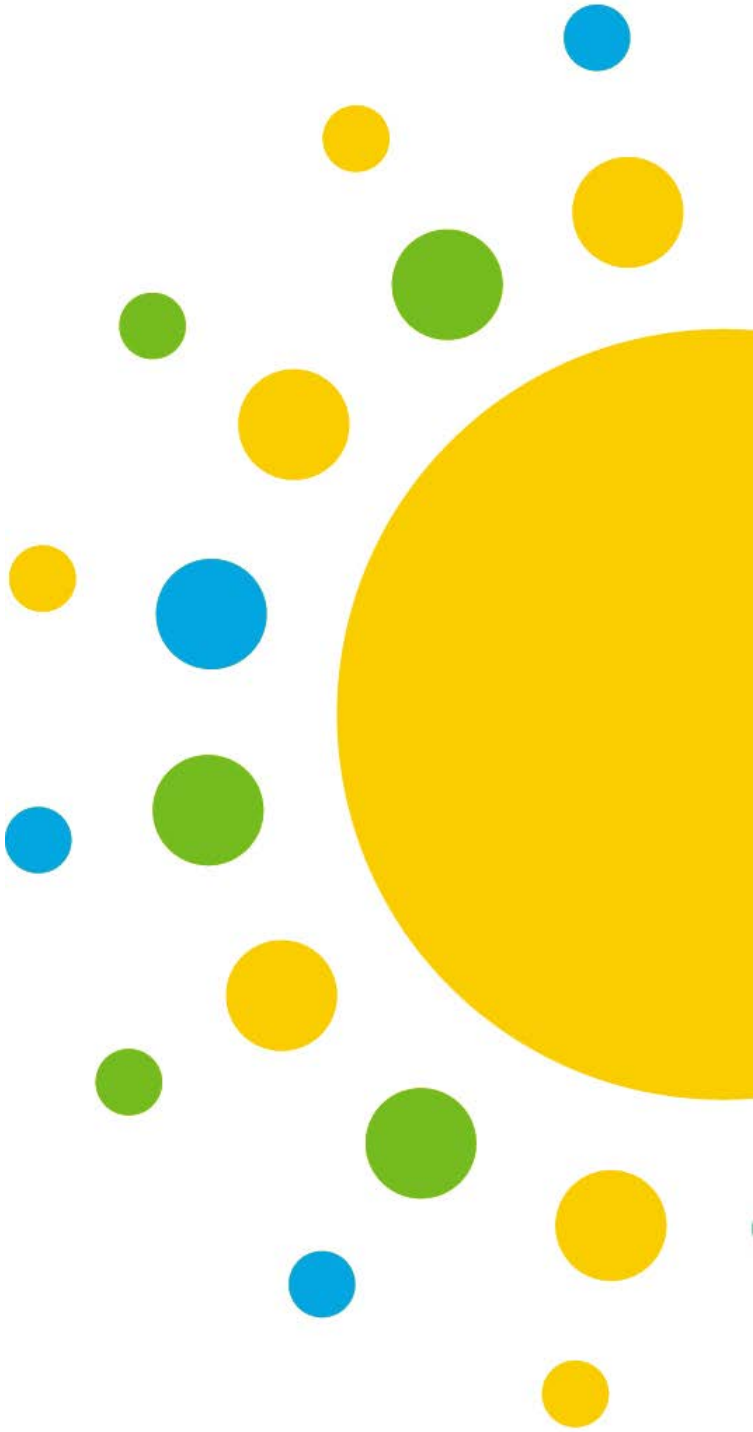
- Energy efficiency and conservation grants to states
- Energy efficiency revolving loan funding grants to states
- State Energy Program funding to states
- Weatherization Assistance Program funds
- Workforce development funding

2022 Inflation Reduction Act (IRA)

- Rebates for heat pumps, energy efficient appliances, and electric panel upgrades
  - Higher rebates for low-income households
- Increased tax credit for solar PV
- Workforce development provisions

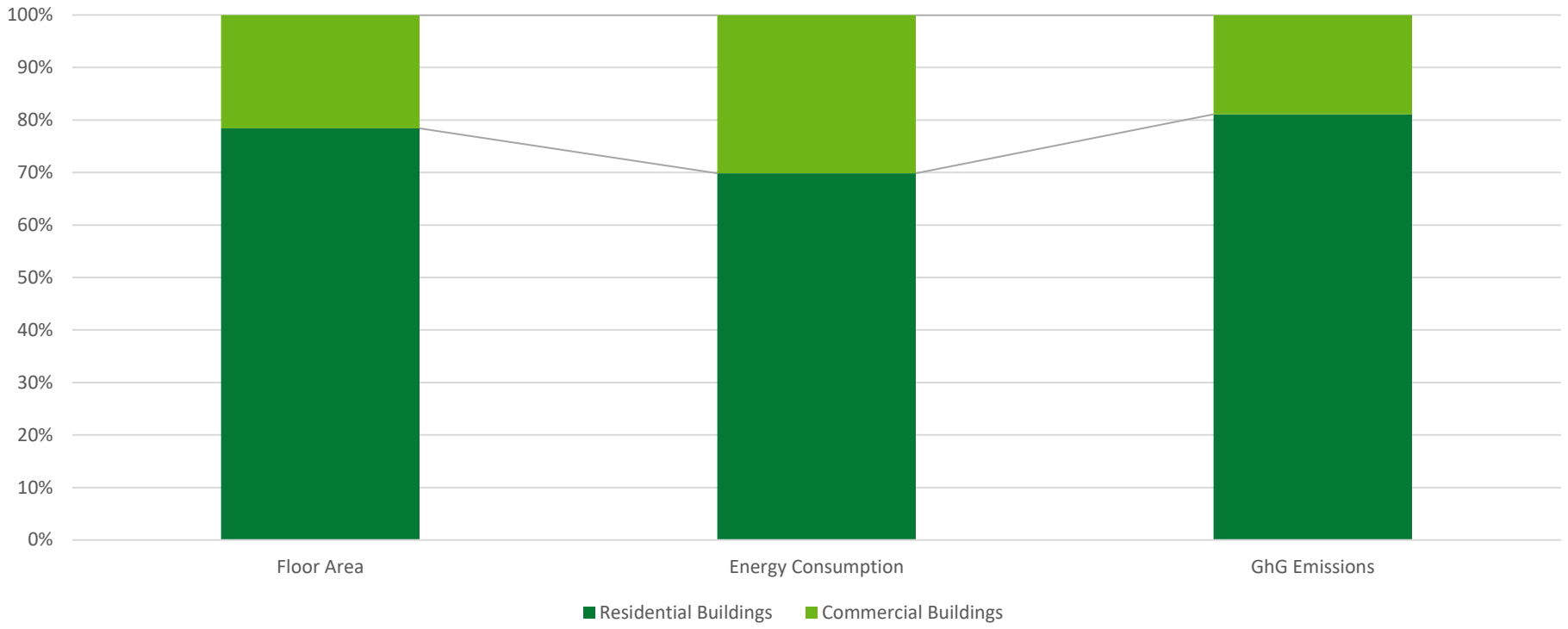
Image Source: Creative Commons

Key Analysis Findings



Overall Modeled Energy Consumption in Richmond Buildings

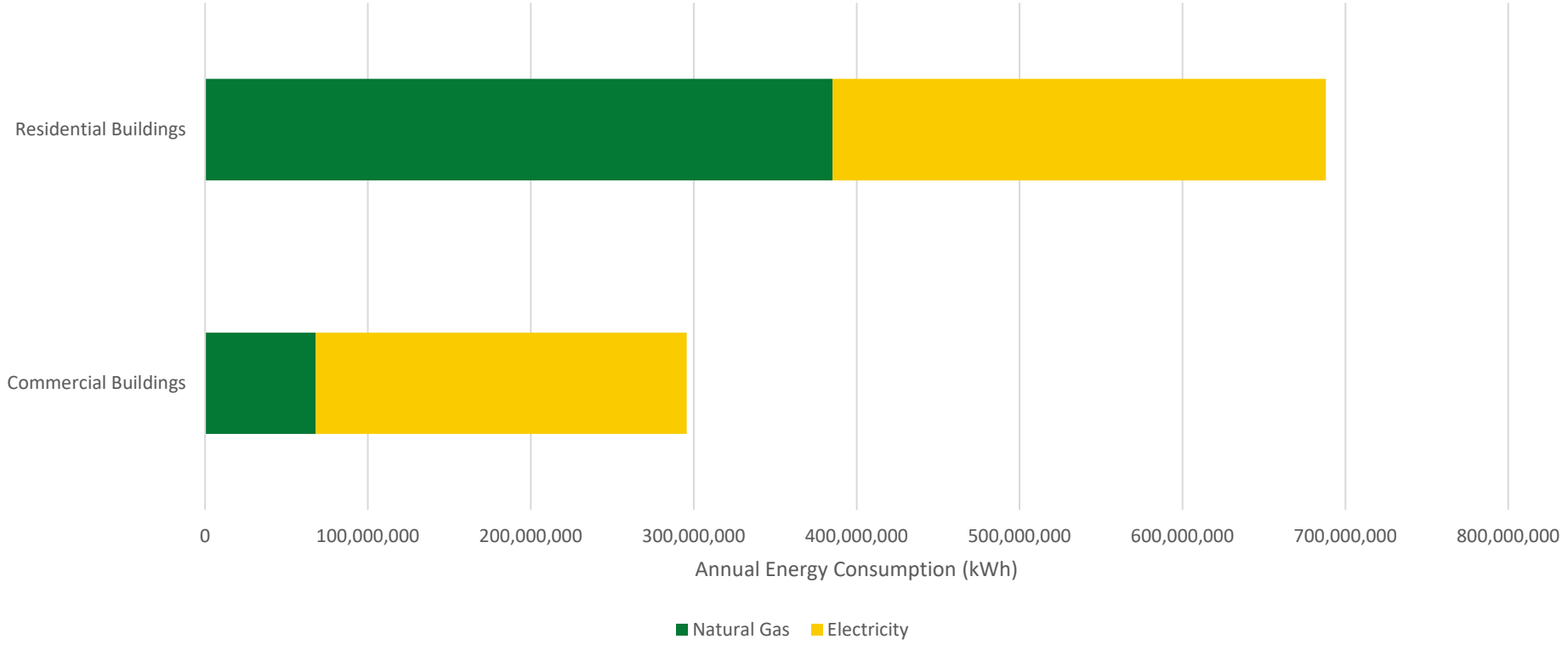
Modeled city-wide floor area, energy consumption, and greenhouse gas emissions by building sector



Report pages 23, 49

Overall Modeled Energy Consumption in Richmond Buildings

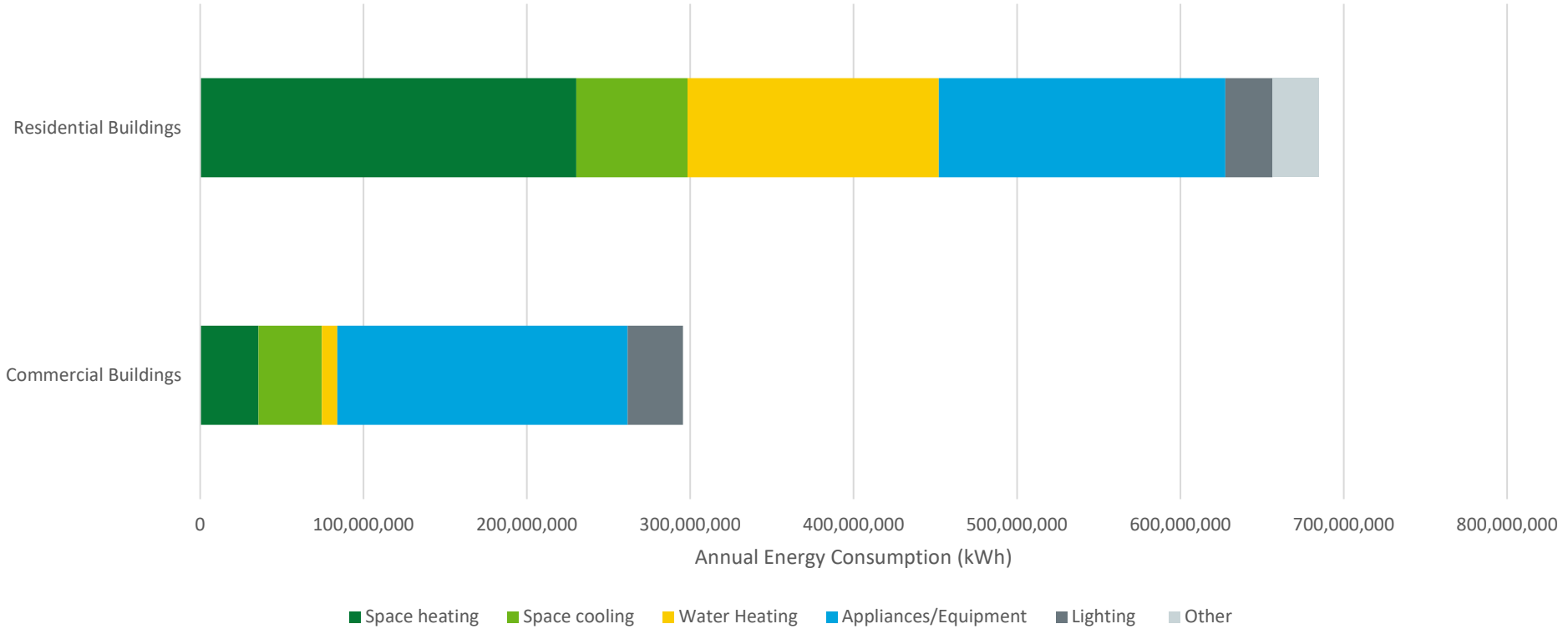
Modeled city-wide energy consumption by building sector and fuel type



Report pages 23, 49

Overall Modeled Energy Consumption in Richmond Buildings

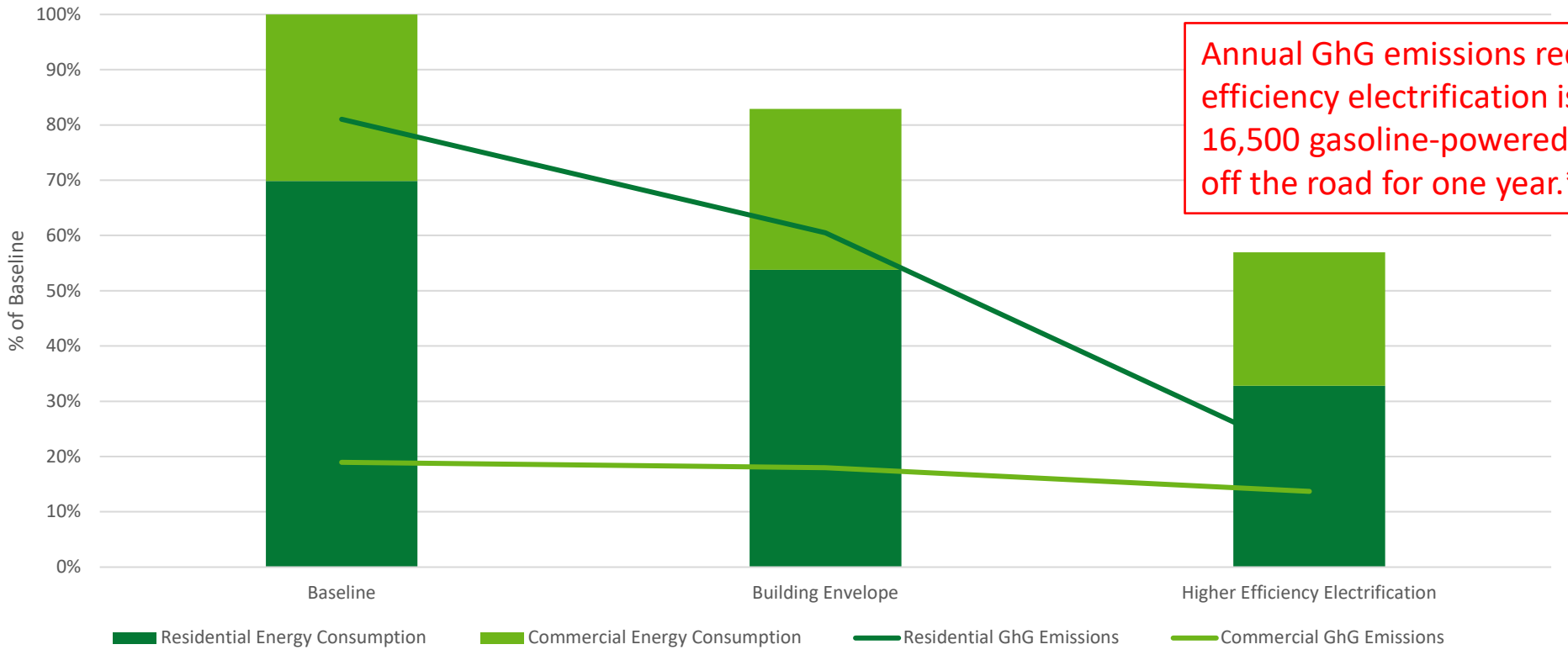
Modeled city-wide energy consumption by building sector and end use



Report pages 23, 49

Overall Impacts of Building Upgrades on Energy Consumption & GhG Emissions

Modeled upgrade scenario impacts on city-wide energy consumption by building sector



Annual GhG emissions reduction for high efficiency electrification is equivalent to taking 16,500 gasoline-powered passenger vehicles off the road for one year.*

* EPA Greenhouse Gas Equivalencies Calculator

Report pages 27, 53

Overall Employment Impacts

California energy efficiency jobs by county

Illustration from E4TheFuture, 2022

- There were about 8,000 energy efficiency workers (residential and commercial work) in Contra Costa County in 2022.
  - This is one of the highest ratios of energy efficiency workers to total workers in the state.
- There are far more workers doing related work, who could shift their focus and/or be re-skilled to perform the types of building envelope and electrification work described in this report.

Overall Employment Impacts

Estimated Jobs Supported by Upgrades to Richmond's Existing Residential Building Stock*

Upgrade Scenario	Residential		Commercial	
	Total Jobs	Net/new Jobs	Total Jobs	Net/new Jobs
Envelope	2,148	2,148	4,938	4,938
Electrification	5,396	1,349	9,407	1,881
Total	7,544	3,497	14,345	6,819

* Jobs is defined here as both direct and indirect jobs. Direct jobs (which are more likely to be local), represent about 2/3 of these job totals.

Report pages 42, 58

Overall Individual Health Impacts

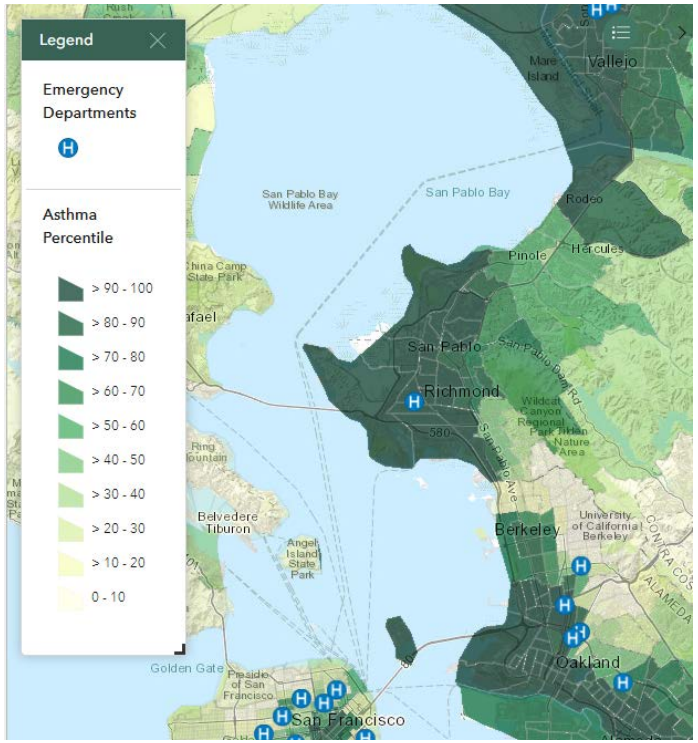
The air quality inside of buildings affects the health of people who live and work in them. Among other factors, indoor air quality is impacted by building materials, quality of building construction, and the type and quality of appliances and ventilation systems.

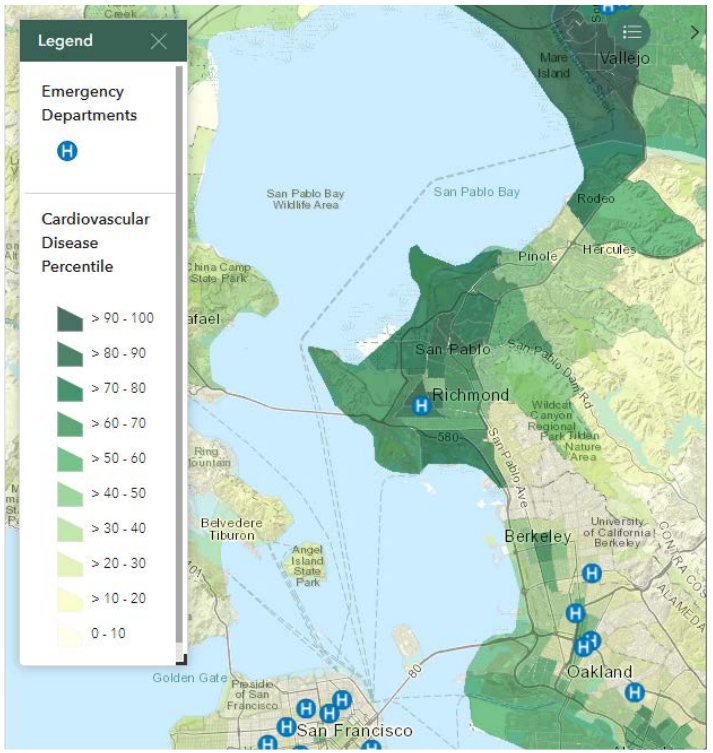
Common Pollutants	Sources	Documented Health Impacts
Nitrogen Oxides	• Unvented combustion appliances (e.g. cooking ranges, etc.) • Vented appliances with defective installations	• Respiratory irritation/Exacerbation of asthma symptoms • Increased mortality from stroke, lung, cancer, and cardiovascular disease
Carbon Monoxide	• Unvented combustion appliances (e.g. cooking ranges, etc.) • Vented appliances with defective installations	• Brain damage • Neurological symptoms (seizures, memory loss, dementia)
Particulate Matter (2.5 microns or less)	• Construction, smokestacks, fireplaces, etc. • Chemical reactions from power plants, industrial facilities, or automobile exhaust	• Respiratory irritation/Exacerbation of asthma symptoms • Increased risk of cardiovascular and respiratory mortality
Mold	• Improperly sealed building envelopes • Improperly ventilated spaces	• Respiratory irritation/Exacerbation of asthma symptoms

Sources: Zhu et al, 2020; EPA, 2023

Overall Individual Health Impacts

Rates of emergency room visits per 10,000 people for asthma (left) and cardiovascular disease (right) by census tract.





Illustrations from California Office of Environmental Health Hazard Assessment, 2023

Overall Individual Health Impacts

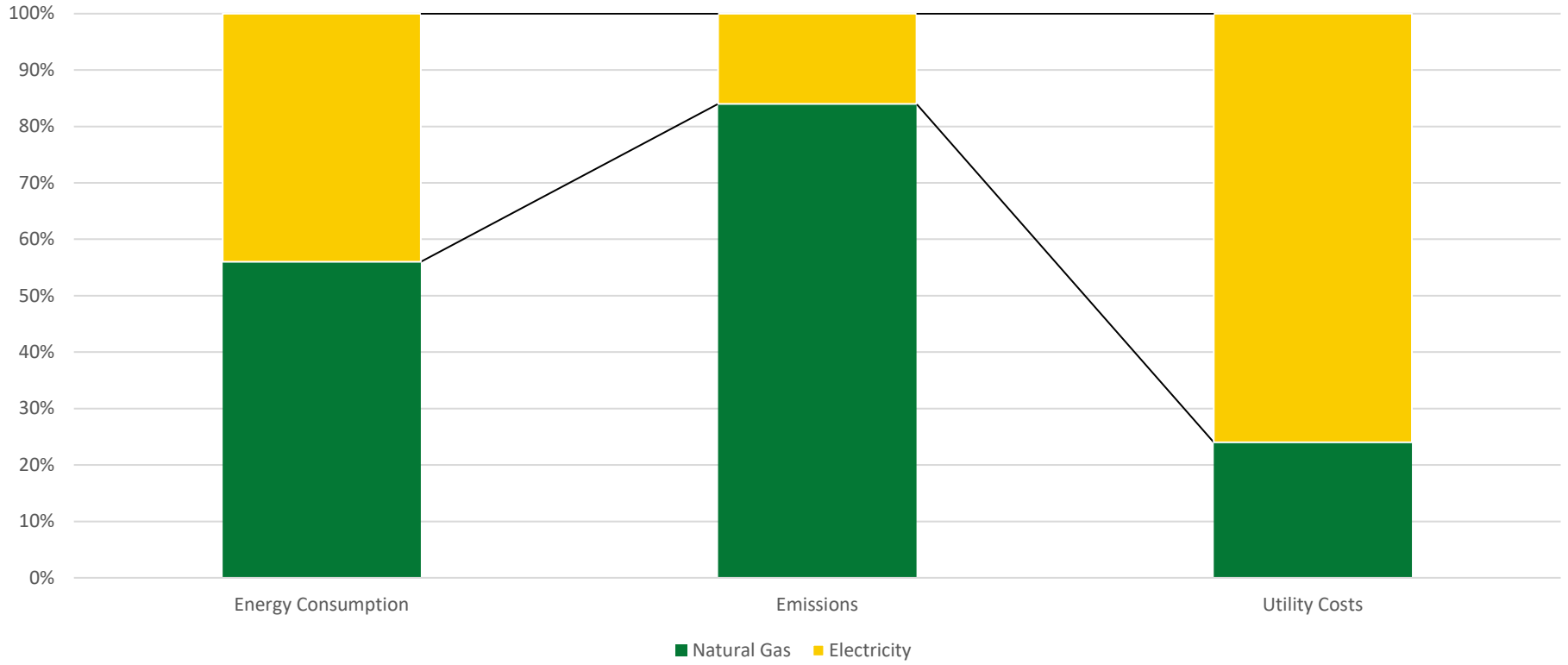
- Building electrification has the potential to improve indoor air quality for both Richmond residents and workers, by reducing or removing pollutants that result from incomplete combustion in natural gas appliances (Seals et al, 2020; Zhu et al, 2020).
- Envelope improvements, when completed by a trained professional, have been shown to increase indoor air quality by reducing outside pollutants and things like mold that can impact the health of Richmond residents and workers (EPA, 2023; Tonn et al, 2014).
- Poorly or incompletely installed envelope measures, especially without proper ventilation or electrification, could result in a decrease in indoor air quality, especially if natural gas appliances are still present. This is because insulation and air sealing decrease the exchange of air between indoors and outdoors, which in some homes serve as passive ventilation for clearing pollutants (EPA, 2023).

Report pages 44-46

Questions?

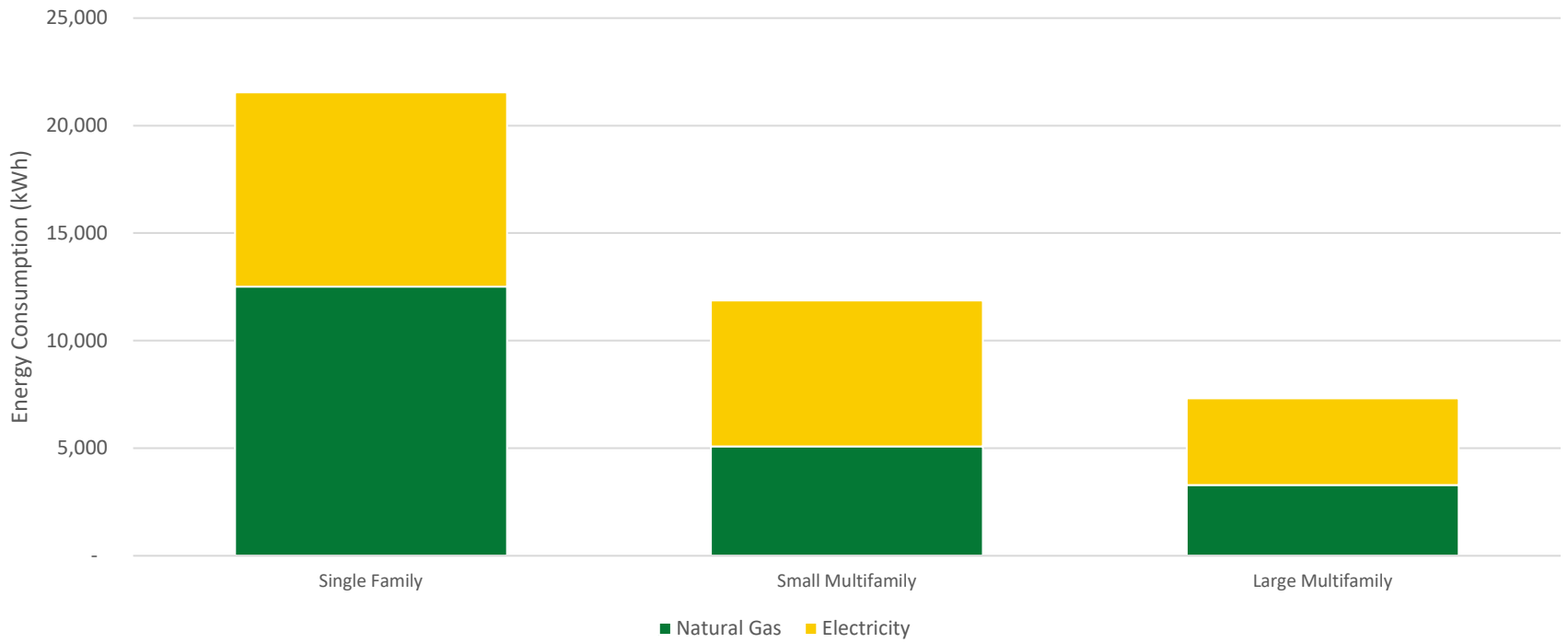
Residential Baseline Analysis

Modeled annual city-wide residential energy consumption, emissions, and utility cost share by fuel type



Residential Buildings

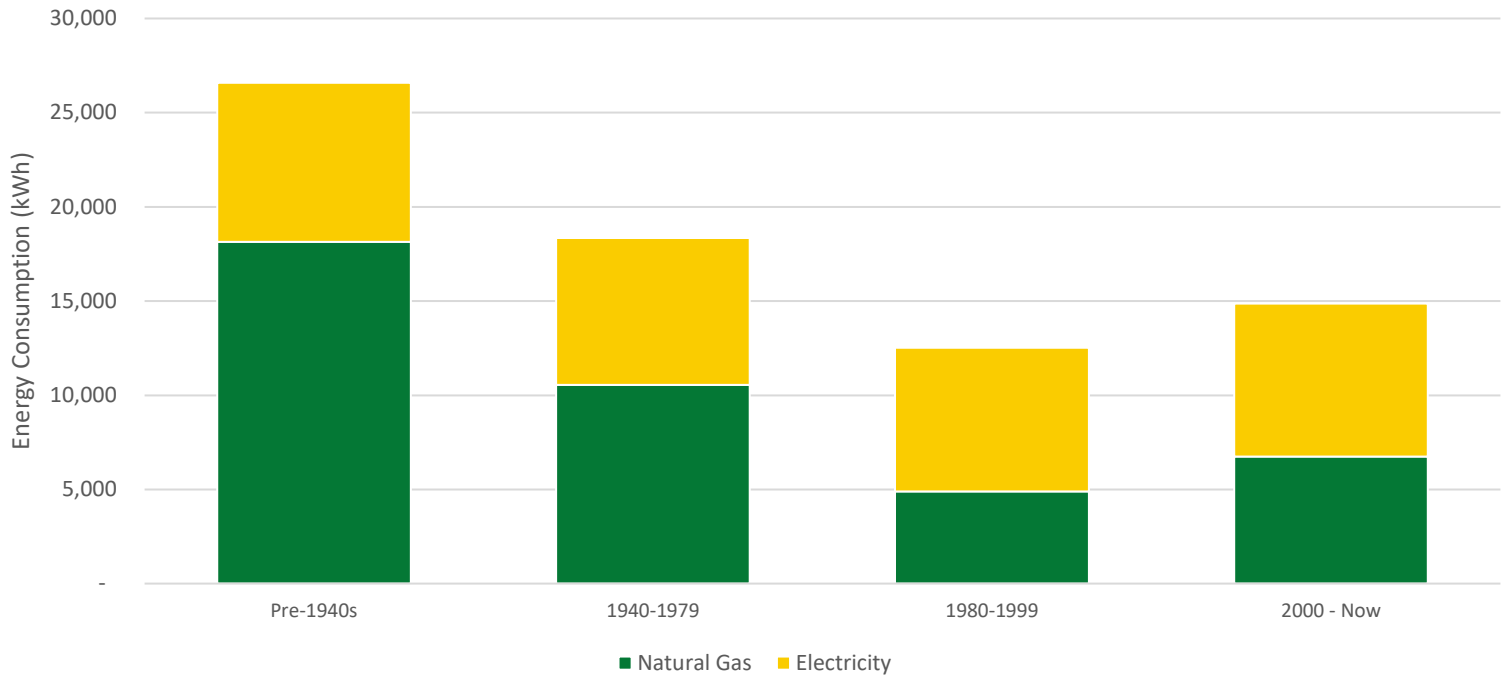
Average annual per unit modeled residential energy consumption by building type



Report page 24

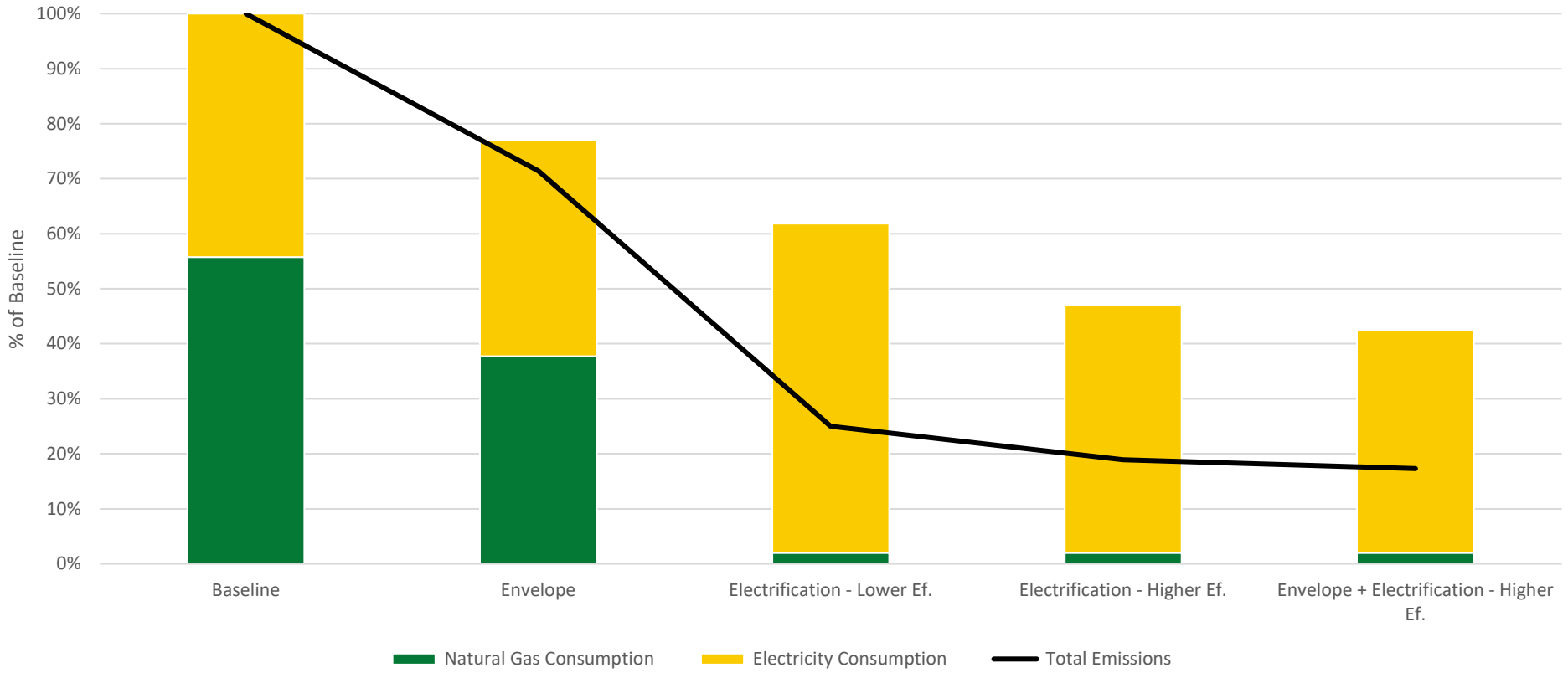
Residential Buildings

Average annual per unit modeled residential energy consumption by building vintage



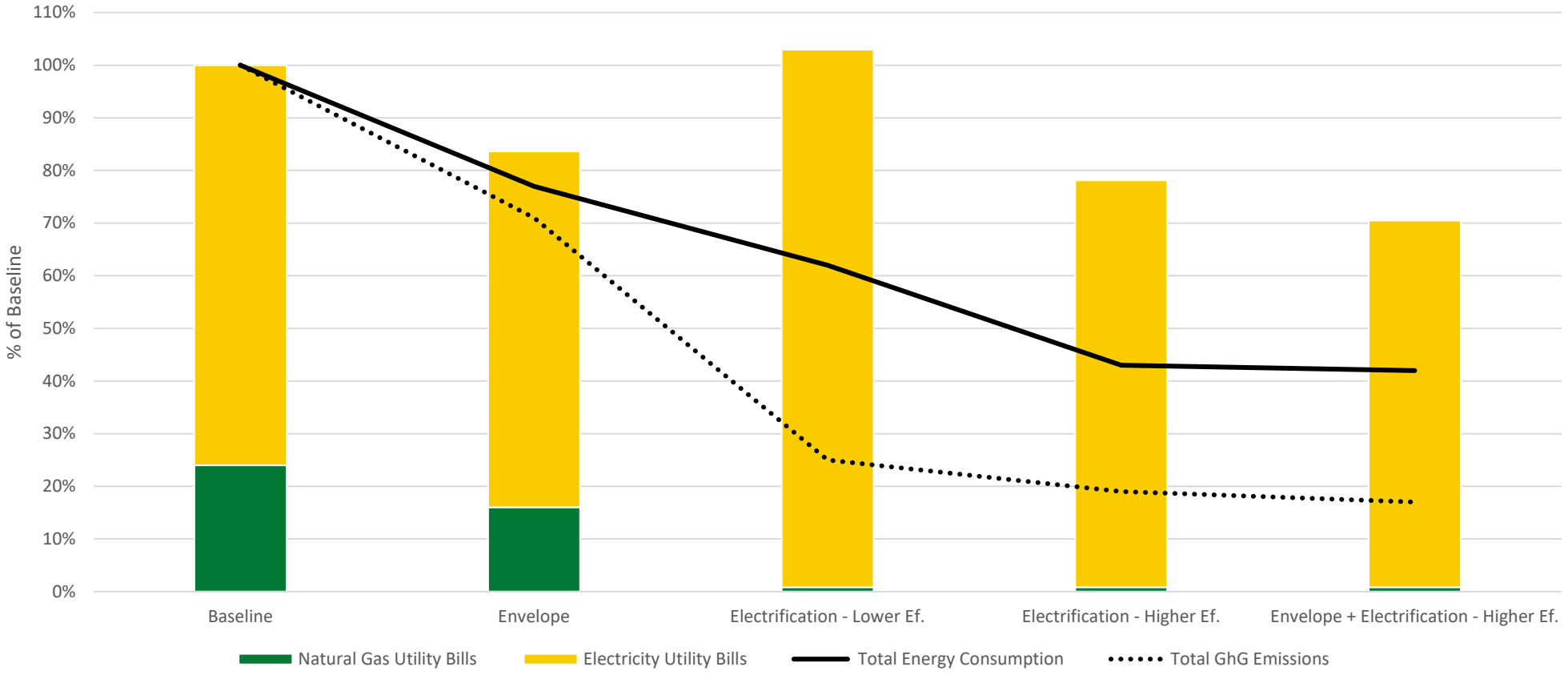
Residential Upgrade Analysis

Modeled upgrade scenario impacts on city-wide annual residential energy consumption by fuel type and emissions

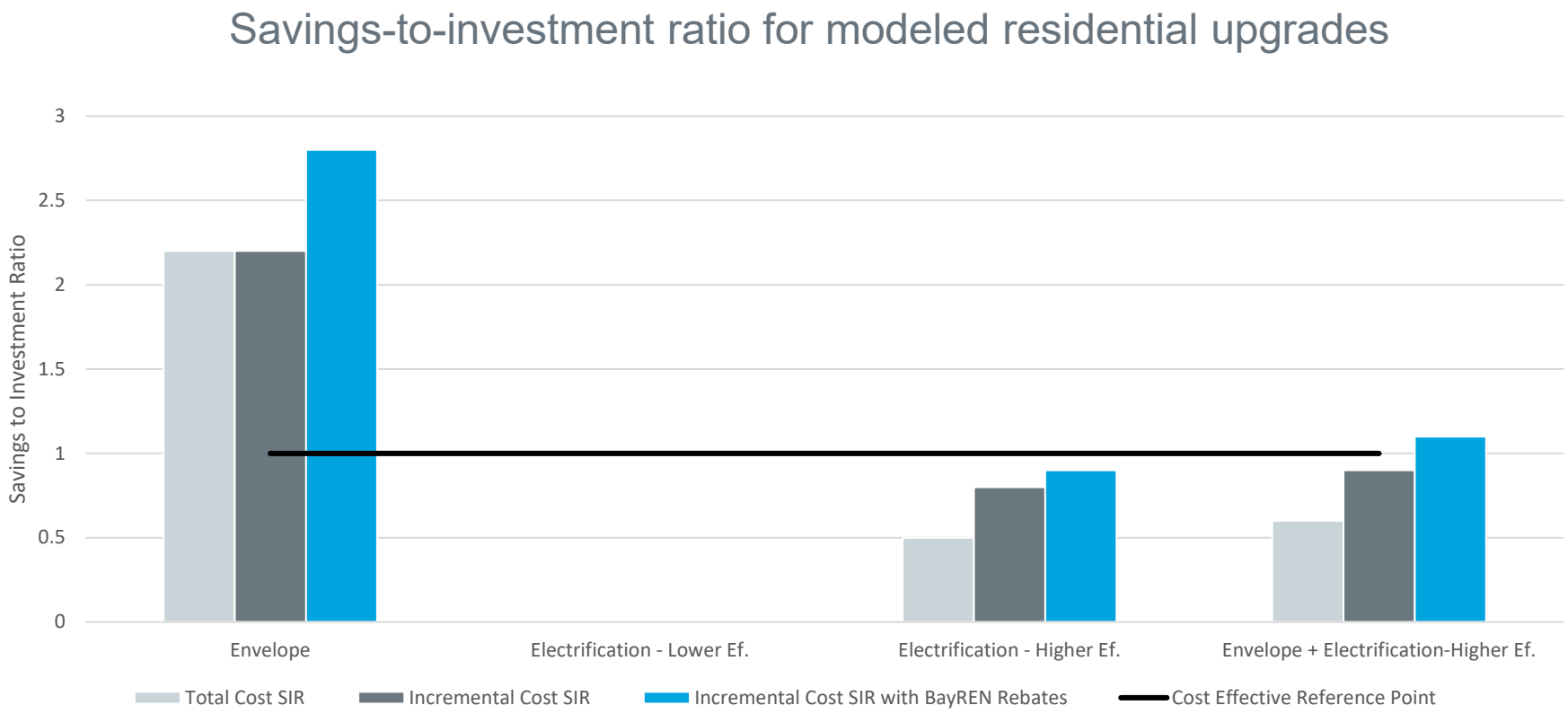


Residential Upgrade Analysis

Modeled impact of upgrade scenarios on city-wide annual residential utility bills by fuel type



Residential Upgrade Analysis

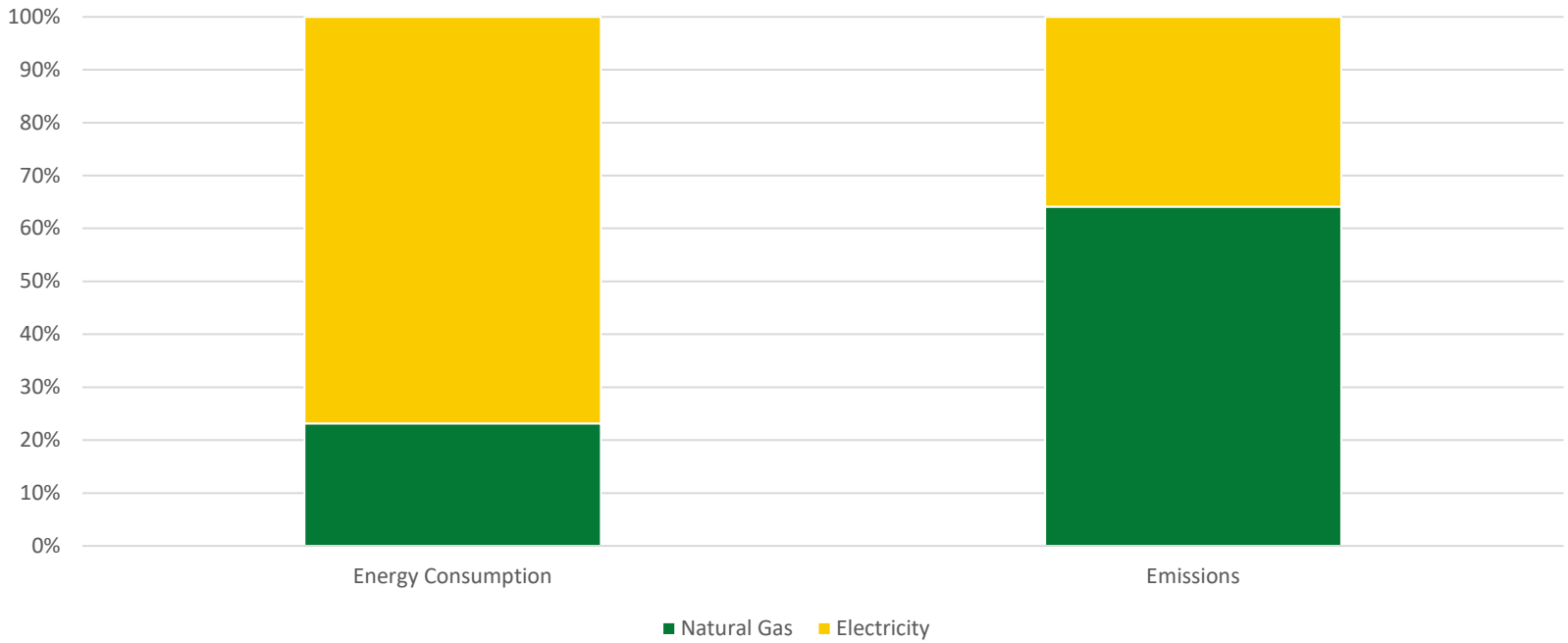


*Savings are based on estimated utility rates for 2023 and do not account for potential future rate changes and the impact on savings.

Questions?

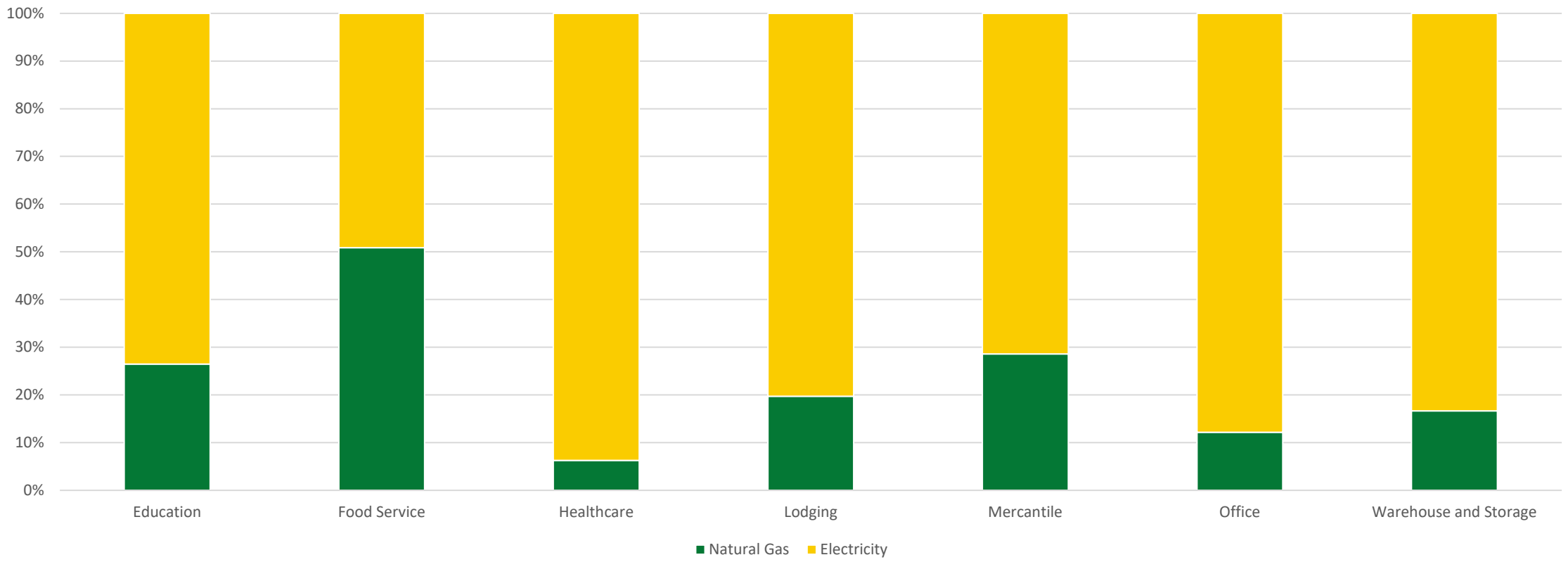
Commercial Baseline Analysis

Modeled city-wide annual commercial energy consumption and emissions by fuel type



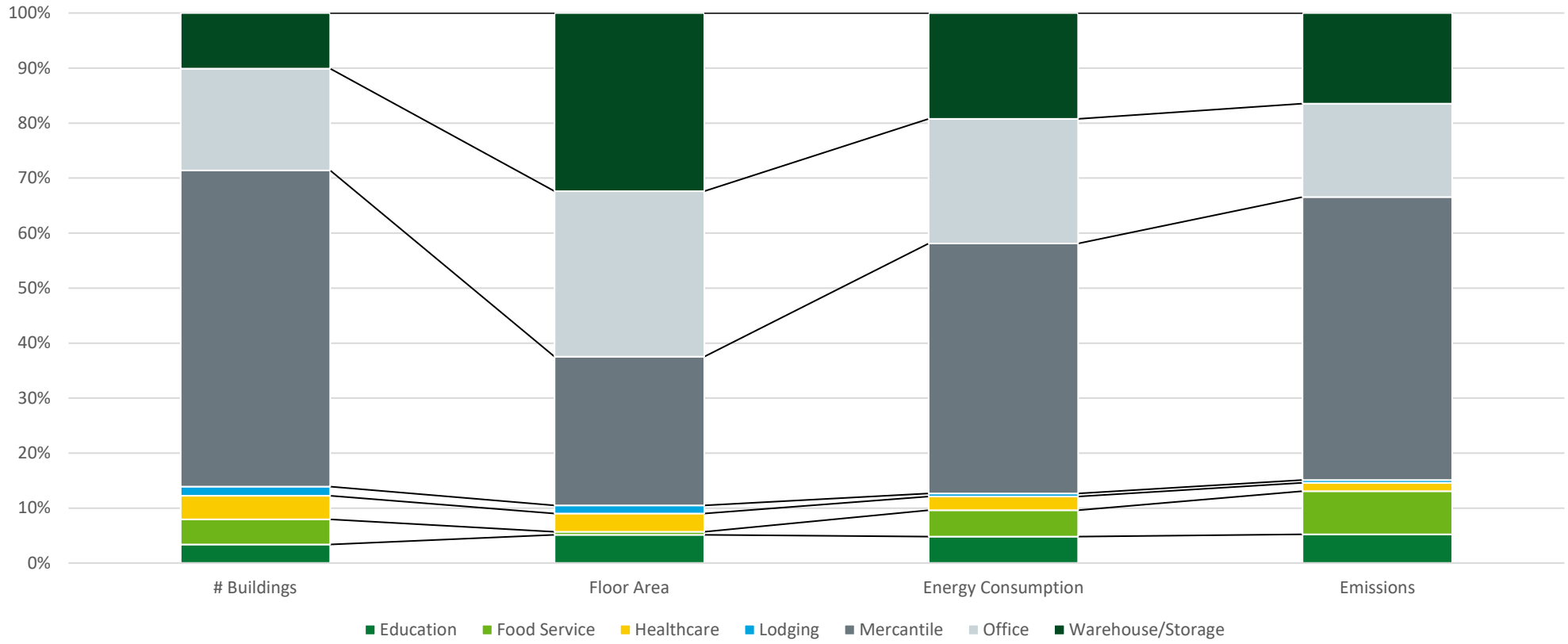
Commercial Baseline Analysis

Modeled city-wide fuel mix by commercial building use



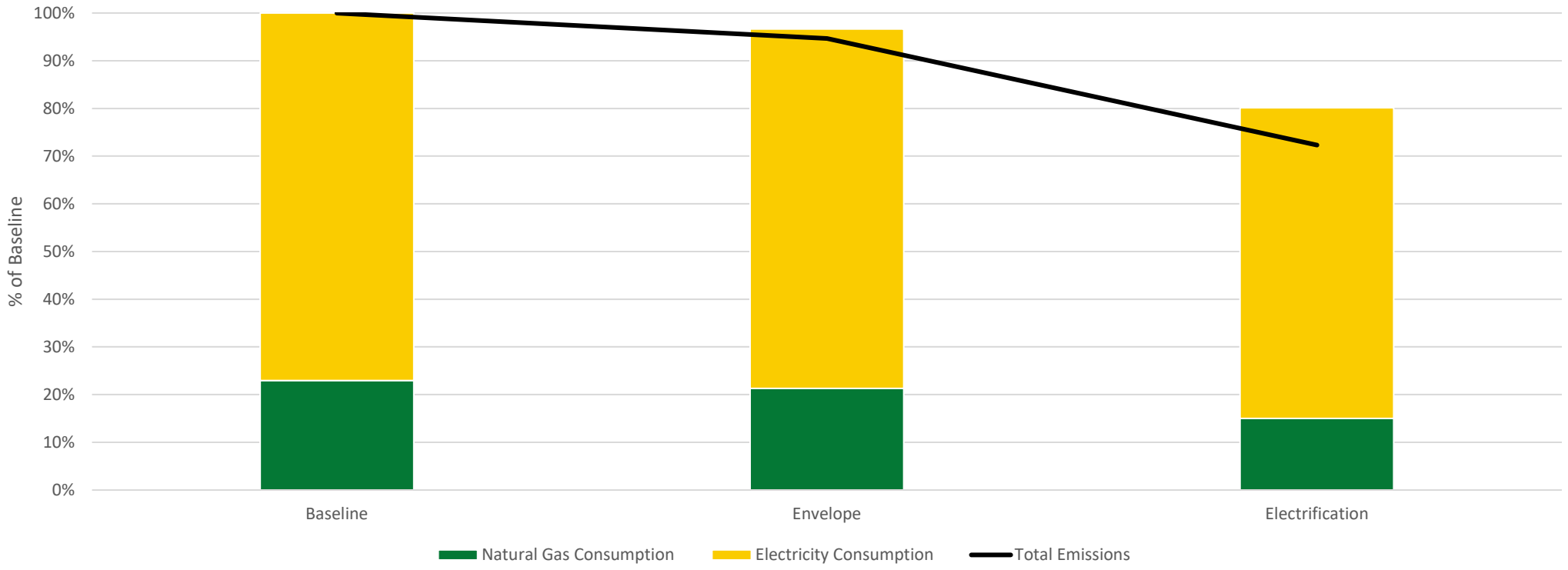
Commercial Baseline Analysis

Modeled city-wide annual commercial energy consumption and emissions share by building use



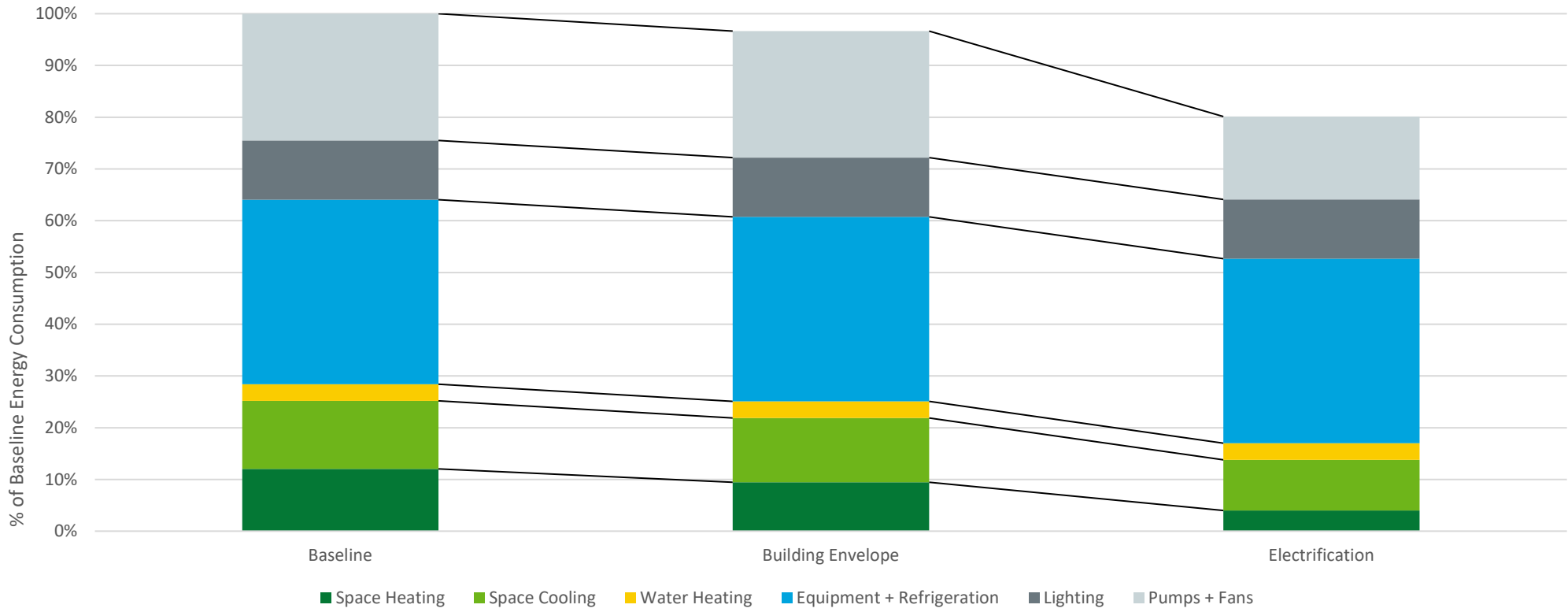
Commercial Upgrade Analysis

Modeled upgrade scenario impacts on city-wide commercial building energy consumption



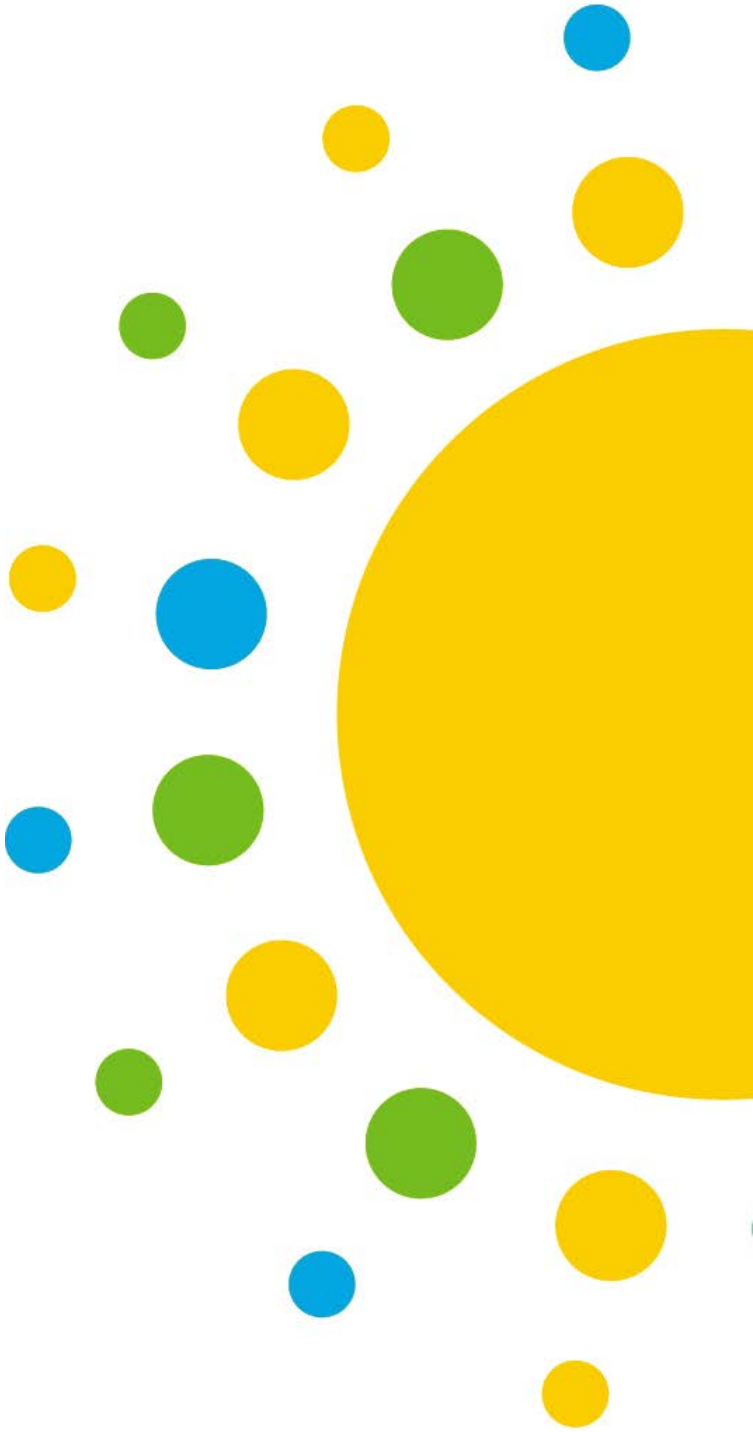
Commercial Upgrade Analysis

Modeled upgrade scenario impacts on city-wide annual commercial energy consumption by end use



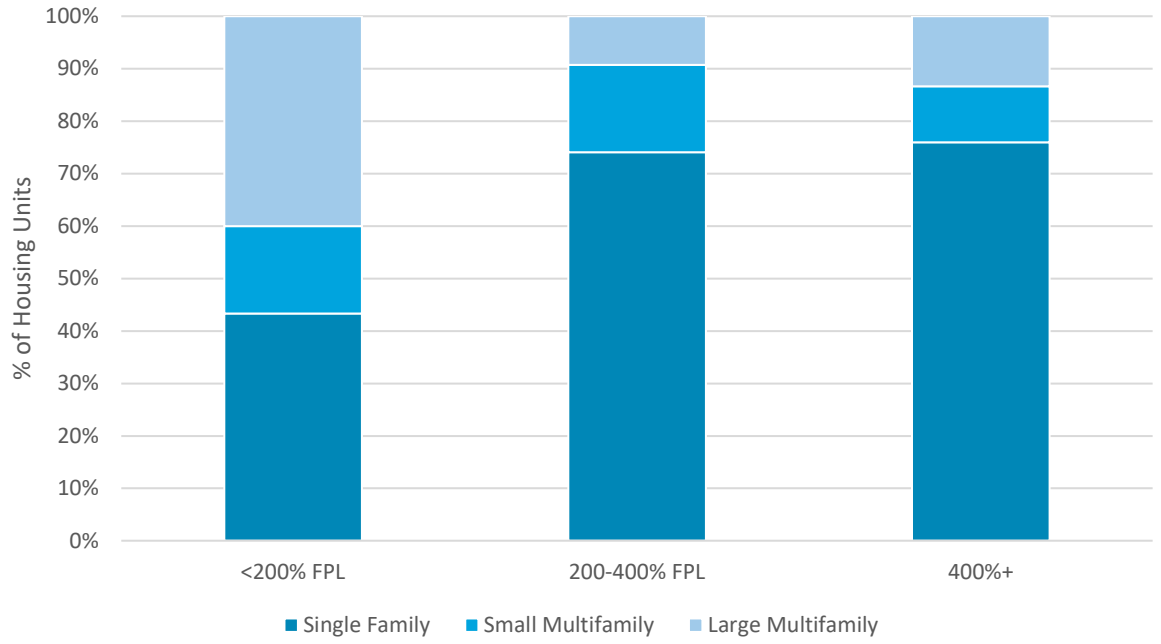
Questions?

Equity Considerations

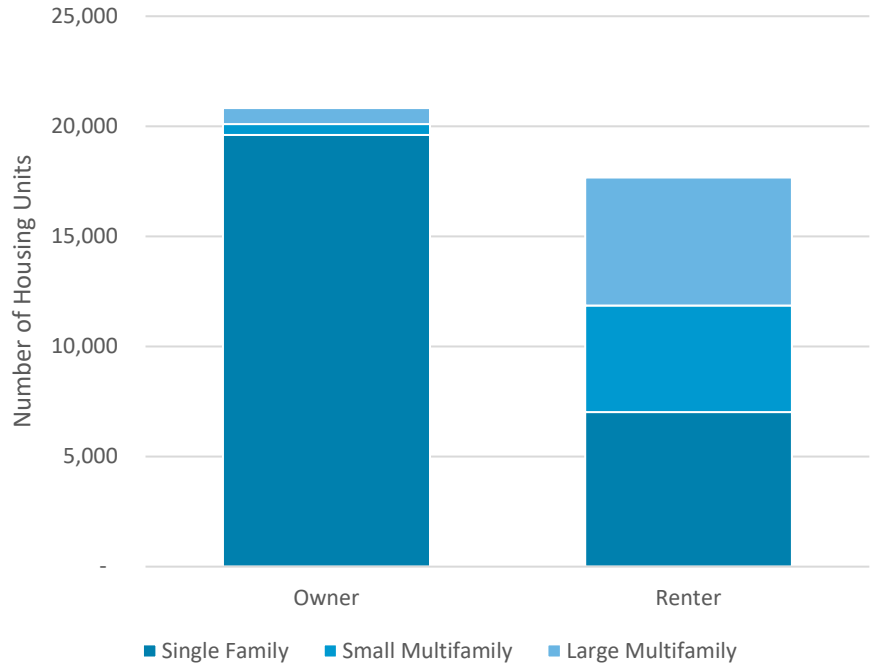


Residential Buildings

Modeled residential building type by federal poverty level

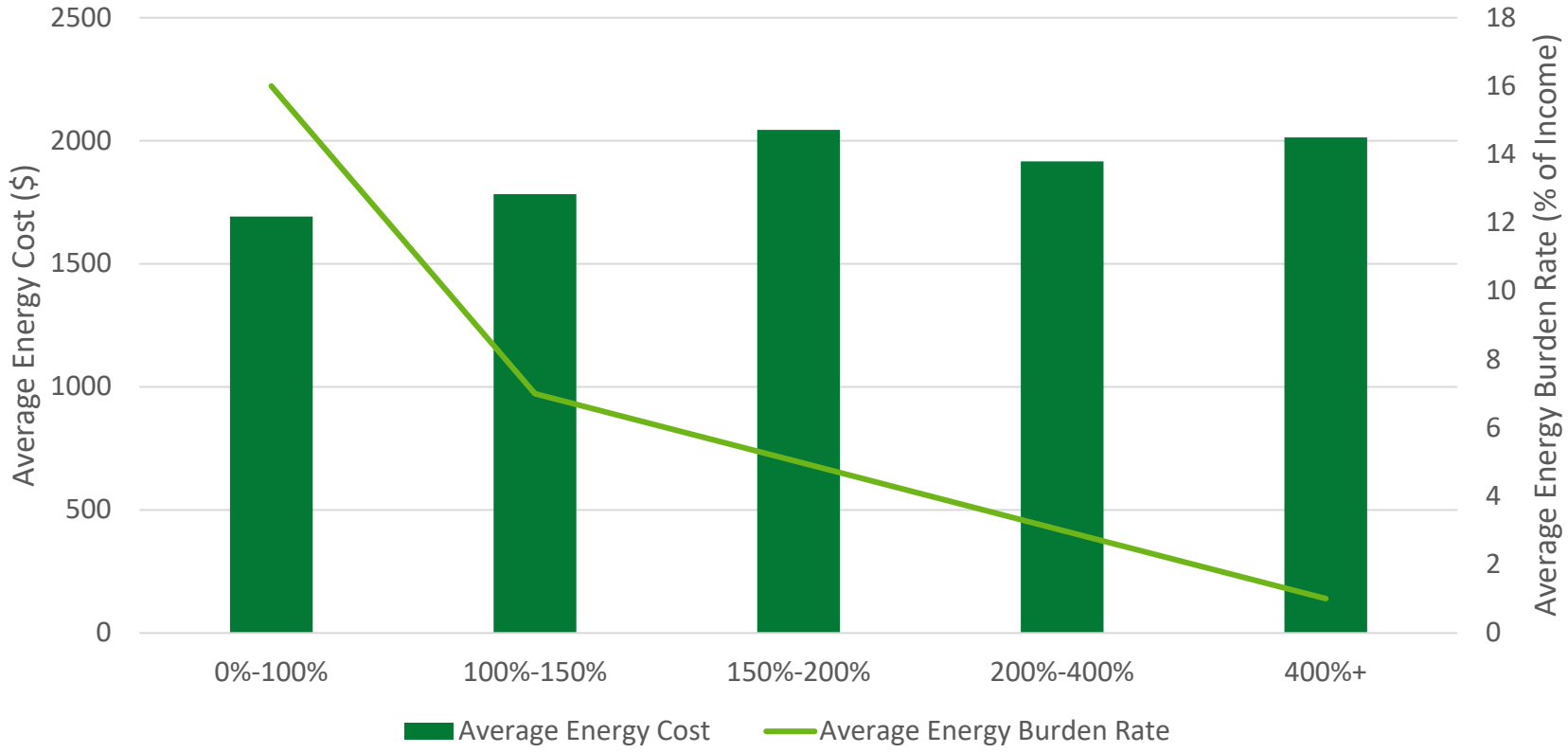


Modeled residential building type by resident tenure



Residential Buildings

Estimated average energy burden rate and energy costs by federal poverty level for Richmond

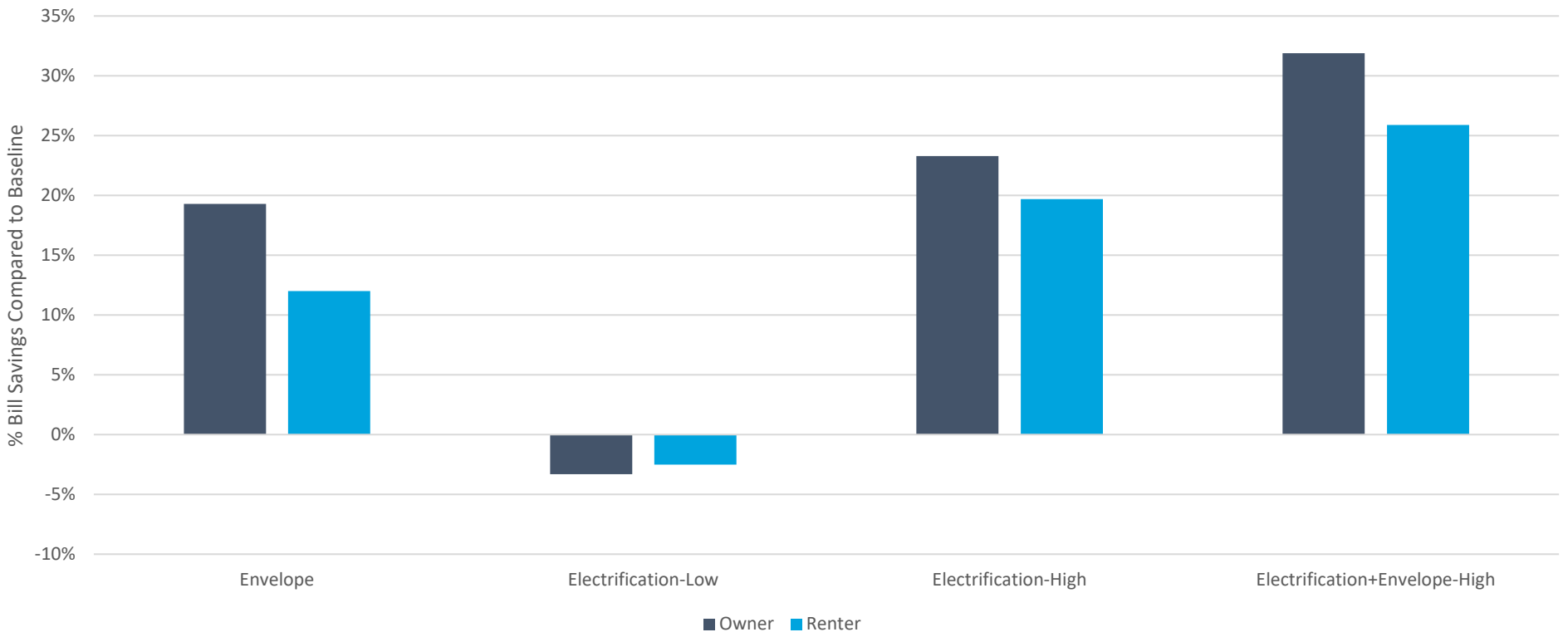


Source: DOE Low-income Energy Affordability Data Tool

Report page 59, 60

Residential Buildings

Modeled impacts of residential upgrade scenarios on annual utility bill savings by tenure



Renters, in particular those living in multifamily buildings, often pay electricity only. Low-efficiency electrification upgrades (especially if not paired with envelope upgrades) could therefor have an adverse impact on those households.

Employment Indicators

Average Annual Wages for Select Industries in Contra Costa County, Bureau of Labor Statistics 2022

Industry	Residential	Commercial
Electrical Contractors	$79,365	$104,380
Plumbing and HVAC Contractors	$76,457	$104,468
Drywall & Insulation Contractors (Both)	$102,671	$102,671
Residential Remodelers	$65,541	N/A

- Average wages for Contra Costa County workers in industries related to envelope and electrification work in the commercial sector are 42% higher than the residential sector.
- Wages for Contra Costa County jobs in industries related to electrification upgrades (HVAC, plumbing, and electrical contractors) are 22% higher than jobs related to envelope improvements.
- For reference: Median wages in Contra Costa County for all occupations in 2022 was $82,050.

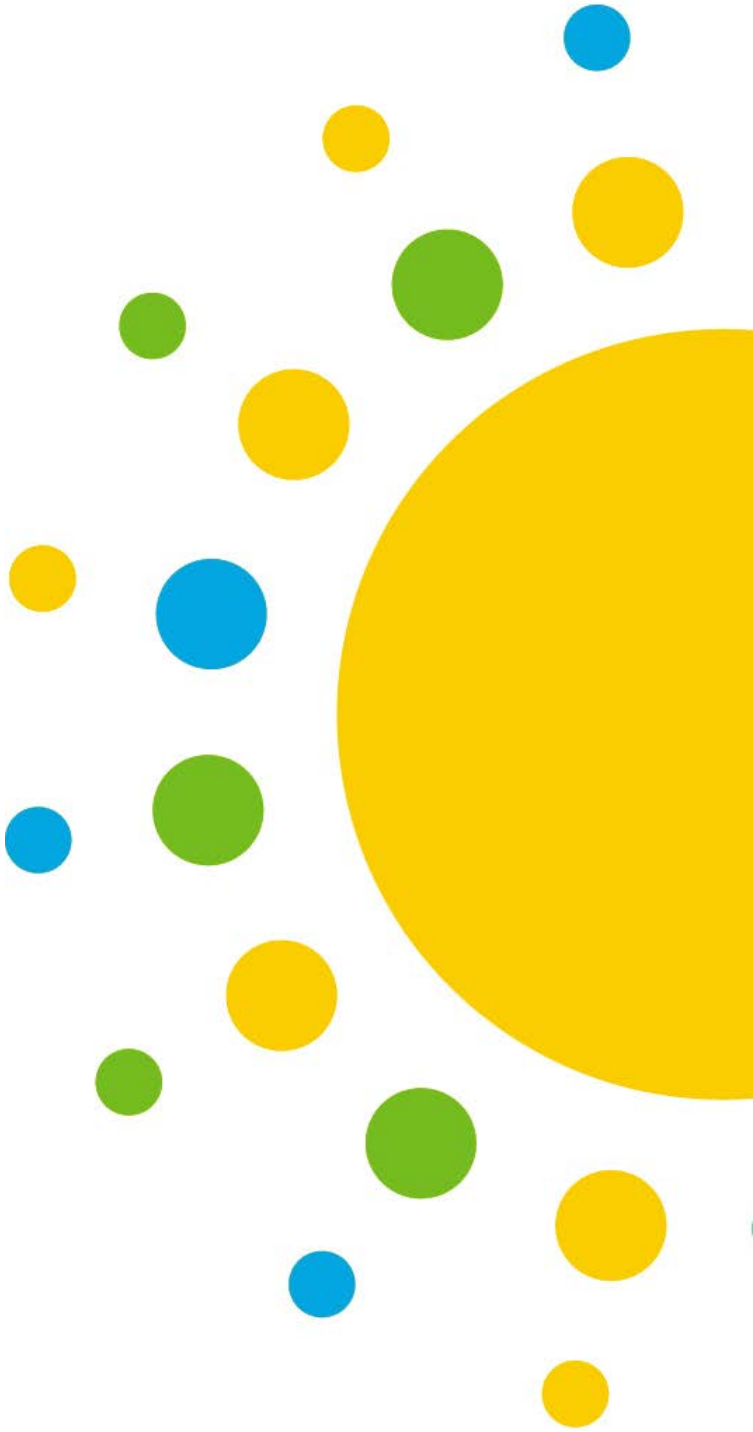
Health Indicators

- Residents living in multifamily buildings may be more likely to have higher levels of indoor air pollutants due to smaller living spaces; multifamily residents in Richmond are also more likely to be low income (Zhu et al., 2020).
- Children have increased risk asthma, wheezing, and other respiratory symptoms associated with exposure to NO_2 (Zhu et al., 2020).
- Women may also be at greater risk due to increased exposure with higher frequency of cooking (Zhu et al., 2020).
- Pursuing building envelope improvements upgrades without proper ventilation or without electrification of gas appliances has the potential to make indoor air quality worse (EPA, 2022, Underhill et al., 2020).

Questions?

Case Studies

What does electrification of existing buildings look like in other places?



What Does Existing Building Electrification Look Like in Other Cities?

Ithaca, NY

Denver, CO

Berkeley, CA

Photo by Will Barkoff on Unsplash

Photo by Colin Lloyd on Unsplash

Photo by Jeremy Huang on Unsplash

What Does Existing Building Electrification Look Like in Other Cities?

	Ithaca, NY	Denver, CO	Berkeley, CA
City Population	~30,000	~715,000	~123,000
Electrification Goal	Electrify and decarbonize every building in the city by 2030 (~6,000 buildings)	Reduce energy use by 30% in commercial and multifamily buildings larger than 25,000 SF by 2030 (~3,000 buildings)	Transition all gas-fired appliances to electric in all residential buildings less than 4 stories by 2045 (32,000+ homes)
Implementation Approach	RFP selected BlocPower to lead financing and deployment • Phase 1 (3-4 years): 600 commercial buildings and 1,000 residential buildings • Phase 2 (4-5 years): The remaining 4,400 buildings	Through amendments to Denver's Building and Fire Code, they will require space and water gas heating and cooling systems to be replaced at end of life with electric options (when cost-effective)	Replacement of gas appliances with electric at end of life, when installing central AC or solar PV, when undergoing major renovation, or when a home is sold. Plan suggested 2 phases. • Phase 1 (3-4 years): Voluntary • Phase 2 (15 years): Mandatory
Source	(Walton, 2022)	(Denver Climate Action, Sustainability, & Resiliency, 2023)	(City of Berkeley, 2021)

Questions?

References

City of Berkeley. 2021. "Berkeley Existing Buildings Electrification Strategy." Aug. 14, 2023. https://berkeleyca.gov/your-government/our-work/adopted-plans/berkeley-existing-buildings-electrification-strategy.

Denver Climate Action, Sustainability, & Resiliency. "Energize Denver Ordinance: Electrification." Aug. 14, 2023. https://www.denvergov.org/files/assets/public/climate-action/documents/energize-denver-hub/energize-denver-electrification.pdf.

EPA. 2023. "The Inside Story: A Guide to Indoor Air Quality." https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality.

Seals, B., and A. Krasner. 2020. *Gas Stoves: Health and Air Quality Impacts and Solutions*. Rocky Mountain Institute. https://rmi.org/insight/gas-stoves-pollution-health/.

Tonn, B., E. Rose, B. Hawkins, and B. Conlon. 2014. *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program*. Oak Ridge, TN: Oak Ridge National Laboratory. ORNL/TM-2014/345. https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_345.pdf.

Underhill, LJ, WS Dols, SK Lee, MP Fabian, and JI Levy. 2020. "Quantifying the impact of housing interventions on indoor air quality and energy consumption using coupled simulation models." *J Expo Sci Environ Epidemiol*. 30(3):436-447. DOI: 10.1038/s41370-019-0197-3.

Walton, Robert. 2022. "Inside Ithaca's plan to electrify 6,000 buildings and grow a regional green workforce using private equity funds." Utility Dive. June 2, 2022. https://www.utilitydive.com/news/inside-ithacas-plan-to-electrify-6000-buildings-and-grow-a-regional-green/623126/

Zhu, Y., R. Connolly, Y. Lin, T. Matthews, and Z. Wang. 2020. *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.* Los Angeles, CA: UCLA. https://coeh.ph.ucla.edu/wp-content/uploads/2023/01/Effects-of-Residential-Gas-Appliances-on-Indoor-and-Outdoor-Air-Quality-and-Public-Health-in-California.pdf.

Thank You

www.energy.gov/communitiesLEAP

Richmond Project Website:
www.ci.richmond.ca.us/4373/US-Department-of-Energy-DOE-Communities-

Produced for the U.S. Department of Energy
by the National Renewable Energy Laboratory (NREL).
DOE/GO-102023-6052 • August 2023